



The association of eating styles with weight change after an intensive combined lifestyle intervention for children and adolescents with severe obesity



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ABSTRACT

The main purpose of this prospective intervention study was to determine whether eating styles after an intensive, partly inpatient, one year combined lifestyle intervention are associated with weight change in the following year in severely obese children and adolescents.

A total of 120 participants (8–19 years) with an average SDS-BMI of 3.41 (SD = 0.38) was included. Measurements were conducted at baseline (T0), at the end of treatment (T12) and at the end of follow up two years after baseline (T24). The primary outcome measurement was the Δ SDS-BMI between T12 and T24. As primary determinant of weight change after treatment, the participants eating styles were evaluated with the Dutch Eating Behavior Questionnaire – child report that measures external, emotional and restraint eating. The association between outcome and determinant was assessed in linear regression analyses. Complete data were available for 76 of the 120 participants.

This study shows that for girls a higher score on restraint eating at T12 and a higher score on external eating at T12 were associated with more weight (re)gain in the year after treatment. No statistically significant association with emotional eating at T12 was found. In addition for girls a higher score on external eating at T0 was associated with more weight (re)gain in the year after treatment. Furthermore, the observed changes in eating styles suggest that on average it is possible to influence these with treatment, although the detected changes were different for girls and boys and for the different eating styles.

More generally, this study indicates that for girls the levels of restraint and external eating after treatment were associated with the weight change during the following year.

Trial registration: : Netherlands Trial Register (NTR1678, registered 20-Feb-2009).

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1. Introduction

The goal of combined lifestyle interventions for children and adolescents with obesity is long-term weight change. Relapse after treatment is common (Wilfley et al., 2007; Yanovski & Yanovski, 2003), but long-term effects vary substantially between persons. In order to improve the care for children and adolescents with severe obesity, knowledge about what determines this inter-individual variability in long-term treatment effects is important but currently limited (Wilfley et al., 2007).

A review (Teixeira, Going, Sardinha, & Lohman, 2005) that looked at psychosocial predictors of treatment success in overweight and obese adults identified only a few factors that were predictive of more total weight loss: less previous dieting, more self-motivation, more general efficacy and more autonomy. Studies with obese children and adolescents that underwent inpatient (Braet, 2006b) or outpatient (Frohlich, Pott, Albayrak, Hebebrand, & Pauli-Pott, 2011; Moens, Braet, & Van Winckel, 2010) lifestyle programs concluded that a higher global self-esteem and less maternal psychopathology were associated with more total weight loss at follow up several years later (Moens et al., 2010). Eating disorder symptoms (Braet, 2006b) and maternal obesity, depression and anxious attachment attitude were predictive of less long-term treatment success (Frohlich et al., 2011).

The scarce knowledge about psychosocial determinants of long-term weight change after treatment, especially for children and adolescents with severe obesity, warrants further investigation.

Eating behavior has extensively been linked to differences in weight status (French, Epstein, Jeffery, Blundell, & Wardle, 2012). Three styles of eating behavior that have repeatedly been investigated in relation to overeating are external eating, emotional eating and restraint eating. These are described in detail elsewhere (Braet & Van Strien, 1997; Cebolla, Barrada, van Strien, Oliver, & Banos, 2014; Van Strien, Frijters, Bergers, & Defares, 1986). In short, external eating is the tendency to eat in response to food-related stimuli regardless of the internal states of hunger and satiety, emotional eating is the tendency to overeat in response to negative emotions and restraint eating is the tendency to consciously restrict food intake.

Research with both adults and children indicated that these three eating styles, as measured with different versions of the Dutch Eating Behavior Questionnaire originally developed by Van Strien et al. (Van Strien et al., 1986), were associated with obesity. The exact direction of the associations found in different cross-sectional studies between the three eating styles and weight status in children varied considerably for external and emotional eating, for unexplained reasons (Braet et al., 2008; Braet & Van Strien, 1997; Snoek, van Strien, Janssens, & Engels, 2007). Regarding restraint eating, there is more consistency: restraint eating was found to be higher in children and adolescents (both boys and girls) with overweight or obesity in the three mentioned studies.

Research in children and adolescents (Braet et al., 2008; Snoek et al., 2007) and in adults (Presnell, Pells, Stout, & Musante, 2008; van Strien, Levitan, Engels, & Homberg, 2015) suggests there are sex differences in the eating styles. For the specific group of boys and girls with severe obesity, it is not established how the three eating styles are related to overeating and weight status.

It has been proposed that differences in eating styles as measured with different versions of the Dutch Eating Behavior Questionnaire may, at least in part, explain differences in weight change after weight loss treatment, but the available evidence shows mixed results (Blair, Lewis, & Booth, 1990; Braet, Tanghe, Decaluwe, Moens, & Rosseel, 2004; Moens et al., 2010; Roosen, Safer, Adler, Cebolla, & van Strien, 2012).

Currently is not known what the role of eating styles is in weight

maintenance for children and adolescents with severe obesity.

Research indicates that the eating styles can be changed through behavioral treatment (Braet et al., 2004; Ho et al., 2013), but the change in children and adolescents with severe obesity has not been researched.

In sum, eating styles may be associated with treatment success and may be a valuable target of the intervention when treating children and adolescents for their obesity. This is particularly relevant for the phase of weight loss maintenance (Braet, 2006b; Seidell, Halberstadt, Noordam, & Niemer, 2012; Van Strien & Van de Laar, 2008) since successful management of obesity requires lifelong behavioral changes (AMA, 2013; Kelly et al., 2013). Therefore, getting insights in eating styles can provide useful information on what determines long-term weight loss.

The main objective of this study was to determine, for boys and girls separately, whether eating styles are associated with long-term weight change in severely obese children and adolescents that take part in an intensive, partly inpatient, combined lifestyle intervention. With a special focus on testing the main hypothesis that eating styles after the one year intervention are associated with weight change during the following year. We assume that the three eating styles are associated with individual differences in weight change, however given the mixed findings in earlier research we cannot formulate the direction of the effect.

Additional objectives were to determine if eating styles before treatment are associated with weight change after treatment and to examine changes in eating styles directly after treatment and at follow-up one year later. To our knowledge this is the first intervention study that looks at these long-term associations and changes for this particular patient group.

2. Materials and methods

The materials and methods of this study are described in brief, as they have been described in detail elsewhere in a report on the study protocol (Halberstadt et al., 2013) and articles on other behavioral determinants (Halberstadt, De Vet et al., (submitted); Halberstadt, Van Weelden et al., (submitted)) the cost-effectiveness of the weight loss program (Makkes et al., 2011) and the demographic and cardiometabolic characteristics of the study participants (Makkes, Renders, Bosmans, van der Baan-Slootweg, & Seidell, 2013).

2.1. Study design

For this prospective intervention study measurements were conducted at three points in time: at baseline (start of treatment; T0), at the end of treatment (12 months after baseline; T12) and at the end of follow-up (24 months after baseline; T24).

The Medical Ethics Committee of VU University Medical Center Amsterdam approved the study design, protocols and informed consents procedure.

2.2. Setting

Data were collected at the childhood obesity clinic Heideheuvel (part of Merem Treatment Centers) in Hilversum, the Netherlands, between August 2009 and July 2013.

2.3. Study population

A total of 120 participants with severe obesity were included in the study: 30 children (8–13 years) and 90 adolescents (13–19 years). Of the 120 participants 99 completed treatment and 91 remained in the study at the end of follow up. One participant

underwent bariatric surgery before the measurement at the end of follow up.

Written informed consents were obtained from both the participants (from age 12) and their parents/caregivers (from age 8 of their child). A 20 Euro gift voucher was provided to reimburse travel expenses for the study participants. The cost of treatment was completely covered.

2.4. Intervention

The treatment program consisted of an intensive combined lifestyle intervention by a multidisciplinary team. The program, that lasted one year, had either a 2 months or a 6 months period of inpatient treatment during weekdays. The intervention required active and frequent participation of the parents/caregivers.

All participants were at the start of treatment informed of their scores on external, emotional and restraint eating as assessed at baseline. During the group treatment attention was given to the three eating styles, by talking with both children and parents about dealing with temptations, ways to handle emotions and how to achieve a structured eating pattern without dieting. In addition individual goals concerning eating styles were formulated if applicable, for example learning how to deal with sadness without eating cookies.

2.5. Measurements

2.5.1. Outcome measure – SDS-BMI change

Height and weight were measured at the obesity clinic and were used to calculate BMI and SDS-BMI at T0, T12 and T24. The primary outcome measurement of this study was the weight change between the end of treatment and the end of follow up.

2.5.2. Primary determinant – eating styles

As primary determinant of weight change, eating styles were assessed at T0 and T12 in the children and adolescents with a version specifically adapted to children (Braet, Beyers, Goossens, Verbeke, & Moens, 2012) of the Dutch Eating Behavior Questionnaire (DEBQ), originally developed by Van Strien and colleagues (Van Strien et al., 1986; van Strien, Herman, Anschutz, Engels, & de Weerth, 2012; van Strien, Peter Herman, & Anschutz, 2012). This DEBQ-child report, a 33-item self-report questionnaire, assesses three eating styles that reflect dysfunctional regulation of food intake: 1) external eating (10 items, e.g. “Do you take a larger portion than usual when the food smells and looks good?”), 2) emotional eating (13 items, e.g. “Do you have a desire to eat when you are angry?”) and 3) restraint eating (10 items, e.g. “How often do you decline offered foods or beverages because you want to pay attention to your weight?”) (Van Strien et al., 1986). All items are rated on a five-point Likert-type scale ranging from never (1) to very often (5). For each scale a mean score can be calculated by dividing the sum of the item scores by the total number of completed items for that scale resulting in a scale score between 1 and 5.

The DEBQ-child report has adequate internal consistency, test-retest reliability, factorial validity and dimensional stability in samples aged 7–17 years (Braet et al., 2012, 2008, 2007; Edlund, Halvarsson, & Sjöden, 1996; Moens et al., 2010). The present study found Cronbach's alphas of 0.86 for the scale external eating, 0.93 for emotional eating and 0.89 for restraint eating at baseline. Belgian norm scores are available for the DEBQ-child report (Braet, 2006a) and for the original DEBQ that can be used for children from the age of 11 years representative Dutch norm scores are available (Van Strien, 2015).

2.5.3. Confounders

As potential confounders, a number of factors were included: SDS-BMI at baseline, age at baseline, ethnicity, highest completed educational level of the parents and intensity of treatment (inpatient period of 2 or 6 months). For ethnicity participants were categorized into two main groups: native Dutch (both parents born in The Netherlands) and other (at least one of the parents born abroad). When both parents were born abroad in different countries, the country in which the mother was born was used to classify the participant. Educational level of the parents was classified according to the definition of Statistics Netherlands (www.cbs.nl) and divided into low (lower vocational training, lower general secondary education and primary school and special primary education or less), medium (intermediate vocational training, higher general secondary training and pre-university education) or high (completed higher vocational training and university).

2.6. Statistical analyses

All analyses except for the description of the baseline characteristics were done for boys and girls separately, because of sex-differences in the eating styles. Statistical analyses were carried out using SPSS 20.0 and R statistical software (Team, 2012). The analyses were restricted to the participants with observed scores for eating styles at T12 and an available SDS-BMI score at T12 and T24 ($n = 76$). They are defined as having ‘complete data’ because the data needed for the analyses for the main research question were complete for them. Additionally, one person had only one item missing for the DEBQ-child report at T12 and was also included in the analyses.

2.6.1. Missing data

The missing data on the questionnaires were handled by multiple imputation at the item level, in order to have the highest power (Eekhout et al., 2014). Of the 77 participants that were used in the analyses, five participants had missing item scores at T0, one at T12 and five at T24. Participants that missed an entire questionnaire at T0 and T24 were excluded from the analyses concerning these time points ($n = 1$ at T0, $n = 3$ at T24).

Multiple imputation was performed using all available data in R statistical software (Team, 2012) by predictive mean matching using the Multivariate Imputation by Chained Equations (MICE) method with 25 imputations (Van Buuren & Groothuis-Oudshoorn, 2011).

As a sensitivity analysis, all analyses were repeated without the participant that underwent bariatric surgery before the measurement at the end of follow up was taken, without imputation of the missing items and with multiple imputation of the missing questionnaires (per scale), to check whether this would affect the results.

2.6.2. Baseline characteristics

Baseline characteristics were determined for all participants and to test the differences between the participants with and without complete data at T0 an independent-samples t-test was done for BMI, SDS-BMI, age and eating styles and a Chi-square test was done for gender, ethnicity and level of education of the parents.

2.6.3. Outcome measure and primary determinant

The means and standard deviations of BMI and SDS-BMI at T0, T12 and T24 were determined for the group with complete data. The change in BMI and SDS-BMI between T0 and T12, T12 and T24 and T0 and T24 was analyzed in a mixed model. Missing data for these analyses were handled in the mixed model. The estimated differences between measuring moments and their 95% confidence

interval were reported.

The primary outcome measurement - weight change between the end of treatment and the end of follow up – was calculated by subtracting SDS-BMI at T12 from SDS-BMI at T24, with a positive outcome indicating weight gain.

To test the main hypothesis of this study, we looked at eating styles after one year of treatment (at T12) as determinant of weight change after treatment in a linear regression analysis for the participants with complete data (n = 77). In addition, we assessed the association between eating styles at baseline (T0) and weight change after treatment in a linear regression analysis for the participants with complete data that had observed eating style scores at T0 (n = 76). The non-standardized regression coefficient β and the confidence interval (95% CI), as well as the effect-size according to Cohen's f² (Cohen, 1988) of the associations were calculated for all eating styles. Effect-size according to Cohen's f²: is calculated with the formula $f^2 = \frac{R_M^2 - R_{M-X}^2}{1 - R_M^2}$ and f² = 0.02 is a small effect, f² = 0.15 is a medium effect and f² = 0.35 is a large effect (Cohen, 1988).

Furthermore, the means and standard deviations of the scores on eating styles at T0, T12 and T24 were described for the participants with complete data. The change over time (between T0 and T12, T12 and T24 and T0 and T24) of eating styles was analyzed in a mixed model, which is a multilevel model that includes the correlation between the measuring moments in the analyses. The analyses were done for each eating style separately. Missing data for these analyses were handled in the mixed model. The estimated differences between measuring moments and their 95% confidence interval were reported.

2.6.4. Confounders

The potential confounders of the relation between eating styles at T12 and T0 and weight change after treatment were included in the analyses.

3. Results

3.1. Baseline characteristics

Table 1 presents baseline characteristics of all study participants and of the participants with (n = 76) and without (n = 44) complete data separately. There were no statistically significant differences between the groups with and without complete data as assessed

for the variables BMI, SDS-BMI, age, the percentage of boys and girls, ethnicity, level of education of the parents and external eating, emotional eating and restraint eating.

For girls with complete data the scores for the eating styles at baseline were on average 2.86 (0.76) for external eating, 2.35 (0.88) for emotional eating and 2.64 (0.76) for restraint eating. For boys with complete data the scores for the eating styles at baseline were on average 2.73 (0.72) for external eating, 2.14 (0.88) for emotional eating and 2.67 (0.83) for restraint eating.

The BMI and SDS-BMI at baseline were on average 41.01 (6.23)/3.34 (0.35) for the girls with complete data and 39.99 (5.85)/3.60 (0.38) for the boys with complete data.

3.2. Change in eating styles and SDS-BMI change

Table 2 shows the change in eating styles between the measuring moments. For girls there is a statistically significant decrease of external eating between T0 and T12, an increase of restraint eating between T0 and T24 and no statistically significant change in emotional eating. For boys there is a statistically significant decrease of external eating between T0 and T12 and between T0 and T24, a decrease of emotional eating between T0 and T12 and between T0 and T24 and no statistically significant change in restraint eating.

Table 3 shows the percentage at the different measuring moments of girls and boys that scored above the mean of the Dutch norm groups. These norm groups, for girls and boys aged 15–20 years, include normal weight as well as overweight and obese adolescents (Van Strien, 2015).

Table 4 shows the change in BMI and SDS-BMI between T0 and T12, T12 and T24 and T0 and T24. Girls and boys separately as well as combined had on average a statistically significant decrease in their BMI and their SDS-BMI between T0 and T12. This effect was maintained at follow up, although there was an average increase of BMI and SDS-BMI between T12 and T24.

3.3. Eating styles as determinant of weight change

As Table 5 shows, for girls a higher score on restraint eating at T12 was statistically significant associated with a higher weight (re) gain between T12 and T24. With an effect-size according to Cohen's f² that was between small and medium.

For girls emotional eating at T12 and external eating at T12 was

Table 1
Participants with (n = 76) and without (n = 44) complete data compared on several variables at baseline (T0).

	Total	Complete data	Incomplete data	P-value group differences
N	120 ^a	76 ^a	44 ^a	
BMI	40.2 (6.1)	40.7 (6.1)	39.2 (6.0)	0.195
SDS-BMI	3.41 (0.38)	3.42 (0.38)	3.39 (0.38)	0.724
Age (y)	14.8 (2.4)	14.8 (2.2)	14.8 (2.6)	0.918
Male/Female (%)	32.5/67.5	30.3/69.7	36.4/63.6	0.627
Ethnicity (%)				0.639
Native Dutch	59.2	60.5	56.8	
Other	40.8	39.5	43.2	
Level of education parents (%)				0.640
Low	40.0	36.8	45.5	
Medium	40.8	43.4	36.4	
High	19.2	19.7	18.2	
Eating styles				
External eating	2.83 (0.76)	2.82 (0.76)	2.85 (0.77)	0.929
Emotional eating	2.32 (0.96)	2.31 (0.90)	2.33 (1.08)	0.962
Restraint eating	2.69 (0.78)	2.65 (0.77)	2.76 (0.80)	0.451

Data are mean (SD); SD = standard deviation; BMI = body mass index; SDS-BMI = standard deviation score of body mass index.

^a Due to missing data at T0 that were not imputed for these descriptive statistics in SPSS, the sample size for ethnicity and for the different scales of the DEBQ-child report is lower. Ethnicity: n = 117,73,44; External eating: n = 115,73,42; Emotional eating: n = 112,70,42; Restraint eating: n = 116,74,42.

Table 2
Change in eating styles of the girls (n = 54^a) and boys (n = 23) with complete data between the measuring moments.

	ΔT0–T12	P-value	ΔT12–T24	P-value	ΔT0–T24	P-value
Girls						
Eating styles						
External eating	–0.25 (–0.42 to –0.08)	0.004	0.09 (–0.08–0.26)	0.297	–0.16 (–0.34–0.01)	0.066
Emotional eating	–0.20 (–0.42–0.01)	0.062	0.05 (–0.16–0.26)	0.642	–0.15 (–0.37–0.06)	0.163
Restraint eating	0.22 (–0.02–0.46)	0.070	0.11 (–0.13–0.35)	0.368	0.33 (0.09–0.57)	0.008
Boys						
Eating styles						
External eating	–0.47 (–0.72 to –0.22)	0.001	0.17 (–0.09–0.43)	0.212	–0.30 (–0.57 to –0.04)	0.030
Emotional eating	–0.33 (–0.63 to –0.03)	0.035	–0.06 (–0.36–0.24)	0.689	–0.39 (–0.70 to –0.09)	0.016
Restraint eating	0.00 (–0.34–0.35)	0.980	–0.15 (–0.51–0.21)	0.423	–0.14 (–0.50–0.21)	0.436

Data are estimated mean changes from the mixed model (95% CI); CI = confidence interval.

^a The differences between the measuring moments were analyzed in a mixed model that handles missing items, resulting in n = 23 for boys and n = 54 for girls.

Table 3
Percentage of the girls (n = 53^a) and boys (n = 23^a) with complete data that scored above the mean of the Dutch norm groups for girls and boys at baseline (T0), after one year of treatment (T12) and at the end of follow up (T24).

	T0	T12	T24
Girls			
Eating styles			
External eating	25.0	9.4	19.2
Emotional eating	28.8	22.6	23.1
Restraint eating	27.5	47.2	48.1
Boys			
Eating styles			
External eating	17.4	8.7	9.5
Emotional eating	30.4	30.4	23.8
Restraint eating	43.5	26.1	33.3

^a Due to missing items that were not imputed for these descriptive statistics in SPSS, the n for girls is lower at T0 (n = 52 for emotional and external eating, n = 51 for restraint eating) and T24 (n = 52 for all three scales) and the n for boys is lower at T24 (n = 21 for all three scales).

not statistically significant associated with ΔSDS-BMI between T12 and T24. However, the analyses were repeated without the one girl that underwent bariatric surgery between T12 and T24. These analyses revealed an additional statistically significant finding: a higher score on external eating at T12 was statistically significant associated with a higher weight (re)gain between T12 and T24. With an effect-size according to Cohen's f^2 that was between small and medium.

For boys there was no relation between external, emotional or restraint eating at T12 and ΔSDS-BMI between T12 and T24.

We also looked at eating styles at baseline (T0) as determinant of weight change after treatment. As Table 5 shows, for girls a higher score on external eating at baseline (T0) was statistically significant associated with a higher weight (re)gain between T12 and T24. With an effect-size according to Cohen's f^2 that was between medium and large.

Table 4
Change in BMI and SDS-BMI for the girls (n = 54^a) and boys (n = 23) with complete data between the measuring moments.

	ΔT0–T12	P-value	ΔT12–T24	P-value	ΔT0–T24	P-value
Girls and boys						
BMI	–4.29 (–5.30 to –3.28)	<0.001	2.64 (1.63–3.65)	<0.001	–1.65 (–2.66 to –0.64)	0.002
SDS-BMI	–0.41 (–0.50 to –0.31)	<0.001	0.16 (0.06–0.25)	0.001	–0.25 (–0.35 to –0.16)	<0.001
Girls						
BMI	–3.69 (–4.82 to –2.55)	<0.001	2.33 (1.20–3.47)	<0.001	–1.36 (–2.49 to –0.22)	0.021
SDS-BMI	–0.35 (–0.44 to –0.25)	<0.001	0.10 (0.01–0.19)	0.039	–0.25 (–0.34 to –0.15)	<0.001
Boys						
BMI	–5.66 (–7.72 to –3.61)	<0.001	3.35 (1.30–5.41)	0.003	–2.31 (–4.37 to –0.26)	0.033
SDS-BMI	–0.54 (–0.76 to –0.32)	<0.001	0.28 (0.06–0.51)	0.016	–0.26 (–0.48 to –0.04)	0.028

Data are estimated mean changes from the mixed model (95% CI); CI = confidence interval.

^a The differences between the measuring moments were analyzed in a mixed model that handles missing items, resulting in n = 23 for boys and n = 54 for girls.

For girls baseline emotional eating and dietary restraint was not statistically significant associated with ΔSDS-BMI between T12 and T24. However, when the analyses were repeated with the not imputed data for the missing items, there was an additional statistically significant finding: for girls (n = 46) a higher score on emotional eating at T0 was statistically significant associated with a higher weight (re)gain between T12 and T24. With an effect-size according to Cohen's f^2 that was between medium and large.

For boys there was no statistically significant relation between external, emotional or restraint eating at T0 and ΔSDS-BMI between T12 and T24.

All analyses were also repeated with the imputed data for the missing questionnaires, which did not affect the outcomes.

4. Discussion

4.1. Main findings

The current study showed that for girls, but not for boys, a stronger restraint and external eating style after an intensive, partly inpatient, multidisciplinary one year intervention for severe obesity in children and adolescents was statistically significant associated with a higher weight (re)gain during the following year. In addition a stronger external eating style before treatment was statistically significant associated for girls, but again not boys, with a higher weight (re)gain the following year. Also, on average it appeared to be possible to influence eating styles with treatment although the detected changes were different for girls and boys and for the different eating styles.

4.2. Significance of main findings

4.2.1. Eating styles as determinant of weight change

The found association for restraint indicates that although the

Table 5Association of eating styles at T12 and at T0 with Δ SDS-BMI T12–T24 for the girls ($n = 54^a$) and boys ($n = 23$) with complete data.

Determinant	β (95% CI)	P-value	Effect-size according to Cohen's f^2 ^b
Girls			
Eating styles T12			
External eating ^c	−0.08 (−0.16 to −0.01)	0.049	0.093
Emotional eating	−0.04 (−0.10–0.02)	0.213	0.035
Restraint eating	−0.09 (−0.16 to −0.02)	0.018	0.135
Boys			
Eating styles T12			
External eating	−0.05 (−0.33–0.23)	0.697	0.011
Emotional eating	−0.01 (−0.22–0.19)	0.879	0.002
Restraint eating	−0.06 (−0.30–0.17)	0.559	0.024
Girls			
Eating styles T0			
External eating	−0.11 (−0.18 to −0.04)	0.003	0.224
Emotional eating ^d	−0.06 (−0.13–0.00)	0.068	0.086
Restraint eating	−0.02 (−0.10–0.06)	0.567	0.015
Boys			
Eating styles T0			
External eating	−0.03 (−0.28–0.23)	0.826	0.003
Emotional eating	−0.01 (−0.23–0.21)	0.930	0.001
Restraint eating	−0.08 (−0.31–0.16)	0.506	0.031

Data are β (95% CI); β = regression coefficient, CI = confidence interval.^a For the analyses including T0 the $n = 53$ because one female participant with complete data did not complete the DEBQ-child report at T0.^b Effect-size according to Cohen's f^2 : $f^2 = 0.02$ is a small effect; $f^2 = 0.15$ is a medium effect; $f^2 = 0.35$ is a large effect.^c Results including the one girls that underwent bariatric surgery: $\beta = -0.08$; CI 95% = $-0.16-0.01$; $P = 0.053$; $f^2 = 0.087$.^d Results with the not imputed data for the missing items: $\beta = -0.10$; CI 95% = $-0.16-0.04$; $P = 0.001$.

restraint eating in girls increased this did not prohibit weight (re) gain in the second year. Several studies found a stronger restraint eating style in children and adolescents with overweight and obesity (Braet et al., 2008; Braet & Van Strien, 1997; Hirsch et al., 2014; Snoek et al., 2007). Research in both adults and children also showed that qualifying as a restraint eater as measured with a self-report questionnaire, does not necessarily mean a person is continually able to refrain from unrestrained eating (de Witt Huberts, Evers, & de Ridder, 2013) or has a lower caloric intake (Stice, Cooper, Schoeller, Tappe, & Lowe, 2007). It seems that dietary restraint scales are measuring the *intention* to eat less, rather than an *actual* caloric restriction that suffices to achieve the desired weight control (Larsen, van Strien, Eisinga, Herman, & Engels, 2007; Stice, Sysko, Roberto, & Allison, 2010; van Strien, Engels, van Staveren, & Herman, 2006). Moreover, restrained eating is eating less than *desired* in order to maintain or to lose body weight. This is not always the same as eating less than is *required* to actually maintain or to lose body weight (van Strien, 2008). For example, one study showed that restraint eaters that have a history of unsuccessful weight regulation can be more prone to overeating when exposed to palatable food (Houben, Nederkoorn, & Jansen, 2012). Other research showed that restrained eating is a determinant of overeating in case a person is impulsive as well (Jansen et al., 2009). And adolescents (Neumark-Sztainer, 2009; Stice, Presnell, Shaw, & Rohde, 2005) and adult women (van Strien, Herman, & Verheijden, 2014) with higher dietary restraint scores appear to have an increased risk of developing obesity in the future. These earlier findings, although not based on studies with severely obese patients, might explain the direction of the found effect of restraint eating in the current study. Nevertheless, some studies suggest that a higher level of restraint eating can actually help children and adolescents with obesity to maintain weight control after treatment in an obesogenic environment (Braet et al., 2004; Johnson & Wardle, 2005) although there are also studies that do not find any association for restraint eating (Moens et al., 2010).

The found association, after an additional analysis, for external eating in girls indicates that although their external eating on average decreased during the treatment this was not enough to prevent weight (re)gain after the treatment. Treatment also

appeared to be less effective in achieving a structural behavior change in girls with a stronger tendency for external eating at the start of treatment, as they also had a higher weight (re)gain in the year following treatment.

For emotional eating there were no statistically significant findings for girls nor boys. However, the additional analyses without the imputed data for the missing items resulted in the finding that girls that scored higher on emotional eating at baseline had a higher weight (re)gain in the year following treatment. This is a potentially interesting finding that is in line with studies with adults (Blair et al., 1990; Roosen et al., 2012) and deserves further research.

In conclusion, we found large variations in long-term weight change. The influence of eating styles on weight change is complex. We found a few potentially important effects that warrant further investigation.

4.2.2. Change in eating styles

The treatment seems to have influenced the eating styles of girls and boys differently. The changes observed are partly in line by the findings in the study by Braet et al. (Braet et al., 2004) that involved obese children and adolescents (7–17 years) that underwent an inpatient weight management program. Their eating styles were measured at baseline, at the end of treatment and at follow up 24 months after baseline for boys and girls combined. Their scores on external eating decreased statistically significant between baseline and end of treatment and between baseline and follow up. This is comparable to our results, except that in our study the decrease for girls was not statistically significant any more at follow up. In the study by Braet et al. emotional eating did not change between baseline and end of treatment or follow up, like was the case in our study for girls but not boys whom had a decreased score after treatment and at follow up. On restraint eating the participants in the study by Braet increased statistically significant between baseline and end of treatment and between baseline and follow up like the girls in our study, while our boys did not change their restraint eating style. Apparently, for the girls in our study the influence of treatment on restrained eating continued after the treatment ended.

To conclude, the observed changes suggest that on average it is possible to influence the eating styles with intensive treatment, although the detected changes were different for girls and boys and for the different eating styles.

4.3. Strengths

This study, to our knowledge, is the first study to prospectively assess the role of eating styles in weight change in a large sample of severely obese children and adolescents undergoing an intensive combined lifestyle intervention. In addition this study contains unique information on eating styles at the start of treatment, at the end of treatment and at follow up of a clinical population of severely obese children and adolescents.

The study participants had an average SDS-BMI of 3.41 (3.42 for the participants with complete data) at baseline which means they are at the top of the obesity pyramid. They represent a growing but often overlooked patient group. The number of study participants, 120 children and adolescents, is relatively high compared to other intervention studies in comparable populations (Oude Luttikhuis et al., 2009). The drop out was relatively low in this study, with 82.5% (99 of the 120) of the participants completing the treatment and 75.8% (91 of the 120) of the participants remaining in the study at the end of follow up. Although for only 64% (77 of the 120) of the initial participants complete data for the main hypothesis were available, their baseline characteristics were not statistically different from the rest of the participants, implying that there was no selective drop out from the study. By handling the missing scale scores of the eating style questionnaire with multiple imputation of the item scores, the most optimal level of information was incorporated in the analyses (Eekhout et al., 2014). Another strength of this study is its relatively long duration, with an intervention of one year and a follow up of two years after baseline, compared to other studies. This made it possible to assess weight change after treatment.

4.4. Limitations

In addition to these strengths, some limitations need to be acknowledged. Interpretation of the study results should be done with caution because the data collection on what happened to the patients in the follow-up year was limited. The effect of, for example, major life events in this period could not be included in the analyses. Another limitation is that the number of boys included in the study was relatively small which has reduced the statistical power to detect meaningful associations for this group. It is also possible the associations for boys does not exist. Weight maintenance is probably influenced by a variety of factors in addition to what the DEBQ-child report measures. These factors likely include among others: parenting styles, the physical environment, genes, socio-economic status, peer pressure and possibly hormonal changes that take place in puberty. How the differences regarding these factors for boys and girls affected our results, we do not know. Further, the fact that this study did not include a control group, prohibits concluding that the observed changes in eating styles were actually caused by the intervention. An additional limitation is that controlling for known confounders as was done in this study, does not mean there was no confounding. Possibly other confounders that play a role were not included or confounders that were included were not measured in the right way.

It is also important to acknowledge that although SDS-BMI that was used for the main outcome measure was the best measure available and practically applicable to capture change in body fatness, this is not an ideal measure. For both BMI and SDS-BMI, pubertal stage affects body composition and fat distribution

partly independent of these measures which makes them less reliable (Demerath et al., 2006). This is especially relevant in a population that contains participants in different pubertal stages like in this study where in addition pubertal stage of individual participants changed during the two year study period. Another limitation is the use of a self-report measurement for eating styles. This implies study participants have a valid notion of their eating behaviors and the triggers of those behaviors which is, especially in younger children, not automatically true (see for a discussion (Nisbett & Wilson, 1977)).

4.5. Research recommendations

Assessing differences between the scores on the used self-report questionnaire and the also administered proxy version that the parents completed, can be a useful addition to this study (Braet et al., 2007), although research indicates children and parents have a moderate to good agreement with regard to all three scales (Braet et al., 2007). Relating the results of the DEBQ that the parents completed for themselves to these findings, to examine possible intergenerational associations in eating behavior, would also be an interesting topic for future research. Finally, new research that focusses on the mechanisms underlying the influence of eating styles on long-term weight change can help understand how to achieve long-term weight loss more effectively. We assume that underlying factors like impulsivity can help explain the influence of eating styles and this can lead to new treatment avenues.

4.6. Implications for clinical practice

Although the influence of eating styles on long-term weight loss according to this study was limited for girls and absent for boys, the scores on restraint and external eating do deserve attention when treating severely obese girls as these eating styles seem to increase their chance of weight (re)gain after treatment. In this regard, it can be helpful to note that a *self-reported* restrained eating style is not necessarily an indicator of *actual* restrained eating and to note that eating less than *desired*, is not always the same as eating less than is *required* to maintain or to lose body weight. Probably, the report on restrained eating reflects the youngsters desire for a better weight control. Therefore, it is a good predictor/indicator of their feelings of failure in weight control. Increasing body satisfaction through cognitive behavioral therapy, can help decreasing the level of restraint eating (Cromley et al., 2012).

Because negative emotions tend to increase the sensitivity for external food cues (Hepworth, Mogg, Brignell, & Bradley, 2010), it is advisable to address these emotions and teach patients skills to regulate their emotions and help them increase their positive affect (Zeman, Cassano, Perry-Parrish, & Stegall, 2006).

More general, the eating styles should be monitored and be topic of conversation not only during the intensive phase of treatment, but also in the following period when relapse prevention is the main focus. It should also be kept in mind that in this relapse prevention phase attention for other possible determinants of weight loss maintenance should be closely monitored as it is clear from our results that besides eating styles other factors are at play.

5. Conclusions

In conclusion, this study indicates that for girls a higher level of restraint eating and a higher level of external eating after treatment were associated with more weight (re)gain during the following year.

Potential conflicts of interest

Tatjana van Strien has a copyright and royalty interest in the Dutch Eating Behavior Questionnaire (DEBQ) and manual. Tatjana van Strien has, through her institution, a pending EU grant with Unilever (not related to this manuscript). Caroline Braet receives payment for lectures in educational programs. Carolien Braet receives royalties for official translation of tests. The other authors declare no conflicts of interest.

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