The influence of preschoolers' emotional and behavioural problems on obesity treatment outcomes: Secondary findings from a randomized controlled trial

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Abstract

Background: Few studies have explored the influence of preschoolers' behavioral problems on obesity treatment.

Objectives: To assess emotional and behavioral problems before and after an obesity intervention and examine relationships between changes in child behavior and changes in weight status.

Method: The study included 77 children (4-6 years, 53% girls, mean Body Mass Index (BMI) z-score 3.0 (SD 0.6)) who participated in the More and Less Study, a randomized controlled trial. Families were randomized to a parenting program or to standard treatment. The children's heights and weights (BMI z-score, primary outcome) were measured at baseline and 12 months post-baseline. Parents rated their children's behaviors (secondary outcome) on the Child Behavior Checklist (CBCL) for ages 1.5-5 years, a questionnaire that measures psychosocial health and functioning, encompassing emotional and behavioral problems. Changes in child behavior during treatment were examined through paired samples t-tests; the influence of child behavior on treatment effects was examined through linear regressions.

Results: Child emotional and behavioral problems significantly improved after obesity treatment. Lower scores were found for Emotional Reactivity, Sleep Problems, Affective Problems, Aggressive Behavior, Externalizing Behaviors, Oppositional Defiant Problems, and Total Problems. Child behavior significantly affected obesity treatment results: Attention Problems and ADHD at baseline contributed to increasing BMI z-scores while Oppositional Defiant Problems, Externalizing Behaviors and a higher number of behavioral problems predicted decreasing BMI z-scores.

Conclusions: Child behaviors at baseline influenced treatment results. Child emotional and behavioral problems improved post-treatment. The results suggest that obesity treatment may help in reducing emotional distress among preschoolers.

Introduction

Emotional and behavioral problems are common among children worldwide, with global prevalence estimates as high as 13% (1). Most common are anxiety disorders (7%), followed by disruptive disorders (6%), depressive disorders (4%), oppositional defiant disorder (4%), attention-deficit-hyperactivity-disorder (ADHD) (3%) and conduct disorders (2%), alongside combinations of the above and other, rarer disorders (1). Research studies have shown that children's emotional and behavioral problems may be associated with psychosocial difficulties and other health problems later in life (2).

Among child behavior problems, externalizing and internalizing behaviors (including those associated with neurodevelopmental disorders such as ADHD and autism spectrum disorder) are particularly prevalent among children with obesity, affecting about one-third of children referred to obesity treatment (3). In children, ADHD may lead to abnormal eating patterns and consequently obesity, although studies have not found consistent associations between child ADHD and Body Mass Index (BMI) (4). Child temperament has also been associated with obesity. A systematic review found that child temperament (i.e. poor self-regulation, distress to limitations, low/high soothability, low negative affectivity) was associated with higher BMI in infants and preschool-age children (5). More recently, a study showed that 5-year-old children with externalizing temperament (e.g. impulsiveness, low self-regulation) are more likely to be overweight (6). Another study showed that certain subgroups of preschoolers with difficult temperament (easily distressed, inhibited, cry often and have low soothability) might be at risk

for eating and weight regulation problems later in life (7). According to a meta-analysis, children with overweight and obesity tend to be more impulsive than children with normal weight (8), and children with overweight are more likely to experience multiple associated psychological problems, such as co-existing depression, anxiety or behavioral difficulties, compared to children with normal weight (9). The associations described above suggest that children's emotional and behavioral problems need to be considered in obesity treatment, particularly because obesity treatment often entails structured and regulated eating routines that may run counter to some children's temperament (9, 10).

Most studies on associations between childhood obesity and behavioral problems have focused on school-aged children and adolescents. However, a recent population-based study has found that overweight at the age of 6 is associated with more total behavioral problems (11). Additionally, a longitudinal analysis of a prospective cohort study has shown that externalizing behavior at 2 years of age is associated with a higher BMI from age 2 to age 12 (12). However, evidence on how behavioral problems influence obesity treatment in children is limited (13-16) and no study has examined associations between obesity treatment and behavioral problems among children under the age of 6 years.

The present study reports on secondary outcomes of a Randomized Controlled Trial (RCT) based in Stockholm County, Sweden, which assessed a new childhood obesity intervention for preschool-aged children (defined as children between the ages of 4 and 6 years). The RCT evaluated a parent support program (whose main focus was evidence-based parenting practices) in comparison to standard treatment (whose main focus was food and physical activity) (17). The RCT's primary outcome was changes in child weight status 12-months post baseline. Parents filled out questionnaires at baseline and after 12 months. Among these, the Child Behavior

75 Checklist (CBCL), a validated instrument with two versions (one for preschool-age children (1.5-

76 5 years old) and one for school-age children (6-18 years old)), enabled us to assess the influence

77 of child emotional and behavioral problems on obesity treatment outcomes over time.

78

79 The CBCL is a robust and widely used instrument (18, 19), several studies have examined

80 associations between child behavior and child obesity using the CBCL. However, all studies but

81 two have focused on children older than 5 years of age, using the CBCL for school-age children

82 (CBCL 6-18). A study based in Greece used the CBCL among school-age children (mean age

83 11, n=141) to assess the prevalence of Internalizing and Externalizing Behaviors in children with

84 and without obesity and found that both Internalizing (e.g. anxiety problems, mood changes,

85 somatic complaints) and Externalizing Behaviors (e.g. aggressive, antisocial and/or delinquent)

86 were more prevalent in children with obesity (20). A large study in Chile (n= 11 207) found that

87 children aged 6 years with overweight or obesity had higher CBCL-measured behavioral

88 problems compared to their peers with normal weight (11). Similarly, a study conducted in South

89 Korea among children aged 10-12 years (n=504) found that children with overweight were more

90 likely to present patterns of emotional and behavioral problems (i.e. more social, delinquent and

91 total problems) compared to children with normal weight (21). Additionally, a study conducted

92 in Turkey that compared emotional and behavioral problems among adolescents aged 12-16

93 years with obesity (n=60) or normal weight (n=30) found that adolescents with obesity had

94 higher rates of emotional and behavioral problems, as measured by scores on the Anxiety-

95 Depression and Withdrawal scales, and by rates of social and total problems (22). Of note, the

96 subsample of adolescents with obesity who were recruited through an endocrinology clinic

97 (n=30) had higher emotional and behavioral problem scores than the subsample of adolescents

98 with obesity who were recruited through a local high school (n=30) (22). Moreover, a Dutch

99 research group found that among children aged 8-14 years (n=248), lower BMI z-score at

100 baseline and higher social competence were associated with obesity treatment success at a

101 younger age and with less somatic complaints (23). In contrast, a cross-sectional study based in

102 the United States with mothers of children aged 3 years of Latino and low-income background

103 (n=174) found no association between emotional problems and obesity (24). To further

104 understandings of how emotional and behavioral problems may be associated with childhood

105 obesity treatment, we decided to include the CBCL among the measurements in our RCT.

106

107 The overall aim of the present study is to examine preschool-aged children's emotional and

108 behavioral problems in relation to changes in weight status during obesity treatment. First, we

109 examined changes in problem behaviors from baseline to 12 months post-baseline. Second, we

110 examined baseline behaviors as predictors of obesity treatment outcomes (child BMI z-score)

111 and how changes in these behaviors may contribute to BMI z-score change 12 months post-

112 baseline.

113

114 We hypothesized that emotional and behavioral problems would be lessened at 12 months post

115 obesity treatment. We hypothesized that the effect would be more pronounced in the parent

116 support treatment, since it emphasized evidence-based parenting practices suitable for addressing

117 child behavioral problems. In addition, we expected that children with higher levels of baseline

118 emotional and behavioral problems would exhibit a smaller change in their BMI z-score, given

119 that managing eating situations might be more challenging for them. As for changes in emotional

120 and behavioral problems from baseline to 12 months post obesity treatment, we hypothesized

121 that greater reductions in emotional and behavioral problems would predict greater reductions in

122 child BMI z-score.

123

124 **Methods**

<u>Study design and intervention</u>

126 The present paper reports on secondary data from the More and Less (ML) Study, a parallel

127 open-label RCT. The overall aim of the ML Study was to evaluate a parent support program

128 compared to standard treatment for childhood obesity, with BMI z-score defined as the primary

129 outcome. Families with children aged 4 to 6 years (hereafter called 'preschool-age') diagnosed

130 with obesity were randomized to one of the two treatment approaches. The parent support

131 program (10 weekly sessions à 90 minutes) was delivered by trained dieticians. The sessions

132 centered on evidence-based parenting practices (e.g. encouragement, monitoring, positive

133 involvement, limit setting and problem solving along with regulation of emotional expression),

134 which were discussed and practiced through role playing. The sessions emphasized specific

135 lifestyle components (e.g. healthy eating, physical activity) to support a healthy home

136 environment (17). Standard treatment was delivered to individual families by pediatricians (the

137 first visit) and pediatric nurses (follow-up visits) in outpatient pediatric clinics.

138 The present paper presents data on child emotional and behavioral problems at baseline and 12

139 months post-baseline in relation to weight status. The primary outcomes of the RCT have been

140 published elsewhere; these findings show that children whose families were randomized to the

141 parent support group had a larger decrease in BMI z-score compared to standard treatment 12

142 months post-baseline (25). The protocol for the study was registered with the Clinical Trials

143 Registry, clinicaltrials.gov on February 14, 2013, (ID: NCT01792531).

144

145

146 <u>Study participants</u>

147 Participant recruitment was conducted through primary child health care, school health care and

148 outpatient pediatric clinics between 2012 and 2016 in Stockholm County, Sweden. The study

149 was approved by the Regional Ethical Board in Stockholm (dnr: 2011/1329-31/4; 2012/1104-32;

150   2012/2005-32; 2013/486-32; 2016/80-32). Informed consent forms were signed by all

151   participating parents. The ML study included children who were 4-6 years old, had obesity as

152   defined by international age- and sex-specific cut-offs (26), were not diagnosed with any chronic

153   disease or developmental problem, and whose parents were sufficiently proficient in Swedish to

154   fill out questionnaires and participate in discussion-centered treatment (17). The sample size was

155   determined based on BMI z-score (primary outcome) adjusting for a 21% dropout rate (17).

156

157   <u>Measurements</u>

158   *The CBCL*

159   The CBCL for the ages of 1.5 to 5 years was filled in by one of the parents at baseline and after

160   12 months. On the CBCL 1.5-5, child behavior is rated by parents in 99 questions plus one open

161   question, encompassing emotional, behavioral and social problems that, together with the total

162   score, allow for the classification of child behavior according to different scales (27). When

163   rating, parents use a 3-Point Likert scale, ranging from 0 (*not true*) to 1 (*somewhat or sometimes*

164   *true*) and 2 (*very often or often true*), and for the open-ended question parents can mention any

165   problem not covered by the preceding 99 questions. Examples include *'My child doesn't want to*

166   *sleep alone'* (part of the scales Sleep Problems and DSM-Anxiety Problems) and *'My child is*

167   *overeating'* (part of the scale DSM-Affective Problems). The questions can be arranged to

168   classify child behavior according to different scales.

169

170   The CBCL consists of two scale systems, the *syndrome scale* and the *DSM scale*. The *syndrome*

171   *scale* categorizes child behavior into seven syndromes: Emotionally Reactive,

172   Anxious/Depressed, Somatic Complaints, Withdrawn, Attention Problems, Aggressive Behavior

173   and Sleep Problems (27). The syndromes can be further divided into two subscales. The

174   Internalizing Behaviors subscale includes the first four syndromes and describes conflicts within

175   the inner self. The Externalizing Behaviors subscale consists of the syndromes Attention

176   Problems and Aggressive Behavior, and describes problems with other people and their

177   expectations. Sleep Problems constitute a stand-alone subscale. Additionally, a Total Problem

178   score can be calculated using all 99 question items (27).

179

180   The *DSM scale* refers to the 4th edition of the American Psychiatric Association's *Diagnostic*

181   *and Statistical Manual of Mental Disorders* (*DSM-IV*) (28). In this scale, child behavior is

182   classified into five subscales: Affective Problems, Anxiety Problems, Pervasive Developmental

183   Problems, Attention Deficit/Hyperactivity Problems (ADHD) and Oppositional Defiant

184   Problems (27). High scores on a CBCL DSM-oriented scale do not correspond to a DSM

185   diagnosis, but help identify children who might meet the criteria for clinically relevant

186   symptoms. In Sweden, the CBCL was validated in clinical and non-clinical population (n=2088).

187   The face validity was assessed with several methods, including pediatric screening interview,

188   Life Stress Score (50 items), Edinburg Postal Depression Scale and Sense of Coherence (19).

189   In this study, we compare our results to reference values from a Danish sample (29) and from a

190   large international sample (30) to place the scores from the Swedish sample of children with

191   obesity in context. The international pool includes both the syndrome scale and the DSM-

192   oriented scale. The Danish sample leaves out the scores for the seven syndromes and includes

193   only Internalizing and Externalizing Behaviors, Total Problems and the DSM-oriented scale.

194

195   *BMI z-score*

196   The children's weight and height were measured to the nearest 0.1 kg/cm by trained healthcare

197   professionals with calibrated measuring tools and in outpatient pediatric clinics at baseline and

198   after 12 months (17). Children were measured in light clothing. Each measurement was taken

199   three times, and a mean value was calculated. The BMI was calculated as follows: (weight in kg)

200   / (height in m)^2. The BMI z-score was derived using Swedish age- and sex-specific reference

201   values (31).

202   <u>Statistical Analyses</u>

203   To assess and evaluate children's behavior before and after the intervention, the mean scores of

204   the subscales of the syndrome scale and the DSM scale and the Total Problem score were

205   computed. The mean scores at baseline and at 12 months post-baseline were then compared by

206   using dependent paired samples t-tests. Linear regression analyses were conducted to examine

207   (1) the relationship between baseline child behaviors and baseline BMI z-score; (2) the

208   relationship between baseline child behaviors and changes in child BMI z-score after 12 months

209   (post BMI z-scores minus pre BMI z-scores); (3) the relationship between changes in child

210   behavior after 12 months (post scores minus baseline scores) and changes in child BMI z-score

211   after 12 months. Each of these analyses was carried out using four different models, which

212   focused on the influence of child behavior according to: (1) the seven syndromes, (2)

213   Internalizing and Externalizing Behaviors, (3) the Total Problem score, and (4) the DSM-

214   oriented sub-scales. All models were adjusted for child age and gender, as well as parents'

215   income, foreign background and BMI self-reported at baseline. The software package 'IBM

216   SPSS Statistics 24' was used for all statistical analyses. P-values <0.05 were regarded as

217   significant in all analyses.

218

219   **Results**

220   Complete questionnaires (with less than 9 items missing) were present for 121 children at

221   baseline and for 83 children at 12 months post-baseline. Among these, 77 children had complete

222   CBCL data both at baseline and at 12 months. The data for the 77 children who had complete

223   CBCL data at both time points form the basis for the present analysis. The background

224   characteristics of the sample are presented in Table 1. Children in the total sample were on

average 5.2 years old (*SD* 0.8), with the children in the parent support program being slightly

younger (5.1 years, *SD* 0.8) than in the standard treatment (5.3 years, *SD* 0.7). Half of the sample

were girls (53%), with more girls in the standard treatment (67%) compared to the parent support

program (40%). The average BMI z-score in the total sample was 3.0 (*SD* 0.6). The mothers

were on average 36.8 years old (*SD* 5.6) and the fathers 39.4 years old (*SD* 6.7). Most parents

had overweight (mothers: 28%; fathers: 42%) or obesity (mothers: 36%; fathers: 49%).

Approximately half of the parents in the total sample were of foreign origin; more mothers than

fathers had a university degree (mothers: 46%; fathers: 40%). The study population, of families

who provided CBCL data, differed from the total population of families enrolled in in the ML

in two aspects: parents who did not fill out any of the CBCL questionnaires were more likely to

be of foreign origin (mothers: 81%; fathers: 62%) compared to the parents who filled out both

CBCL questionnaires at baseline and at 12 months (mothers: 51%; fathers: 52%); these parents

were also less likely to have a university degree (mothers: 28%; fathers: 29%), compared to the

parents who provided complete CBCL data (mothers: 46%; fathers: 40%) (data not shown).

Mean scores on the different CBCL scales for the total sample, parent support program and the

standard treatment are presented in Table 2a, in comparison to reference values from an early

validation study among Danish preschoolers and the international reference values (19, 20). The

mean scores of our population are similar to those of a non-clinical population (18) and to a

Danish population (30). Table 2b presents differences related to changes in CBCL scores

between baseline and follow-up. For the total sample, significant decreases were observed from

baseline to 12 months in Aggressive Behavior, Externalizing Behaviors, Total Problems and

Oppositional Defiant Problems. Children in the parent support program had no significant

changes in CBCL scores from baseline to 12 months. In the standard treatment group there was

249 a significant decrease from baseline to 12 months in Emotional Reactivity, Sleep Problems, Total

250 Problem score, Affective Problems and Oppositional Defiant Problems.

251

252 Linear regression analyses of associations between child behavior and BMI z-score before

253 childhood obesity treatment found that child behavior at baseline had no association with child

254 BMI z-score at baseline (data not shown). However, significant associations were found between

255 child behavior at baseline and changes in child BMI z-score (Table 3). In the parent support

256 program, children who scored high on ADHD at baseline were more likely to experience

257 increases in BMI z-score after 12 months, whereas children who scored high on Oppositional

258 Defiant Problems at baseline were more likely to experience decreases in BMI z-score. In the

259 standard treatment group, children with more baseline Externalizing Behaviors, Total Problems

260 and/or Oppositional Defiant Problems were more likely to experience decreases in BMI z-score.

261 For the whole sample, children who scored high on Attention Problems and ADHD at baseline

262 were more likely to experience increases in BMI z-score, while children who scored high on

263 Oppositional Defiant Problems were more likely to experience decreases in BMI z-scores.

264

265 Table 4 demonstrates how changes in child behavior were associated with changes in BMI z-

266 scores. Only one significant association was identified, in the standard group, between reductions

267 in symptoms of Depression and Anxiety and increasing BMI z-scores.

268

Discussion

270 This is the first study to assess how preschool-age children's emotional and behavioral problems

271 evolve over the course of obesity treatment and to identify the influence of specific behaviors on

272 obesity treatment effects. Fewer problematic behaviors were reported by parents at 12 months

273 post-baseline in the total sample of children and in the standard treatment group; no significant

274 changes were found in the parent support group. Examining baseline emotional problems as

275 predictors of treatment results, we found that for the total sample and for the parent support

276 group, children with Attention Problems and ADHD were more likely to have increased BMI z-

277 scores. For all groups, children with Oppositional Defiant Problems were more likely to

278 experience a decrease in BMI z-scores. Finally, when examining how changes in child behaviors

279 influenced changes in weight status during treatment, we found that children in standard

280 treatment with reduced Anxiety and Depression scores were more likely to experience an

281 increase in their BMI z-scores.

282

283 It is promising that obesity treatment was associated with reduced levels of emotional and

284 behavioral problems in preschool-age children. Previous childhood obesity intervention studies,

285 which involved parents of older children, have shown favorable results with respect to child

286 behavioral problems (15, 32). Obesity interventions that target preschool-age children are still

287 rare (33, 34),with few RCTs; of the extant RCTs, the secondary outcomes are rarely reported,

288 especially with regard to child psychosocial functioning. In the present study, the positive gains

289 in emotional and behavioral wellbeing post-treatment may indicate that parents were empowered

290 through the program, and were better able to respond to their children's emotional distress and

291 behavioral problems. Although the study had low statistical power due to the small sample sizes

292 in each treatment arm, and as such warrants cautious interpretations, it is interesting that, contrary

293 to our hypothesis, children's emotional and behavioral problems improved more significantly

294 after standard treatment. This is particularly surprising because the evidence-based practices

295 taught in the parent support group have been successful in improving difficult child behavior

296 (35). However, as child behaviors were reported by parents, it is possible that the parent group

297 approach made parents more attuned to children's emotional and behavioral expressions,

298 resulting in higher behavioral problem scores compared to the standard treatment group.

299

The reported degree of behavioral problems was very low in comparison with rates in the international validation study, with the exception of Sleep Problems and Affective Problems (30). While the prevalence of Sleep Problems among preschoolers is known to differ among populations (36), it should be noted that the parents in this study constituted a treatment-seeking clinical population. Hence, the high prevalence of Sleep Problems could be an indicator of a challenging or stressful home environment. Poor sleep quality has also been associated with obesity in children and adolescents (37). For Affective Problems, the scores in this study were higher than the international and Danish scores (29, 30). While few studies have explored affective problems in young children, stress is an important risk factor for the development of affective problems, especially in high-risk groups (38). Although stress was not measured in this study, elevated stress in the home environment might underlie the high reported scores of Affective Problems. In a previous study, a significant association between maternal depression and child emotional and behavioral problems was found in a subsample of the ML population (39). Maternal depression is also a major risk factor for the development of distress and depression among children (40), and the high scores of reported Affective Problems might be due, in part, to maternal affective problems.

316

The study's findings of a relationship between baseline ADHD and Attention Problems and an increase in BMI z-score after treatment are in line with previous research (41). Especially in young children, Attention Problems or ADHD symptoms predict increased body fat mass later in childhood (42). While the association between ADHD and obesity is not yet understood, ADHD may affect obesity treatment through an interplay of environmental, biological and lifestyle factors (e.g. physical activity, eating patterns, genetics, impulsivity, parental behavior) (43). In particular, impulsivity may influence obesity treatment, as children who display

324   impulsivity have been found to be food-reactive and experience difficulties in self-control (44,

325   45). It is important to note that although Attention Problems were associated with increased BMI

326   z-scores after obesity treatment, BMI z-scores might have increased even further without any

327   treatment.

328

329   Compared to potential associations between ADHD and obesity, previous research has not paid

330   as much attention to potential associations between Oppositional Defiant Problems and

331   childhood obesity. We found that a higher baseline degree of Oppositional Defiant Problems was

332   associated with decreases in children's BMI z-score over the course of obesity treatment. These

333   findings stand in contrast to a study conducted in Germany, which found that Oppositional

334   Defiant Disorder, together with conduct disorder, were strong predictors of overweight and

335   obesity, even after controlling for comorbid ADHD (46). A possible explanation is that the data

336   used in the German study included older children (6 to 12 years old) referred to psychiatric

337   treatment (46). We also found that higher scores at baseline in Externalizing Behaviors were

338   associated with a decrease in BMI z-score in the standard treatment group. Although we did not

339   find an association between changes in Externalizing behaviors and changes in BMI z-score, we

340   found that these behaviors decreased for both groups during the 12-month intervention. A study

341   conducted in the U.S. also found a co-occurrence for Externalizing Behaviors and obesity among

342   5-year-old children (47). Neither the German study nor the U.S. study reported on obesity

343   interventions, such that their findings are not directly comparable to the present study. Our

344   findings are in line with a recent study that evaluated a clinical population of 662 children

345   (ranging in age from 4 to 20 years) who participated in a family-based obesity program focusing

346   on nutrition over one year (16). The authors highlighted the role of impulsivity in externalizing

347   behaviors, suggesting that the structure provided by the program was particularly beneficial for

348   children exhibiting those behaviors (16). This explanation might also apply to the standard

349   treatment group in our study. Further analysis is needed to understand whether the parent support

350   group's reduced focus on lifestyle components such as eating patterns and physical activity might

351   have contributed to the lack of significant reduction in externalizing behaviors in this group.

352

353   Finally, while we found that changes in child emotional and behavioral problems were associated

354   with changes in BMI z-score in the standard treatment group, it remains unclear why children

355   whose parents reported reductions in depression/anxiety also experienced increases in BMI z-

356   score levels. Though depression/anxiety results for the parent support program did not reach

357   statistical significance, they pointed to reductions over time, which is in accordance with

358   previous research. The evidence from previous research on associations between depression and

359   weight status presents mixed results. Some studies have indicated that weight increases with

360   depressive symptoms in adolescence (48), while other studies found that adolescents with

361   depressive symptoms have a lower BMI (49), but no studies have assessed how affective

362   symptoms might related to body weight among young children. Hence, more research is needed

363   to evaluate associations between affective problems among preschool-age children and obesity.

364

365   *Strengths and limitations*

366   A notable strength of this study was the use of high-quality measurements. The CBCL has been

367   validated in 23 countries in Asia, Australasia, Europe (including Sweden), the Middle East and

368   South America, including 19,000 children of preschool age, and was found to be valid and

369   reliable in measuring children's emotional, behavioral and social problems across cultures (18).

370   Moreover, the child anthropometrics were measured by trained health care professionals, thus

371   removing possible self-reporting bias concerning height and weight (17). Another strength of the

372   study was its pre- and post-treatment design, which allowed us to examine changes in CBCL

373   scores following an obesity intervention. The study was limited by the absence of blinding for

15

374   participants and researchers, who were all aware of which treatment was being administered.

375   Further, for ethical reasons, this RCT did not include a control group with a no-treatment

376   approach; given that all recruited children were diagnosed with clinical obesity, they were

377   offered treatment. Additionally, the study's power, established on primary outcomes (the BMI

378   z-score and not on the CBCL), may have influenced results close to significance although they

379   had a high standardized beta. While the sociodemographic variation among parents with regards

380   to educational level and foreign background was wide, children with missing CBCL data were

381   more likely to have parents with a foreign background and lower educational levels. This may

382   have affected the results and could be due to the nature of the comprehensive CBCL, which

383   includes 100 items. Finally, the clinical relevance of the reported changes in child behavior

384   problems is not clear.

385

386   *Conclusions*

387   This study was the first to assess how preschool-age children's behavior changes following

388   obesity treatment, and to identify the influence of specific behavioral patterns on obesity

389   treatment effects. After 12 months of treatment, children in the total sample experienced

390   reductions in scores for Emotional Reactivity, Sleep and Affective Problems, Aggressive and

391   Externalizing Behaviors, Oppositional Defiant Problems, and Total Problems. Attention

392   Problems were more likely to contribute to increasing BMI z-scores, while Oppositional Defiant

393   Problems, Externalizing Behaviors and Total Problems contributed to decreasing BMI z-scores.

394   The results suggest that obesity treatment may provide the necessary structure to support children

395   with emotional and behavioral problems and their parents. Future childhood obesity

396   interventions should incorporate the measurement of child emotional and behavioral problems

397   to assess the impact of these interventions on children's emotional and behavioral wellbeing.

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585 **Table 1.** Background characteristics of the study sample

	Whole sample (n=77)	Parent-group treatment (n=38)	Standard treatment (n=39)
	Mean (sd) or %	Mean (sd) or %	Mean (sd) or %
Child			
Age (years)	5.2 (0.7)	5.1 (0.8)	5.3 (0.7)
Sex (girl)	53	40	67
First born	49	40	58
Live with both parents	78	76	77
Number of siblings	1.1 (0.8)	1.1 (0.8)	1.0 (0.9)
BMI z-score	2.9 (0.6)	3.0 (0.6)	2.9 (0.6)
Mother			
Age (years)	36.8 (5.6)	38.1 (5.5)	36.6 (5.9)
BMI	28.4 (6.3)	28.7 (6.9)	28.1 (5.7)
Weight category			
Normal weight	36	38	34
Overweight	28	27	29
Obesity	36	35	37
Foreign origin	51	50	53
University degree	46	50	42
Income (SEK/month)			
< 10 000	18	11	26
10 000 < 20 000	40	29	50
20 000 < 30 000	33	45	21
30 000 < 40 0000	8	13	3
40 0000 < 50 000	0	0	0
> 50 000	1	3	0
Fathers			
Age (years)	39.4 (6.7)	39.8 (6.8)	38.9 (6.6)
BMI	30.3 (4.7)	30.4 (4.8)	30.2 (4.6)
Weight category			
Normal weight	9	9	8
Overweight	42	42	42
Obesity	49	49	50
Foreign origin	52	55	50
University degree	40	34	44
Income level (SEK/month)			
< 10 000	9	7	11
10 000 < 20 000	21	19	22
20 000 < 30 000	54	52	56
30 000 < 40 000	13	16	11
40 00 < 50 000	2	3	0
> 50 000	2	3	0

586 **Note**: Parents weight categories according to the World Health Organization's BMI cut-off criteria (Normal
587 weight BMI=18.5-24.9; Overweight BMI ≥ 25.0; Obesity BMI ≥ 30.0). **Abbreviations**: BMI, Body Mass Index;
588 SEK, Swedish kronor (mean monthly income level in 2015: 33 600 SEK (men), 26 400 SEK (women)); Foreign
589 origin, parent and both grandparents born in other country than Sweden or parent born in Sweden and
590 grandparents born abroad. **Missing values:** 1 child for 'First born' and 'Number of siblings', 1 mother for all

591 maternal variables + 1 mother for 'BMI' and 'weight category', 8 fathers missing for all variables + 1 for 'Age'
592 and 'University degree' + 2 for 'income level'

Table 2.a. Child Behavior Checklist for Ages 1.5-5. Total scores for all subscales at baseline and 12-months with mean values (*SD*) for the whole sample, Parent-group treatment and Standard treatment including reference values

	Whole Sample (n=77)		Parent-group treatment (n=38)		Standard treatment (n=39)		Danish Reference values**	International Reference values*
	Baseline	12 months	Baseline	12 months	Baseline	12 months		
Syndrome Scale (No of items)								
Emotionally Reactive (9 items)	2.30 (2.76)	1.91 (2.92)	2.08 (2.47)	1.97 (3.16)	2.51 (3.03)	1.85 (2.70)	n.a.	2.7 (0.7)
Anxious/Depressed (8 items)	1.47 (1.95)	1.43 (2.27)	1.39 (1.82)	1.76 (2.67)	1.54 (2.10)	1.10 (1.78)	n.a.	3.1 (1.0)
Somatic Complaints (11 items)	1.32 (1.82)	1.19 (1.38)	1.24 (1.83)	1.03 (1.32)	1.41 (1.83)	1.36 (1.44)	n.a.	2.3 (0.6)
Withdrawn (8 items)	1.08 (1.29)	1.12 (1.34)	1.39 (1.32)	1.26 (1.48)	0.77 (1.20)	0.97 (1.20)	n.a.	1.7 (0.7)
Sleep Problems (7 items)	2.88 (2.22)	2.57 (2.62)	2.87 (2.18)	3.37 (2.91)	2.90 (2.29)	1.79 (2.05)	n.a.	2.7 (0.3)
Attention Problems (5 items)	1.78 (1.68)	1.51 (1.84)	2.00 (1.75)	1.66 (1.79)	1.56 (1.60)	1.36 (1.89)	n.a.	2.3 (0.6)
Aggressive Behavior (19 items)	6.90 (5.44)	5.66 (5.96)	7.03 (5.11)	6.00 (5.53)	6.77 (5.80)	5.33 (6.41)	n.a.	9.7 (1.8)
Total Internalizing Behaviors (36 items)	6.17 (6.55)	5.65 (6.68)	6.11 (6.21)	6.03 (7.45)	6.23 (6.95)	5.28 (5.91)	3.9 (5.1)	9.6 (2.6)
Total Externalizing Behaviors (24 items)	8.68 (6.55)	7.17 (7.33)	9.03 (6.31)	7.66 (6.75)	8.33 (6.83)	6.69 (7.91)	6.7 (6.0)	12.0 (2.3)
Total Problems score (100 items)	25.7 (18.34)	22.29 (19.27)	25.82 (16.72)	24.13 (19.26)	25.59 (20.01)	20.49 (19.37)	17.3 (15.3)	33.3 (7.1)
DSM Scale (No of items)								
Affective Problems (10 items)	2.86 (2.14)	2.60 (2.31)	2.74 (2.03)	2.82 (2.60)	2.97 (2.26)	2.38 (1.99)	1.1 (1.6)	2.3 (0.7)
Anxiety Problems (10 items)	2.68 (2.41)	2.58 (2.52)	2.61 (2.40)	2.87 (2.48)	2.74 (2.46)	2.31 (2.56)	1.6 (1.9)	3.8 (1.2)
Pervasive Developmental Problems (13 items)	2.27 (2.61)	2.09 (2.35)	2.79 (2.50)	2.42 (2.46)	1.77 (2.66)	1.77 (2.21)	1.6 (2.3)	3.2 (0.9)
ADHD (6 items)	3.04 (2.34)	2.66 (2.46)	3.26 (2.42)	2.97 (2.42)	2.82 (2.27)	2.36 (2.50)	2.3 (2.2)	4.7 (1.0)
Oppositional Defiant Problems (6 items)	2.83 (2.42)	2.13 (2.37)	2.71 (2.34)	2.08 (2.25)	2.95 (2.52)	2.18 (2.51)	2.3 (2.1)	3.3 (0.6)

* International Reference Values from Rescorla et al. (2011)
** Danish Reference Values from Kristensen, Henriksen & Bilenberg (2010)

Abbreviations: ADHD, Attention Deficit/Hyperactivity Problems; BMI, Body Mass Index (weight in kilograms/ height in meters squared); DSM, Diagnostic and Statistical Manual of Mental Disorders (4th edition, 1994), Parent-group treatment = child obesity treatment focused on general parenting; Standard treatment = child obesity treatment focused on lifestyle

Table 2.b. Child Behavior Checklist for Ages 1.5-5. Changes in total scores for all subscales at 12 months compared to baseline with mean values (*SD*) for the whole sample, Parent-group treatment and Standard treatment

	Whole sample (n=77)			Parent-group treatment (n=38)			Standard treatment (n=39)		
	Mean (SD)	p-value	95% CI	Mean (SD)	p-value	95% CI	Mean (SD)	p-value	95% CI
Syndrome Scale (No of items)									
Emotionally Reactive (9 items)	-0.39 (2.06)	0.10	(-0.85;0.07)	-0.10 (2.05)	0.75	(-0.77;0.56)	**-0.66 (2.06)**	**0.05**	(-1.33;0.00)
Anxious/Depressed (8 items)	-0.03 (2.02)	0.86	(-0.49;0.42)	0.36 (1.79)	0.21	(-0.22;0.95)	-0.43 (2.17)	0.21	(-1.14;0.26)
Somatic Complaints (11 items)	-0.13 (1.72)	0.51	(-0.52;0.26)	-0.21 (1.63)	0.43	(-0.74;0.32)	-0.05 (1.83)	0.86	(-0.64;0.54)
Withdrawn (8 items)	-0.03 (1.47)	0.81	(-0.29;0.37)	-0.13 (1.63)	0.62	(-0.66;0.40)	0.20 (1.30)	0.33	(-0.21;0.62)
Sleep Problems (7 items)	-0.31 (2.04)	0.18	(-0.77;0.15)	0.50 (2.02)	0.13	(-0.16;1.16)	**-1.10 (1.75)**	**0.00**	(-1.67;-0.53)
Attention Problems (5 items)	-0.27 (1.48)	0.11	(-0.60;0.06)	-0.34 (1.52)	0.17	(-0.84;0.16)	-0.20 (1.45)	0.38	(-0.67;0.26)
Aggressive Behavior (19 items)	**-1.23 (4.82)**	**0.02**	(-2.32;-0.13)	-1.02 (5.03)	0.21	(-2.68;0.63)	-1.43 (4.66)	0.06	(-2.94;-0.07)
Total internalizing Behaviors (36 items)	-0.51 (5.29)	0.39	(-1.72;0.68)	-0.07 (4.93)	0.92	(-1.70;1.54)	-0.94 (5.65)	0.30	(-2.78;0.88)
Total externalizing Behaviors (24 items)	**-1.50 (5.62)**	**0.02**	(-2.78;-0.23)	-1.36 (5.64)	0.14	(-3.22;0.48)	-1.64 (5.67)	0.07	(-3.48;0.19)
Total Problem score (100 items)	**-3.41 (14.50)**	**0.04**	(-6.70;-0.12)	-1.68 (13.82)	0.45	(-6.22;2.85)	**-5.10 (15.12)**	**0.04**	(-10.00;-0.19)
DSM Scale (No of items)									
Affective Problems (10 items)	-0.26 (1.94)	0.24	(-0.70;0.18)	0.07 (2.01)	0.81	(-0.58;0.74)	**-0.59 (1.83)**	**0.05**	(-1.18;0.00)
Anxiety Problems (10 items)	-0.09 (2.30)	0.73	(-0.61;0.43)	0.26 (2.02)	0.42	(-0.40;0.92)	-0.43 (2.52)	0.28	(-1.25;0.38)
Pervasive Developmental Problems (13 items)	-0.18 (1.94)	0.41	(-0.62;0.26)	-0.36 (2.09)	0.28	(-1.05;0.32)	0.00 (1.79)	1.00	(-0.58;0.58)
ADHD (6 items)	-0.37 (1.92)	0.09	(-0.81;0.06)	-0.28 (1.90)	0.35	(-0.91;0.33)	-0.46 (1.97)	0.15	(-1.10;0.17)
Oppositional Defiant Problems (6 items)	**-0.70 (2.10)**	**0.00**	(-1.17;-0.22)	-0.63 (2.21)	0.08	(-1.35;0.09)	**-0.76 (2.01)**	**0.02**	(-1.42;-0.11)

Significant associations are shown in **bold.**

Abbreviations: ADHD, Attention Deficit/Hyperactivity Problems, BMI, Body Mass Index; DSM, Diagnostic and Statistical Manual of Mental Disorders (4th edition, 1994)

Notes: Parent-group treatment = child obesity treatment focused on general parenting; Standard treatment = child obesity treatment focused on lifestyle.

Table 3. Estimates from linear regression models for associations between Child Behavior Checklist scores at baseline and change in child BMI Z-score from baseline to 12 months follow-up after obesity treatment

	Whole sample (n=77)				Parent-group treatment (n=38)				Standard treatment (n=39)			
	R^2	p	β	95% CI	R^2	p	β	95% CI	R^2	p	β	95% CI
Syndrome Scale												
Model 1	0.30				0.52				0.51			
Emotionally Reactive		0.15	-0.35	(-0.78;0.13)		0.46	-0.39	(-1.74;0.84)		0.47	-0.34	(-0.88;0.43)
Anxious/Depressed		0.28	0.29	(-0.23;0.77)		0.72	0.21	(-1.24;1.73)		0.10	0.67	(-0.09;0.99
Somatic Complaints		0.23	0.22	(-0.14;0.55)		0.30	0.40	(-0.42;1.25)		0.46	0.20	(-0.27;0.56)
Withdrawn		0.78	-0.05	(-0.43;0.33)		0.58	-0.23	(-1.20;0.71)		0.94	0.02	(-0.48;0.52)
Sleep Problems		0.63	-0.08	(-0.42;0.26)		0.66	0.16	(-0.68;1.05)		0.64	-0.13	(-0.53;0.33)
Attention Problems		**0.03**	**0.40**	**(0.03;0.72)**		0.16	0.48	(-0.24;1.26)		0.29	0.31	(-0.21;0.67)
Aggressive Behavior		0.12	-0.36	(-0.77;0.09)		0.54	-0.24	(-1.22;0.67)		0.13	-0.79	(-1.23;1.72)
Model 2	0.14				0.40				0.32			
Total internalizing Behaviors		0.88	0.03	(-0.34;0.39)		0.90	0.04	(-0.67;0.75)		0.39	0.30	(-0.28;0.68)
Total Externalizing Behaviors		0.53	-0.12	(-0.48;0.25)		0.51	0.18	(-0.44;0.85)		**0.04**	**-0.72**	**(-0.96;0.10)**
Model 3	0.14				0.43				0.27			
Total Problem score		0.48	-0.09	(-0.32;0.15)		0.15	0.30	(-0.14;0.84)		**0.03**	**-0.44**	**(-0.55;0.02)**
DSM Scale												
Model 4	0.29				0.74				0.42			
Affective Problems		0.63	-0.09	(-0.45;0.28)		0.39	0.18	(-0.29;0.70)		0.30	-0.41	(-0.83;0.27)
Anxiety Problems		0.68	0.09	(-0.36;0.54)		0.70	0.10	(-0.50;0.73)		0.46	0.30	(-0.40;0.85)
Pervasive Developmental Problems		0.66	-0.09	(-0.49;0.31)		0.42	0.23	(-0.41;0.91)		0.86	-0.06	(-0.59;0.50)
Attention Deficit/Hyperactivity Problems		**0.01**	**0.42**	**(0.09;0.72)**		**0.00**	**0.68**	**(0.29;1.21)**		0.24	0.29	(-0.16;0.58)
Oppositional Defiant Problems		**0.00**	**-0.45**	**(-0.72;-011)**		**0.00**	**-0.83**	**(-1.46;-0.40)**		**0.05**	**-0.53**	**(-0.72;0.01)**
Covariates[1]	0.13				0.37				0.12			
Child age		0.88	-0.01	(-0.28;0.24)		0.54	0.12	(-0.30;0.55)		0.59	-0.10	(-0.45;0.27)
Child sex		0.76	0.04	(-0.22;0.30)		0.45	0.15	(-0.30;0.65)		0.30	-0.20	(-0.49;0.16)
Mother BMI		0.24	0.15	(-0.10;0.40)		**0.04**	**0.41**	**(0.01;0.85)**		0.60	-0.10	(-0.42;0.25)
Mother foreign background		0.36	0.14	(-0.16;0.43)		0.17	0.27	(-0.15;0.77)		0.77	0.09	(-0.44;0.58)
Mother income		0.69	-0.05	(-0.34;0.23)		0.35	0.17	(-0.26;0.69)		0.66	-0.08	(-0.48;0.31)
Father BMI		**0.03**	**0.27**	**(0.02;0.51)**		**0.05**	**0.35**	**(-0.01;0.77)**		0.32	0.20	(-0.16;0.45)
Father foreign background		0.70	-0.05	(-0.35;0.24)		0.57	0.10	(-0.31;0.54)		0.66	-0.15	(-0.62;0.40)
Father income		0.83	-0.02	(-0.27;0.22)		0.86	-0.03	(-0.41;0.34)		0.98	0.00	(-0.33;0.34)

Significant associations are shown in **bold.** Abbreviations: p, p-value; β, standardized beta; CI, confidence intervals; BMI, Body Mass Index; DSM, Diagnostic and Statistical Manual of Mental Disorders (4th edition, 1994) [1]Covariates included as step one in all models. Notes: Parent-group = child obesity treatment focused on evidence-based parenting practices; Standard treatment group = child obesity treatment focused on lifestyle.

Table 4. Estimates from linear regression models for the associations between changes in Child Behavior Checklist scores and change in weight status (BMI z-scores) after an obesity treatment.

	Whole sample (n=77)				Parent-group treatment (n=38)				Standard treatment (n=39)			
	R^2	p	β	95% CI	R^2	p	β	95% CI	R^2	p	β	95% CI
Syndrome Scale												
Model 1	0.17				0.49				0.46			
Emotionally Reactive		0.86	0.03	(-0.38;0.45)		0.53	-0.23	(-1.71;0.93)		0.51	0.18	(-0.28;0.54)
Anxious/Depressed		0.45	-0.15	(-0.54;0.25)		0.57	0.26	(-0.87;1.51)		**0.01**	**-0.90**	**(-1.08;0.11)**
Somatic Complaints		0.53	-0.10	(-0.41;0.22)		0.87	-0.06	(-1.06;0.91		0.93	0.02	(-0.41;0.44)
Withdrawn		0.43	0.12	(-0.19;0.43)		0.70	0.13	(-0.63;0.90)		0.09	-0.45	(-0.78;0.07)
Sleep Problems		0.71	-0.06	(-0.39;0.27)		0.73	0.10	(-0.59;0.81)		0.34	0.29	(-0.28;0.77)
Attention Problems		0.79	-0.04	(-0.35;0.27)		0.79	-0.10	(-1.00;0.78)		0.15	-0.38	(-0.67;0.11)
Aggressive Behavior		0.31	0.20	(-0.19;0.58)		0.62	0.18	(-0.70;1.12)		0.20	0.48	(-0.20;0.90)
Model 2	0.14				0.41				0.20			
Total internalizing Behaviors		0.64	-0.09	(-0.46;0.29)		0.39	0.26	(-0.51;1.23)		0.18	-0.45	(-0.73;0.15)
Total Externalizing Behaviors		0.49	0.13	(-0.24;0.50)		0.89	-0.03	(-0.75;0.66)		0.71	0.11	(-0.36;0.52)
Model 3												
Total Problem score		0.63	0.07	(-0.22;0.35)		0.36	0.20	(-0.31;0.80)		0.46	-0.18	(-0.46;0.22)
DSM Scale												
Model 4												
Affective Problems		0.75	0.06	(-0.30;0.41)		0.73	-0.11	(-0.82;0.59)		0.42	0.24	(-0.30;0.67)
Anxiety Problems		0.66	0.08	(-0.28;0.44)		0.07	0.47	(-0.08;1.47)		0.23	-0.36	(-0.63;0.16)
Pervasive Developmental Problems		0.94	-0.01	(-0.36;0.33)		0.86	-0.05	(-0.78;0.67)		0.86	-0.05	(-0.51;0.43)
Attention Deficit/Hyperactivity Problems		0.33	-0.16	(-0.47;0.16)		0.22	-0.30	(-0.95;0.24)		0.62	-0.13	(-0.48;0.29)
Oppositional Defiant Problems		0.34	0.16	(-0.18;0.50)		0.32	0.31	(-0.38;1.07)		0.85	-0.04	(-0.44;0.37)
Covariates[1]	0.13				0.37				0.12			
Child age		0.88	-0.01	(-0.28;0.24)		0.54	0.12	(-0.30;0.55)		0.59	-0.10	(-0.45;0.27)
Child sex		0.76	0.04	(-0.22;0.30)		0.45	0.15	(-0.30;0.65)		0.30	-0.20	(-0.49;0.16)
Mother BMI		0.24	0.15	(-0.10;0.40)		**0.04**	**0.41**	**(0.01;0.85)**		0.60	-0.10	(-0.42;0.25)
Mother foreign background		0.36	0.14	(-0.16;0.43)		0.17	0.27	(-0.15;0.77)		0.77	0.09	(-0.44;0.58)
Mother income		0.69	-0.05	(-0.34;0.23)		0.35	0.17	(-0.26;0.69)		0.66	-0.08	(-0.48;0.31)
Father BMI		**0.03**	**0.27**	**(0.02;0.51)**		**0.05**	**0.35**	**(-0.01;0.77)**		0.32	0.20	(-0.16;0.45)
Father foreign background		0.70	-0.05	(-0.35;0.24)		0.57	0.10	(-0.31;0.54)		0.66	-0.15	(-0.62;0.40)
Father income		0.83	-0.02	(-0.27;0.22)		0.86	-0.03	(-0.41;0.34)		0.98	0.00	(-0.33;0.34)

Significant associations are shown in **bold.** Abbreviations: p, p-value; β, standardized beta; CI, confidence intervals; BMI, Body Mass Index; DSM, Diagnostic and Statistical Manual of Mental Disorders (4th edition, 1994) [1]Covariates included as step one in all models. Notes: Parent-group treatment = child obesity treatment focused on general parenting; Standard treatment = child obesity treatment focused on lifestyle.