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Associations of preschoolers' dietary patterns with eating behaviors and parental feeding practices at a 12-month follow-up of obesity treatment

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ABSTRACT

Although dietary patterns are key to the management of childhood obesity, they are rarely assessed and thus poorly understood. This study examines preschoolers' dietary patterns and correlates 12 months after the start of obesity treatment (n = 99, mean age 5.2 years, 52% girls). A food frequency questionnaire (FFQ), the Child Eating Behavior Questionnaire (CEBQ), Child Feeding Questionnaire (CFQ) and Lifestyle Behavior Checklist (LBC) were answered by parents to assess children's food intake, eating behaviors, parental feeding practices, and obesity-related behaviors, respectively. Principal component analysis identified dietary patterns based on FFQ data. Through multiple linear regressions we examined correlations between a healthy (HD) and a less healthy (LHD) dietary pattern and mean scores of the CEBQ, CFQ, LBC scales as well as BMI z-scores. The reported intake of items in the LHD decreased after treatment while no differences were found for the HD. Children's eating behaviors, in particular food fussiness, showed consistent associations with diet (b = −0.39, 95% CI −0.63, −0.14 for HD and b = 0.41, 95% CI 0.15, 0.66 for LHD). Feeding practices and obesity-related behaviours were weakly associated with the dietary patterns (HD and Monitoring: b = 0.36, 95% CI 0.09, 0.62; LHD and Screen time b = 0.08, 95% CI 0.01, 0.15). Among the measured variables, eating behaviors had the largest impact on children's dietary patterns. The LHD was associated with a higher BMI z-score but no associations were found between changes in LHD intake and changes in BMI z-scores. Our findings suggest that decreasing food fussiness in children with obesity is key to positive dietary changes. Assessment of children's eating behaviors can help tailor dietary advice and provide support for families of children with obesity.

1. Background

Insights into dietary patterns are a vital part of effective interventions for childhood obesity (Ells et al., 2018; Duncanson et al., 2021). The recommended dietary patterns are high in fruit and vegetables and low in energy-dense, nutrient-poor (EDNP) foods and sugar-sweetened beverages (Spear et al., 2007). EDNP foods include fast foods such as pizza and hamburgers, and different types of snack foods such as potato chips, sweet pastries, ice cream, sweets, and chocolate. EDNP foods are associated with a higher intake of energy, sugar, total fat and saturated fat, as well as with a higher intake of sugar-sweetened beverages (Powell & Nguyen, 2013). A high intake of sugar-sweetened beverages increases obesity risk in both children and adults (Malik, Pan, Willett, & Hu, 2013), possibly due to their being high in calories but not satiating (Mattes, 2006). As opposed to EDNP foods, intake of fruit and vegetables has numerous positive health effects, such as supporting a healthy body weight (Slavin, 2005) and reducing the risk of developing the metabolic syndrome (Tian, Su, Wang, Duan, & Jiang, 2018), cardiovascular disease, cancer and all-cause mortality (Aune et al., 2017).

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This study addresses a crucial gap in the field of childhood obesity treatment research: while studies have focused on weight outcomes, children's food intake has largely remained unexplored as most treatment studies do not report on food intake (Burrows et al., 2012, Duncanson et al., 2021). This is especially important in the preschool age, a developmental period that might be particularly challenging for parents due to high prevalence of food fussiness (Cardona Cano et al., 2015), and for which few treatment options exist. Further, obesity is a chronic condition that needs continuous management, and, to our knowledge, no previous study has explored associations between weight outcomes, behavioral characteristics, and healthier or less healthy food patterns among preschoolers who received treatment for obesity. Insight into factors associated with the food intake of children who are managing their obesity can aid in the tailoring of future interventions, particularly with regards to long-term management.

Eating behaviors affect how much and how often a child eats (Syrad, Johnson, Wardle, & Llewellyn, 2016) and can also influence what children eat. Some eating behaviors in children are linked to a less healthy dietary pattern and/or a higher weight status. These include a high enjoyment of food (Quah et al., 2019; Spahić & Pranjić, 2019; Spence, Carson, Casey, & Boule, 2011; Viana, Sinde, & Saxton, 2008; Webber, Hill, Saxton, Van Jaarsveld, & Wardle, 2009), eating more in response to emotions (Jalo et al., 2019), a low satiety response and a high interest in food (Spahić & Pranjić, 2019; Spence et al., 2011; Viana et al., 2008; Webber et al., 2009). The most widely used measure to study children's eating behaviors (de Lauzon-Guillain et al., 2012) is the Child Eating Behavior Questionnaire (CEBQ) (Wardle, Guthrie, Sanderson, & Rapoport, 2001). The instrument consists of statements that describe the child's appetite, clustered into eight subscales. The subscale Enjoyment of food has been associated with fruit and vegetable liking, while the subscales Slowness in Eating, Food Fussiness and Satiety Responsiveness have been inversely associated with fruit and vegetable liking (Fildes et al., 2015). Food Fussiness has also been associated with a low intake of vegetables (Hayes et al., 2016; Sandvik et al., 2019), whilst children who are highly responsive to food have shown a higher preference for EDNP foods (Fildes et al., 2015).

Parental feeding practices are strategies used during mealtime to affect the child's eating habits, often as a response to child eating behaviors (Ek et al., 2016). These practices are modifiable and can alter children's dietary habits (Holland et al., 2014). The practices are frequently measured using the Child Feeding Questionnaire (CFQ), which includes the subscales Restriction (limiting the availability of certain foods), Monitoring (overseeing the child's food intake) and Pressure to Eat (encouraging the child to eat more) (Birch et al., 2001). How feeding practices affect children's eating patterns and weight status is not completely clear. Monitoring has been negatively associated with non-core food intake and sweetened beverage intake in young children with overweight (Haszard, Skidmore, Williams, & Taylor, 2015). Studies have found that higher levels of parental restriction of certain foods are associated with higher child weight status, while pressuring the child to eat is not associated with higher child weight status (Birch, 2001; Nowicka, Sorjonen, Pietrobelli, Flodmark, & Faith, 2014). These relationships are likely explained by parents' responses to a child's eating behavior and/or concern for the child's weight status (Ek et al., 2016; Hurley, Pallan, Lancashire, Adab & WAVES Study; Investigators, 2018; Webber, Cooke, Hill, & Wardle, 2010), rather than indicating a causal relationship between restriction/pressure to eat and a child's weight.

Parents influence young children's behaviors and the most recent Cochrane review concludes that childhood obesity interventions that provide specific support regarding parenting practices result in lowering child weight status (body mass index (BMI) z-scores) (Colquitt et al., 2016). Targeting parents in treatment was also supported in an umbrella review, which included 14 systematic reviews and showed that interventions where only parents were involved were as effective as interventions involving parents and children (Chai et al., 2019). Thus, it is important to understand how parents perceive their children's weight-related behaviors, such as overeating and low engagement in physical activity. The Lifestyle Behavior Checklist (LBC) (West & Sanders, 2009) was developed to evaluate what problematic behaviors parents perceive in their children and how confident they are in handling these problems. Compared to parents of children with a healthy weight, parents of children with overweight and obesity report more food-related problems, such as the child eating too much and too fast, and a lower confidence in handling these perceived problems (Ek, Sorjonen, Nyman, Marcus, & Nowicka, 2015; Morawska & West, 2013; West & Sanders, 2009). However, it is unknown how these perceptions are associated with children's food patterns.

The aim of this study is to explore dietary patterns and correlates of healthy and less healthy dietary patterns in preschool-aged children, 12 months after the start of obesity treatment. Specifically, we explore associations between children's dietary patterns and weight status, child eating behaviors, parental feeding practices, parents' perceptions of obesity-related problem behaviors and parents' confidence in handling these behaviors.

2. Method

This is an exploratory study based on secondary data from the More and Less study (ML) that took place from 2011 to 2017 at Karolinska Institutet, Stockholm, Sweden (Ek, Chamberlain, et al., 2015).

2.1. Design of the More and Less study

The ML was a randomized controlled trial which aimed to evaluate two obesity treatments for preschool-age children in Stockholm County, Sweden (Ek, Chamberlain, et al., 2015). In the present paper, we assess associations for the total study population. We do not compare treatment groups because no differences were observed across treatments in changes in reported intake of FFQ items (Somaraki et al., 2020).

In the ML, a parent-only support program focusing on parenting skills was delivered by a trained facilitator in a group setting. This program was compared to standard treatment focusing on lifestyle behavior advice, delivered in individual meetings between a healthcare professional and both parent and child. The results for the primary outcome (child body mass index (BMI)-z score) have been published previously (Ek et al., 2019). The participants (n = 174) were mainly recruited through child health care centers between March 2012 to March 2016. The included children were 4–6 years old and had obesity according to international standards (Cole, Bellizzi, Flegal, & Dietz, 2000; Cole & Lobstein, 2012). Children were excluded if they had a chronic disease or developmental problems that could affect weight and height and if parents were not able to communicate in Swedish. The ML study was approved by the Regional Ethical Board in Stockholm (ID: 2011/1329-31/4) on November 16, 2011. Written informed consent was provided by both parents.

Children and their parents were randomized to either the parent program or standard treatment. The parent program was delivered weekly for 10 weeks by registered dieticians in a group setting. Each of the sessions had a main theme which featured an evidence-based parenting practice and discussions about a lifestyle component such as diet or physical activity. Standard treatment was provided in an outpatient pediatric unit according to the action program for overweight and obesity in Stockholm County (The Health Care Administration, 2010). Families had at least four visits scheduled with a pediatrician and/or pediatric nurse, focusing on lifestyle changes. A treatment plan was formed, with treatment frequency and the involvement of different clinicians adjusted according to the individual needs of the child.

2.2. Measures

This study used data collected in the ML, from an FFQ, the CEBQ (Ek et al., 2016; Wardle et al., 2001), the CFQ (Birch et al., 2001; Nowicka et al., 2014) and the LBC (Ek, Chamberlain, et al., 2015; West & Sanders, 2009). The analysis used baseline FFQ data, BMI-z scores and demographic information and data collected at the 12-month follow-up. Brief descriptions of the behavior-related questionnaires are presented in Table 1.

2.2.1. The food frequency questionnaire

A 10-item FFQ (see Appendix 1) was answered at baseline and at 12 months and was used to assess how often the children consumed different categories of foods: “fresh fruits”, “vegetables”, “pizza/hamburger”, “fish”, “ice cream”, “cakes/cookies/buns”, “soft drinks”, “juice”, “sweets/chocolate”, “chips/snacks”. The FFQ had 13 possible responses ranging from “once a month or less” to “four times per day or more”. FFQs tend to have a higher reporting quality when measuring diet intake in children compared to other tools such as food diaries and 24-h recalls, possibly due to their structure and simplicity (Burrows et al., 2012) as well as a low respondent burden (Magarey et al., 2011). The Swedish National Food Agency has used a more comprehensive FFQ when examining the dietary intake of 4-, 8-, and 11-year-olds (Becker & Enghardt, 2004). An FFQ similar to the one used in this study was validated in an intervention trial focusing on the prevention of childhood obesity in Swedish health care centers (Döring et al., 2014). Changes in reported intake of the individual FFQ items in the RCT have previously been studied (Somaraki et al., 2020). The focus of the present study is exploring food patterns in the whole study sample.

Table 1
Behavior-related questionnaires used in the study.

Name of instrument	Domains measured	Number of items	Brief description of measures
Child Eating Behavior Questionnaire (CEBQ)			
	Food approach		
	Food responsiveness	5	The child’s general appetite and desire to eat
	Emotional overeating	4	If the child eats more in response to emotions
	Enjoyment of food	4	The child’s interest in and enjoyment of food
	Desire to drink	3	The child’s desire to drink
	Food avoidance		
	Satiety responsiveness	4	If the child gets full easily or not
	Slowness in eating	4	The child’s eating pace
	Emotional undereating	4	If the child eats less in response to emotions
	Food fussiness	6	The child eats and tastes a limited variety of foods
Child Feeding Questionnaire (CFQ)			
	Restriction	6	The extent to which parents restrict the child’s access to different foods
	Pressure to eat	4	Parents’ tendency to pressure the child to eat more food
	Monitoring	3	The extent to which parents oversee the child’s intake of different foods
Lifestyle Behavior	Overeating	9	If the child eats large amounts or often asks for or takes food
Checklist (LBC)	Physical activity	3	If the child complains about and refuses physical activity
	Emotional correlates of being overweight	3	If the child complains about his/her weight and appearance
	Misbehavior in relation to food	2	If the child throws tantrums about food
	Screen time	2	If the child has sedentary interests
	Confidence scale	19	Parents’ confidence in handling the problematic behaviors

2.2.2. The Child Eating Behavior Questionnaire

The 35-item CEBQ was used to evaluate children’s eating behaviors. The items cluster into eight factors: Food responsiveness, Emotional overeating, Enjoyment of food, Desire to drink, Satiety responsiveness, Slowness in eating, Emotional undereating and Food fussiness. The first four represent the dimension Food approach and the other four represent Food avoidance. The questionnaire was filled out by one parent in each family. Each behavior was rated on a 1–5 Likert scale from “never” to “always”. The CEBQ has been validated in several studies (Sleddens, Kremers, & Thijs, 2008; Spence et al., 2011; Wardle et al., 2001) including in Swedish settings (Ek et al., 2016; Svensson, Lundborg, Cao, Nowicka, Marcus & Sobko, 2011). One item regarding snacking was excluded from the analysis as it loaded weakly on the Satiety responsiveness subscale (Ek et al., 2016).

2.2.3. The Child Feeding Questionnaire

The CFQ was designed for parents of 2 to 11-year-olds (Birch et al., 2001) and has been translated and validated in a Swedish population of almost 900 parents of 4-year-olds (Nowicka et al., 2014). The CFQ was used to assess mothers’ and fathers’ attitudes and feeding practices using the subscales Restriction, Pressure to eat and Monitoring. The subscales consist of 15 items in total and the parents rated each item on a Likert scale from 1 (never) to 5 (always). In this analysis two items concerning using food as a reward were excluded as previous research has shown that Swedish parents score low on these items due to social desirability (Nowicka et al., 2014).

2.2.4. The Lifestyle Behavior Checklist

The 25-item LBC, developed in Australia, is based on interviews with experts on childhood obesity and feedback from participants in a parenting program (West, Morawska, & Joughin, 2010; West & Sanders, 2009). The instrument has been translated and validated, with a few modifications, in a study with a Swedish population of close to 500 parents of preschoolers (Ek, Chamberlain, et al., 2015). The LBC was used to assess parents’ perceptions of their child’s obesity-related problem behaviors (the Problem scale). Both parents reported the degree to which their child’s behaviors were problematic on a 7-point problem scale, ranging from “not at all” to “very much”. The items were divided into the subscales Overeating, Physical activity, Emotional correlates, Misbehavior in relation to food and Screen time. The parents were also asked to rate their confidence in dealing with each behavior from 1 (“certain I can’t do it”) to 10 (“certain I can do it”) (the Confidence scale). 19 items were included from the analysis. Excluded items were less relevant to preschoolers or fitted poorly into the model, possibly due to ambiguous meaning (Ek, Chamberlain, et al., 2015).

2.2.5. Weight status at baseline and change after 12 months

The child’s weight and height were measured three times by trained staff at baseline and 12 months. The mean of the three measurements was used to calculate the child’s BMI. BMI was then used to identify the child’s BMI z-score as derived from age- and sex-specific reference data (Cole et al., 2012). A mean change in BMI z-score variable was computed by subtracting the baseline value from the 12-month value.

2.2.6. Covariates

At baseline, parents completed sociodemographic questionnaires where they reported the child’s sex and age, and the parents’ ages, self-reported height and weight, education, and whether or not they had foreign background (defined as having been born outside Sweden, or having parents born outside Sweden).

2.3. Statistical analysis

Baseline descriptive variables were calculated as mean and standard deviations (SD) for continuous variables and numbers and percentages for categorical variables. To assess differences between ML participants who answered the FFQ at the 12-month follow-up and those who did not, descriptive data were analyzed using two-sided independent *t*-tests (continuous variables) and Chi-squared tests (categorical variables).

To explore dietary patterns at 12 months, Principal Component Analyses (PCA) was performed using Varimax rotation with Kaiser Normalization. PCA is a widely used exploratory method in epidemiology to derive dietary patterns from habitual diet (Lioret et al., 2020; Northstone & Emmett, 2008). Two components with Eigenvalues >1 were identified (the detailed description of the process in Appendix 2).

Based on current dietary guidelines, one component was called "Healthy dietary pattern" (HD) and the other was called "Less healthy dietary pattern" (LHD). The dietary patterns are further described in the result section. Each child was provided standardized scores pertaining to each of the two patterns, based on their reported consumption frequency of the different FFQ items. Pearson correlation coefficient was used to explore the association between these two scores. In addition, frequency equivalents (monthly consumption) for the items in the FFQ and the total intake of items characterizing the HD and the LHD were calculated. Paired samples *t*-test were used to study differences between baseline and 12 months.

Multiple linear regression was used to explore associations between children's HD and LHD scores (dependent variables) and the mean overall scores of the subscales of the CEBQ, the CFQ, and the LBC. The mean scores from the CEBQ and the CFQ and the summary score from the LBC were calculated and used in all models in accordance with earlier findings (Ek, Chamberlain, et al., 2015, Ek et al., 2016; Nowicka et al., 2014). For each analysis, only participants who answered all items in the subscale were included. All models were adjusted for child's sex, age, and BMI z-score at baseline, as well as parent's age, BMI, education level and foreign background. Education level was defined as either having a university degree or not. Foreign background was defined as both the participant's parents having been born abroad, regardless of the participant's own birthplace. Because only one parent per family completed the CEBQ, with the great majority of questionnaires completed by mothers, the mothers' background variables were used in the adjusted models for the CEBQ. Unstandardized regression coefficients (b) and confidence intervals (CI) of 95% were calculated.

To study the dietary patterns in relation to weight status in the context of obesity treatment, linear regressions were conducted. BMI z-scores were specified as the dependent variable. In two separate models, HD and LHD at 12 months were used to predict BMI z-scores at 12 months. Changes in mean total frequency intake of the items in the two food patterns were used to predict changes in BMI z-scores from baseline to 12 months. These models were adjusted for child's sex and age.

The level of significance was set to $p < 0.05$. All statistical tests were performed in SPSS version 25.

3. Results

Of the 174 families enrolled in the ML study, 99 completed the FFQ 12 months after baseline and were included in the analysis (see Table 2). A greater percentage of the parents who did not complete the FFQ at 12 months was of foreign background compared to the study sample (mothers: 76.6% vs 54.1%; fathers: 74.4% vs 50.4%).

Table 2
Sample descriptives at baseline for the participants with and without a completed FFQ at the 12-month follow-up.

Variables	Completed FFQ at 12 months (n = 99)[a]	Not completed FFQ at 12 months (n = 75)[a]
	n (%) or mean (SD)	
Children		
Girls	51 (51.5)	47 (62.7)
Age in years	5.2 (0.8)	5.3 (0.8)
BMI z-score	2.9 (0.6)	3.0 (0.6)
Mother		
Age in years	36.7 (5.4)	36.4 (5.9)
BMI kg/m^2	28.3 (6,1)	27.8 (4.7)
University degree	44 (45.4)	14 (30.4)
Foreign background*	53 (54.1)	36 (76.6)
Father		
Age in years	39.3 (6.9)	41.2 (7.7)
BMI kg/m^2	29.5 (4.4)	29.2 (4.6)
University degree	36 (40.0)	13 (34.2)
Foreign background*	46 (50.5)	29 (74.4)

Abbreviations: FFQ, Food Frequency Questionnaire; SD, standard deviation; BMI, body mass index.
[a] For parents' variables, n vary due to missing values.
* denote the presence of a significant difference between the groups, $p < 0.05$.

Mean BMI-z scores of the children included in the analysis were at baseline 2.9 (SD 0.6), and at the 12-month follow-up 2.7 (SD 0.8) ($p < 0.001$). At the 12-month follow-up, two dietary patterns were identified. The HD explained 17% of the variance and was formed through correlations between "fresh fruit", "vegetables" and "fish" (Cronbach's alpha 0.56). The LHD explained 31% of the variance and was formed through correlations between "pizza/hamburger", "ice cream", "cakes/cookies/buns", "soft drinks", "juice", "sweets/chocolate" and "chips/snacks" (Cronbach's alpha 0.76). The Pearson correlation coefficient showed no significant association between the two patterns' scores (r=<0.001, p = 1.000).

The children's mean (SD) food frequency intake per month as reported at baseline and after 12 months is presented in Table 3. The

Table 3
Frequency of food intake per month as reported at baseline and at 12 months from baseline.

Food items (FFQ)	N[a]	Baseline Mean (sd)	12 months Mean (sd)	p-value[b]
Healthy dietary pattern (HD)	98	104 (50)	104 (44)	0.920
Fresh fruit	98	49 (27)	48 (25)	0.546
Vegetables	98	48 (28)	49 (25)	0.914
Fish	98	7 (6)	8 (8)	0.220
Less healthy dietary pattern (LHD)	94	31 (17)	24 (12)	<0.001
Pizza/hamburgers	97	2 (1)	2 (1)	0.302
Ice cream	99	4 (4)	3 (2)	0.017
Cakes/cookies/buns	98	5 (4)	4 (3)	0.016
Soft drinks	96	5 (5)	4 (3)	0.004
Juice	96	8 (9)	5 (7)	0.005
Sweets/chocolate	97	5 (4)	4 (2)	0.010
Chips/snacks	97	3 (2)	3 (2)	0.156

[a]Including children with FFQ data at both baseline and 12 months.
[b]Paired samples *t*-test.
$p < 0.05$ denote the presence of a significant difference between baseline and 12 months.

Table 4
Unstandardized regression effects for associations between dietary patterns (HD and LHD) and behavior related questionnaires 12 months after an obesity intervention.

Questionnaire/subscales	n	Healthy dietary pattern (HD) B (CI 95%) unadjusted	Healthy dietary pattern (HD) B (CI 95%) adjusted[a]	Less healthy dietary pattern (LHD) B (CI 95%) Unadjusted	Less healthy dietary pattern (LHD) B (CI 95%) adjusted[a]
Child eating behavior Questionnaire					
Food responsiveness	94	0.19 (−0.01,0.39)	0.17 (−0.04, 0.39)	−0.01 (−0.23, 0.22)	0.002 (−0.23, 0.23)
Emotional overeating	92	−0.08 (−0.30, 0.14)	−0.09 (−0.32, 0.13)	0.11 (−0.13, 0.35)	0.03 (−0.20, 0.27)
Enjoyment of food	93	**0.49 (0.24, 0.74**)**	**0.54 (0.26, 0.81**)**	−0.13 (−0.43, 0.17)	−0.08 (−0.39, 0.23)
Desire to drink	94	−0.06 (−0.27, 0.15)	−0.08 (−0.30, 0.13)	**0.28 (0.05, 0.51*)**	**0.23 (0.003, 0.45*)**
Satiety responsiveness	92	**−0.43 (-0.77, -0.09*)**	**−0.47 (-0.85, -0.09*)**	0.28 (−0.11, 0.67)	0.31 (−0.09, 0.71)
Slowness in eating	93	−0.23 (−0.48, 0.02)	−0.19 (−0.47, 0.09)	0.12 (−0.16, 0.40)	0.19 (−0.10, 0.47)
Emotional undereating	93	−0.17 (−0.40, 0.06)	−0.13 (−0.37, 0.11)	0.14 (−0.13, 0.40)	−0.09 (−0.16, 0.34)
Food fussiness	93	**−0.41 (−0.64, −0.18**)**	**−0.39 (−0.63, −0.14*)**	**0.35 (0.09, 0.61*)**	**0.41 (0.15, 0.66*)**
Child feeding questionnaire (mothers)					
Restriction	87	0.10 (−0.17, 0.37)	0.15 (−0.11, 0.41)	0.01 (−0.29, 0,30)	−0.01 (−0.28, 0.27)
Pressure to eat	87	−0.25 (−0.52, 0.02)	−0.13 (−0.42, 0.16)	0.21 (−0.08, 0.50)	0.18 (−0.12, 0.47)
Monitoring	89	**0.34 (0.07, 0.62*)**	**0.36 (0.09, 0.62*)**	0.06 (−0.24, 0.37)	0.13 (−0.16, 0.41)
Child feeding questionnaire (fathers)					
Restriction	77	0.11 (−0.18, 0.41)	0.21 (−0.11, 0.53)	−0.10 (−0.37, 0.16)	−0.13 (−0.42, 0.16)
Pressure to eat	77	−0.16 (−0.45, 0.13)	−0.14 (−0.46, 0.19)	0.19 (−0.07, 0.45)	0.17 (−0.11, 0.45)
Monitoring	76	0.12 (−0.21, 0.45)	0.04 (−0.30, 0.38)	−0.01 (−0.30, 0.28)	0.002 (−0.29, 0.30)
Lifestyle behavior checklist (mothers)					
Overeating	89	0.01 (−0.01, 0.03)	0.003 (−0.02, 0.02)	0.01 (−0.01, 0.03)	0.01 (−0.01, 0.03)
Physical activity	91	0.03 (−0.01, 0.07)	0.04 (−0.001, 0.08)	0.03 (−0.01, 0.07)	0.02 (−0.02, 0.06)
Emotional correlates of being overweight	91	0.02 (−0.05, 0.08)	0.03 (−0.04, 0.01)	0.03 (−0.04, 0.10)	0.001 (−0.07, 0.07)
Misbehavior in relation to food	90	−0.06 (−0.13, 0.01)	−0.04 (−0.11, 0.03)	0.05 (−0.02, 0.13)	0.03 (−0.04, 0.10)
Screen time	91	**−0.08 (−0.14, −0.01*)**	−0.07 (−0.14, 0.005)	0.06 (−0.01, 0.13)	**0.08 (0.01, 0.15*)**
Confidence scale	87	0.003 (−0.003, 0.01)	0.003 (−0.003, 0.01)	**−0.007 (−0.013, 0.000*)**	−0.01 (−0.01, 0.001)
Lifestyle behavior checklist (fathers)					
Overeating	77	<0.000 (−0.02, 0.03)	−0.01 (−0.03, 0.02)	0.01 (−0.01, 0.03)	0.004 (−0.02, 0.03)
Physical activity	76	−0.02 (−0.09, 0.05)	−0.02 (−0.09, 0.05)	0.05 (−0.01, 0.11)	0.04 (−0.02, 0.15)
Emotional correlates of being overweight	77	0.03 (−0.06, 0.11)	0.01 (−0.10, 0.09)	0.03 (−0.05, 0.10)	0.01 (−0.09, 0.08)
Misbehavior in relation to food	77	−0.04 (−0.14, 0.06)	−0.05 (−0.15, 0.05)	0.07 (−0.02, 0.15)	0.04 (−0.05, 0.14)
Screen time	77	−0.03 (−0.11, 0.05)	−0.02 (−0.10, 0.07)	0.05 (−0.02, 0.12)	0.02 (−0.05, 0.10)
Confidence scale	72	−0.003 (−0.01, 0.004)	−0.002 (−0.01, 0.01)	−0.002 (−0.01, 0.004)	−0.003 (−0.01, 0.004)

[a]Adjusted for child's sex, age, baseline BMI z-score, parents' age, BMI, education, foreign background. *$p < 0.05$, **$p < 0.001$. Significant results are in bold.

aggregated food frequency intake for the items representing the 12-month HD and LHD is also presented. No changes were found for frequency intake of the HD items from baseline to follow-up. Reported frequency intake of LHD items, however, had significantly decreased, mainly due to a significant reduction in the consumption frequency of all LHD items except "pizza/hamburgers" and "chips/snacks".

The results from the multiple linear regressions for associations between the dietary patterns at 12 months and questionnaire subscales are presented in Table 4.

For the CEBQ subscales, a significant positive association was found between HD and Enjoyment of food ($p < 0.001/< 0.001$ in the unadjusted and the adjusted model) and a significant negative association was found between HD and Satiety responsiveness ($p = 0.013/0.015$). For Food fussiness, there was a significant negative association with HD ($p < 0.001/< 0.001$) and a positive association with LHD. A significant, positive association was found between LHD and Desire to drink ($p = 0.017/0.047$). For the CFQ, one significant association was found: a higher degree of CFQ Monitoring among mothers was associated with HD ($p = 0.013/0.010$). For the LBC, there were two significant associations with problematic Screen time, as reported by mothers: a negative association with HD (only in the unadjusted model, $p = 0.017$) and a positive association with LHD (only in the adjusted model, $p = 0.037$). LHD was inversely associated with mothers' Confidence in the unadjusted model ($p = 0.048$); however, the significance disappeared in the adjusted models.

The LHD showed a positive association with BMI-z scores at 12 months ($b = 0.20$, 95% CI 0.05 to 0.35, $p = 0.01$). The association remained significant when adjusting for child's sex and age ($b = 0.21$, 95% CI 0.06–0.36, $p = 0.007$). No associations were found between the HD and BMI z-scores at 12 months. No associations were found between changes in total frequency intake of the food items included in the patterns and changes in BMI-z scores.

4. Discussion

This study is among the first to examine correlations between preschoolers' dietary patterns following obesity treatment and their eating behaviors and weight status, as well as their parents' feeding practices and perceptions of children's problematic obesity-related behaviors. In this clinical sample, we found that it was mainly children's eating behaviors, measured by the CEBQ, that showed associations with the two parent-reported PCA-derived dietary patterns: a healthy dietary pattern (HD) and a less healthy dietary pattern (LHD). Compared to children perceived as less fussy, children perceived as fussy eaters had less healthy dietary patterns, with both a lower average score on the HD and a greater average score on the LHD. Other findings showed that enjoyment of food was positively associated with the HD, whereas a higher satiety responsiveness was negatively associated with the HD. Additionally, greater desire to drink was positively associated with the LHD. Among parental feeding practices, measured by the CFQ, only mothers' monitoring was positively associated with the HD. Problematic screen time behavior was the only obesity-related behavior measured by the LBC that was associated with the LHD. All associations were largely unaffected when adjusted for background factors.

Although the reported intake of foods relevant to obesity treatment was within recommended levels in all groups already at baseline, we did see a significant reduction in LHD items. Juice was the FFQ item that had decreased the most, from a mean intake of 8 times per month to 5 times per month. A previous study has found that mothers are ambivalent about whether juice may be considered part of a healthy diet (Eli, Hörnell, Malek, & Nowicka, 2017). It is possible that parents gained insights about juice through the treatment program, thereby reducing their children's consumption of juice. Changes in the total intake of items belonging to either HD or LHD showed no association with changes in weight status. This is consistent with Somaraki et al.'s (2020) finding that changes in intake of individual FFQ items did not mediate child weight loss in the ML study. Nonetheless, the reported intake of LHD foods showed a positive association with a higher BMI-z score.

The subscales of the CEBQ showed the strongest and most coherent associations with dietary patterns. Food fussiness was the only child eating behavior associated with both HD and LHD but in opposite directions, indicating that children perceived as fussy eaters were more likely to have obesity-related dietary patterns. Notably, a previous paper, focusing on picky eating, used baseline data from this cohort and did not find significant associations between food fussiness and individual EDNP food items or sweet beverages (Sandvik et al., 2019). Our findings might reflect changes from pre-to post treatment but may also indicate the importance of studying dietary patterns instead of individual food items when trying to identify links between children's food intake and their eating behaviors. Sandvik et al. (2019) also found that the inverse association between food fussiness and vegetable intake was present at baseline and was not affected by treatment. Only a few other studies have examined food intake and food fussiness in children with overweight and obesity. A study with 4-8-year-olds with overweight found that Food fussiness was associated with a lower fruit and vegetable intake and a higher consumption of sweetened beverages, but not with non-core foods (Haszard et al., 2015). In a non-clinical population, food fussiness was associated with a lower intake of dietary fiber from vegetables (Taylor, Northstone, Wenimont & Emmet, 2016a). Further, in 3-year-olds, picky eating was associated with a lower intake of micronutrients (carotene, iron and zinc) while no differences were found for energy intake compared to non-picky eaters (Taylor, Northstone, Wenimont & Emmet, 2016b). Interestingly, no clear associations have been found between picky eating and weight status, although picky eating may be indicative of a lower weight (Brown, Vander Schaaf, Cohen, Irby, & Skelton, 2016). However, some children with obesity also exhibit picky eating behaviors. A previous study showed that one third of parents with children with obesity perceived their children as being picky eaters (Sandvik et al., 2018). Further research should explore the food patterns of picky eaters of different weight status.

Our finding that a less healthy dietary pattern was associated with a higher desire to drink may reflect the higher consumption of sugar-sweetened beverages and juice among these children. This is possibly explained by greater access to these beverages, such that if parents remove sugar-sweetened beverages from the home the child may eventually stop expressing a desire to drink them. A US-based study conducted with 2-5-year-old African-American children and their fathers found that the child's desire to drink predicted an increased intake of sugar-sweetened beverages (Lora, Hubbs-Tait, Ferris, & Wakefield, 2016). In a UK-based study with older children, Desire to drink was associated with a more frequent intake of sugar-sweetened beverages but not fruit juice (Sweetman, Wardle, & Cooke, 2008). Since the risk of developing obesity increases with a high intake of sugar-sweetened beverages, guiding parents in what beverages to offer children who frequently express desire to drink is an important part of childhood obesity prevention (Malik et al., 2013).

A notable finding is that children's dietary patterns are associated with enjoyment of food. In a previous study of Australian and British children's food preferences, children who liked fruits and vegetables were more often described as enjoying food and eating and having a low satiety response (Fildes et al., 2015). However, our finding goes beyond this focus on individual food items, suggesting a healthy dietary pattern as a whole is associated with children's enjoyment of food. In contrast, Fildes et al. (2015) found an association between Food Responsiveness and a preference for EDNP foods, whereas we found no association between Food Responsiveness and a less healthy dietary pattern. This could be due to the effects of obesity treatment, either on children's eating directly, or on their parents' awareness of what constitutes healthy eating and how to report dietary intake.

The limited associations we identified between parental feeding practices and children's dietary patterns were only partially consistent with previous research. We found a positive association between mothers' monitoring and the healthy dietary pattern. This is aligned with findings we reported in a previous study, where we found that an increase in mothers' monitoring led to decreased intake of sweets and chocolates 12 months after the initiation of obesity treatment (Somaraki et al., 2020). Along similar lines, in a study with Portuguese mothers and their 4-year-old children, Durão et al. (2015) reported that both Monitoring and Restriction increased the odds that children would consume amounts of fruits and vegetables that matched the national recommendations. However, Haszard et al. (2015) found that monitoring children's eating was associated with a lower intake of healthy food, though it should be noted that Haszard et al. (2015) did not use the CFQ and did not report which parent responded to the questionnaire. We found no associations between parental pressure to eat and children's dietary patterns. This is contrary to our previous findings where an increase in pressure to eat was associated with an increased intake of cookies and buns (Somaraki et al., 2020). The association between pressure to eat and less healthy diets among young children was also found in a systematic review and meta-analysis by Yee, Lwin, and Ho (2017). One possible explanation for this discrepancy is that our study focused on dietary patterns, whereas these earlier studies focused on individual types of food.

Of children's problematic obesity-related behaviors, as perceived by parents, only screen time behavior was associated with dietary patterns. Our finding that screen time was inversely associated with a healthy dietary pattern aligns with previous studies, which reported similar associations between television viewing and diet (Ford, Ward, & White, 2012). This finding may reflect associations between particular eating behaviors and screen time. Food fussiness, slowness in eating and more screen time are associated behaviors, and we have previously found an association between picky eating and screen time in a large sample of preschoolers (Sandvik et al., 2018). Further research is needed to understand why other problematic obesity-related behaviors were not associated with children's dietary patterns.

4.1. Strengths and limitations

Because the original ML was an intervention study for childhood obesity, the present analysis was not planned as part of ML. The analysis is therefore limited by the lack of power calculations, which were not performed due to the exploratory nature of this study. Furthermore, the multiple linear regressions performed introduce a risk of false significant results. However, because the study was exploratory, we chose not to adjust the p-values (Bender & Lange, 2001). In the intervention, there was a considerable loss to follow-up and the sample size of the present study was relatively small. In particular, fathers had more missing data than mothers, and a larger percentage of parents with foreign background did not complete the 12-month follow-up questionnaires. However, our sample was still sociodemographically diverse, which strengthens the external validity of the study. An additional limitation relates to the identified dietary patterns, as no correlations were found between the two patterns and an overlap between the two patterns is therefore probable. When studying a large sample of preschool-aged children in the US, Andersson, Ramsden and Kaye (2016) found no inverse association between two dietary patterns similar to the ones used in our study. In addition, we relied on parents' reports to assess children's food intake. Parent-reported intake can be fairly accurate if parents observe the child's meals (Collins, Watson, & Burrows, 2010). Because most Swedish 5-year-olds are enrolled in preschool where they are served main meals and snack food, this may have limited parents' ability to report food intake accurately, particularly regarding fruit and vegetable intake, which is promoted in Swedish preschools. Moreover, as with all FFQs, the one used in this study is a targeted dietary assessment that only measures frequency and not amounts of a few selected food items; thus, total diet or energy intake cannot be assessed. Still, the short form FFQ can capture the consumption frequency of relevant food items, which is important when studying food patterns (Magarey et al., 2011).

A notable strength of this study is the use of data from both mothers and fathers. The great majority of studies has focused on mothers' feeding practices. Because mothers and fathers can differ in feeding practices (Davison, Haines, Garcia, Douglas, & McBrideet, 2020), as well as in their reporting of children's problematic obesity-related eating behaviors (Sandvik et al., 2019), including fathers increases the study's external validity. This is particularly the case in Sweden, where it is common for parents to share feeding responsibilities. An additional strength is the study's adjustment for sociodemographic factors in modeling associations between children's dietary patterns, eating, feeding, and obesity-related behaviors. It is well established that background factors such as socioeconomic status and parents' weight affect children's risk of developing obesity (Shrewsbury & Wardle, 2008; Svensson et al., 2014; Wang, Min, Khuri, & Li, 2017) and diet quality early in life (Cameron et al., 2015), and a strength of our study is that we adjust for these factors.

5. Conclusion

Twelve months after the start of childhood obesity treatment, children's dietary patterns had stronger associations with children's eating behaviors than with parental feeding practices and parental perceptions of children's problematic obesity-related behaviors. Thus, the results indicate that eating behaviors have a larger impact on children's dietary patterns. Reported intake of items in a less healthy dietary pattern decreased after treatment while no differences were found in the reported intake of items in a healthy dietary pattern. A less healthy dietary pattern was associated with a higher BMI-z score. Additionally, our findings suggest that addressing food fussiness in children with obesity is key to positive dietary changes, as decreasing food fussiness may lead children to develop healthier dietary patterns.

Author contributions

PN conceived the idea of this study in collaboration with MS, AE and PS. SK and HRR drafted the paper under the supervision of PN and together with KE and PS. PS led the revision of the manuscript. All authors made substantial contributions to the study's conception and design, data collection and analyses, and to the interpretation of the data. All authors contributed to reviewing and approving the final manuscript.

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Ethical statement

The study was approved by the Regional Ethical Board in Stockholm (ID: 2011/1329-31/4) on November 16, 2011.

Declaration of competing interest

The authors declare no conflicts of interest.

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Appendix 1

How often does the child eat or drink the food items below? Please, mark one alternative for each item.

	Times per month			Times per week						Times per day			
	1 (or less)	2	3	1	2	3	4	5	6	1	2	3	4 (or more)
Fresh fruit	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Vegetables	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Pizza/ hamburgers	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Fish	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Icecream	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cookies, buns, biscuits	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sugar sweetened drinks	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Fruit juice	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sweets/ chocolates	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Potato chips, snacks, peanuts	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Appendix 2

Principal Component Analysis (PCA) 12 months. Table 1 shows the total explained variance, Fig. 1 shows the scree plot, Table 2 shows the rotated component matrix and Fig. 2 shows the component plot.

Two factors have been obtained based on the raw coding (range 1–13) namely:

- Factor 1 (the less healthy dietary pattern, LHD): pizza/hamburger, ice-cream, cakes/cookies/buns, soft drinks, juice, sweets/chocolate, chips/snacks.
- Factor 2 (the healthy dietary Pattern, HD): fruits, vegetables, fish.

Table 1
Total variance explained, 12 months dietary patterns.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3142	31,423	31,423	3142	31,423	31,423	3142	31,422	31,422
2	1655	16,547	47,970	1655	16,547	47,970	1655	16,549	47,970
3	,999	9987	57,957						
4	,917	9174	67,132						
5	,798	7980	75,112						
6	,730	7296	82,408						
7	,539	5394	87,802						
8	,452	4519	92,321						
9	,395	3951	96,271						
10	,373	3729	100,000						

Extraction Method: Principal Component Analysis.

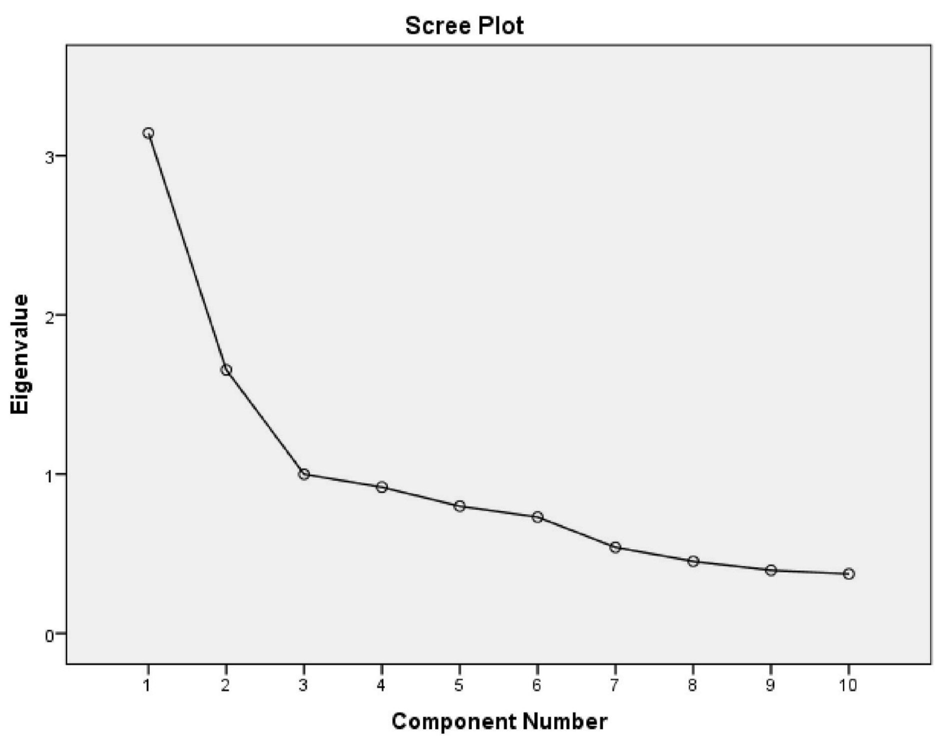

Fig. 1. Scree plot, 12-months dietary pattern

Table 2
Rotated component matrix[a], 12-months

	Component	
	1	2
C_1yr12a_Fruit C_1yr12a_Fruit	-,004	,768
C_1yr12b_Vegetables C_1yr12b_Vegetables	,045	,797
C_1yr12c_Pizza_ham C_1yr12c_Pizza_ham	,523	-,249
C_1yr12d_Fish C_1yr12d_Fish	,011	,579
C_1yr12e_Icecream C_1yr12e_Icecream	,541	,133

(continued on next page)

Table 2 (*continued*)

Component	1	2
C_1yr12f_Cookies_buns C_1yr12f_Cookies_buns	,790	,018
C_1yr12g_Sweet_drink C_1yr12g_Sweet_drink	,807	-,081
C_1yr12h_Juice C_1yr12h_Juice	,522	,027
C_1yr12i_Sweets C_1yr12i_Sweets	,750	,029
C_1yr12j_Snacks C_1yr12j_Snacks	,679	,075

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

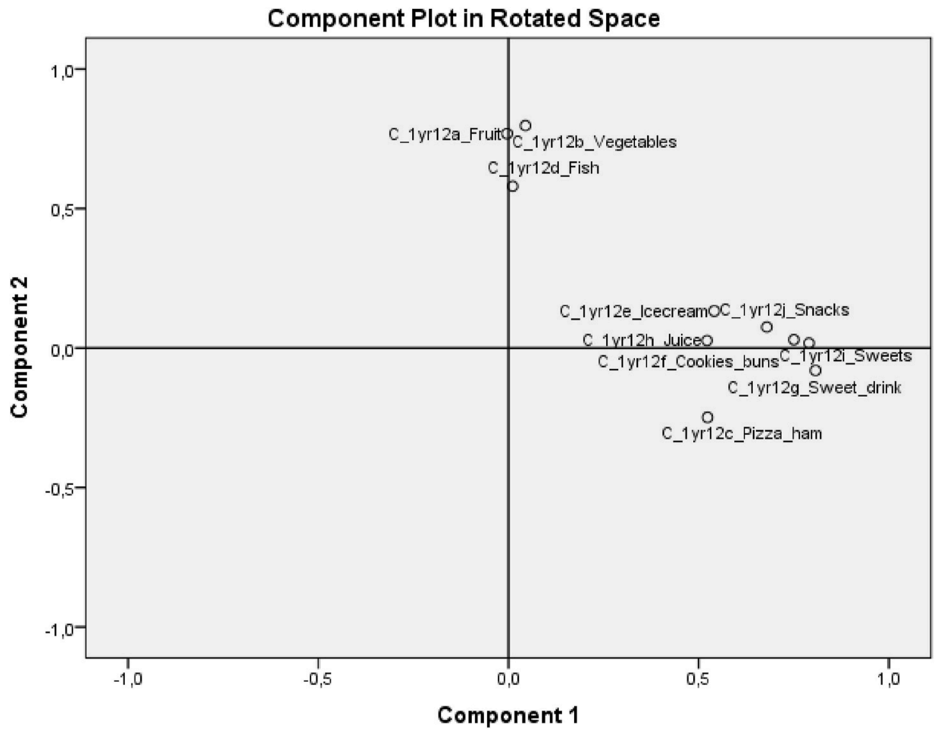

Fig. 2. Component plot in rotated space, 12 months' dietary patterns.

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