How do young children eat after an obesity intervention? Validation of the Child Eating Behaviour Questionnaire using the Rasch Model in diverse samples from Australia and Sweden

Maria Somaraki, A. Ek, P. Sandvik, R. Byrne, P. Nowicka

Appetite 169 (2022) 105822

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

How do young children eat after an obesity intervention? Validation of the Child Eating Behaviour Questionnaire using the Rasch Model in diverse samples from Australia and Sweden

M. Somaraki [a], A. Ek [b], P. Sandvik [a], R. Byrne [c,1], P. Nowicka [a,b,1,*]

[a] Department of Food Studies, Nutrition and Dietetics, Uppsala University, Sweden
[b] Division of Paediatrics, Department of Clinical Science, Intervention and Technology, Karolinska Institutet, Stockholm, Sweden
[c] Centre for Children's Health Research, School of Exercise and Nutrition Sciences, Faculty of Health, Queensland University of Technology, Brisbane, Australia

ARTICLE INFO

Keywords:
Pre-schoolers
Obesity treatment
CEBQ
Eating behaviours
Rasch

ABSTRACT

Child eating behaviours have consistently been linked to child weight status. Yet, changes in child eating behaviours during early obesity treatment are rarely evaluated. Psychometric evaluation of the Child Eating Behaviour Questionnaire (CEBQ) is common, but results are sample-dependent and included items may not capture the full range of the underlying traits. Rasch analysis can overcome these disadvantages. The aim of this paper was to assess child eating behaviours measured by the CEBQ after a 12-month obesity intervention applying the Rasch model for the validation of the CEBQ. The Rasch-based fit statistics were applied in children from two samples, Australian and Swedish ($n = 1724$). Changes in eating behaviours amongst children aged 4–6 years were examined in the More and Less RCT for obesity treatment ($n = 177$), which compared a parenting programme (with and without boosters) against standard treatment. Parents completed the CEBQ at four time points over 12-months. Linear mixed models were applied to estimate treatment effects on the CEBQ, refined according to Rasch, over time. We found that the validity of CEBQ was confirmed after removing 4 items (item fit statistics outside range 0.5–1.5). When the refined CEBQ was used in the assessment of the RCT, there were no differences in parental reports of changes in children's eating behaviours between the parenting programme and standard treatment (group-by-time interactions $p > 0.05$). However, in the total sample food approach behaviours decreased while fussy eating behaviours increased ($p < 0.05$). In conclusion, the refined CEBQ proved to be a valid tool for examining parent-reported child eating behaviours. Early obesity treatment may decrease eating behaviours associated with higher child weight. Future research should address the associations between changes in child weight status and eating behaviours.

1. Background

Modifying child food related behaviours is a necessary component for weight management (Grossman et al., 2017; Llabre et al., 2020). In the context of treatment, it is useful to account for children's appetite that can be described by distinct tendencies defining *how* they eat (Wardle, Guthrie, Sanderson, & Rapoport, 2001). Some children are more susceptible to high availability of food in their environment, and tend to eat more in response to that (Carnell & Wardle, 2007; Syrad, Johnson, Wardle, & Llewellyn, 2016). These tendencies termed *child eating behaviours* have consistently been associated with child weight status (Carnell & Wardle, 2008a; Jansen et al., 2012; McCarthy et al., 2015; Quah et al., 2019; Sleddens, Kremers, & Thijs, 2008; Somaraki et al., 2018; Viana, Sinde, & Saxton, 2008). Thus, eating behaviours may provide the pathway for the genetic risk for obesity to manifest through higher susceptibility to a ubiquitous obesogenic environment (Carnell & Wardle, 2008a; Llewellyn, Trzaskowski, van Jaarsveld, Plomin, & Wardle, 2014; van Jaarsveld, Boniface, Llewellyn, & Wardle, 2014).

1.1. Child eating behaviours and weight status

Eating behaviours among young children are commonly measured by the 35-item Child Eating Behaviour Questionnaire (CEBQ), which defines two distinct dimensions: food approach and food avoidance (de

* Corresponding author. Department of Food Studies, Nutrition and Dietetics, Uppsala University, Sweden.
E-mail address: Paulina.nowicka@ikv.uu.se (P. Nowicka).
[1] Equal contributions as senior authors.

https://doi.org/10.1016/j.appet.2021.105822
Received 6 May 2021; Received in revised form 27 October 2021; Accepted 20 November 2021
Available online 23 November 2021

Lauzon-Guillain et al., 2012). Each dimension comprises four scales representing unique and well-characterised obesity-related eating behaviours, which have been consistently shown using varied methodology, i.e. psychometric instruments and experimental paradigms (Carnell et al., 2016; Carnell & Wardle, 2008b; Jackson et al., 2021; Kral et al., 2018; Rendall, Dodd, & Harvey, 2020). Food approach behaviours describing higher responsiveness to food cues have been associated with higher weight status, while food avoidance behaviours, defined by higher responsiveness to internal hunger and satiety cues have been associated with lower weight status (Carnell & Wardle, 2008a; Jansen et al., 2012; Kininmonth et al., 2021; McCarthy et al., 2015; Quah et al., 2019; Sleddens et al., 2008; Somaraki et al., 2018; Viana et al., 2008). These associations may be explained by higher liking of noncore (palatable, energy dense) foods among children with food approach behaviours, and less pleasure from eating among children exhibiting food avoidance behaviours (Carnell et al., 2016; Fildes et al., 2015).

Although eating behaviours are associated with child weight status with increasing responsiveness to external cues and decreasing responsiveness to internal cues relating to obesity (Carnell & Wardle, 2008a), variation occurs within weight status categories (Croker, Cooke, & Wardle, 2011; Sandvik et al., 2018). In particular, children attending obesity treatment programs display extreme behaviours (combining food approach and food avoidant behaviours) that can present particular challenges for parents (Croker et al., 2011).

1.2. Evaluating obesity treatment amongst pre-schoolers

Few randomized controlled trials (RCTs) have evaluated obesity treatment programmes in the preschool years, despite evidence that early intervention is key for a healthy growth trajectory (Ells et al., 2018; Reinehr, Kleber, Lass, & Toschke, 2010; Stark et al., 2018). In the preschool years, parents lay the foundation for life-long food preferences (Birch & Fisher, 1998). Parents also influence their children's environments through feeding practices, which in turn are shaped by general parental beliefs and attitudes toward child rearing (Yee, Lwin, & Ho, 2017). Treatment programmes may increase parental awareness of the strong genetic components of child eating behaviours, so that parents apply developmentally appropriate feeding, which can help to prevent further weight gain (Golan & Weizman, 2001; Llewellyn & Fildes, 2017; Loveman et al., 2015; Morgan, Schoonees, Sriram, Faure, & Seguin-Fowler, 2020; Yavuz, van Ijzendoorn, Mesman, & van der Veek, 2015). To our knowledge, no earlier study has examined the direct effects of obesity treatment on child eating behaviours in the preschool years.

The More and Less Study (ML study) in Sweden is a RCT with families of pre-schoolers with obesity, that evaluates the effectiveness of a parenting programme, with and without follow-up booster sessions, against standard treatment (Ek et al., 2015). Analysis of the primary outcome changes in child weight status over 12 months follow-up—showed that the parenting programme, in particular the condition enhanced with follow-up (booster) sessions, facilitated a greater reduction in child weight status (Ek et al., 2019). This paper evaluates child eating behaviours over the same 12-month-follow-up (secondary outcomes of the ML Study).

1.3. Use of the Rasch model

In the context of the Swedish ML study, the CEBQ was used to assess child eating behaviours (Ek et al., 2015; Sandvik et al., 2019). The CEBQ has been validated in Sweden using factor analytic methods and reliability statistics (Ek et al., 2016; Svensson et al., 2011). The same classical test theory approach was used in the original development of the tool by Wardle et al. (2001), and by all subsequent validation studies (Behar et al., 2018; Cao et al., 2012; Domoff, Miller, Kaciroti, & Lumeng, 2015; Loh, Moy, Zaharan, & Mohamed, 2013; Mallan et al., 2013; Purwaningrum et al., 2020; Quah et al., 2017; Quah et al., 2019; Sleddens et al., 2008; Sparks & Radnitz, 2012; Viana et al., 2008). While these studies contributed to a better understanding of child eating behaviours and their correlates (Freitas, Albuquerque, Silva, & Oliveira, 2018; Wardle et al., 2001), the validation approach has limitations. Classical test theory is sample-dependant and the validity of measurement depends on patterns of correlations between the items making up the scale (Gordon, 2015). First, it may lead to the inclusion of similar items for assessing a single aspect of a certain behaviour (such as child eating behaviour), but miss assessing the full range of the behaviour ('the underlying trait'). In other words, one aspect of the behaviour may be overemphasized through the inclusion of several highly correlated items (according to classical test theory) while it can be perfectly captured by one item only (Gordon, 2015). Second, any item that does not assess typical behaviour (i.e. average levels of the behaviours in the specific sample) disturbs the pattern of correlations and is discarded (Gordon, 2015). Thus, applying classical test theory in a homogeneous population, which presumably exhibits similar levels of the underlying trait, may introduce significant floor effects (i.e. low scores).

The Rasch model may overcome the limitations associated with highly correlated items that confirm the assumptions of the classical test theory. In particular, the Rasch analysis places all respondents and items on the same measure of the underlying trait (i.e. the measure is independent of the sample population). According to this model, respondents have a higher probability to endorse items, which measure levels of the trait they exhibit. Accordingly, respondents have a low probability to endorse items that measure levels of the trait higher than theirs (Bond & Fox, 2015; Linacre, 2020). Items that are placed on the same level along the measure are redundant (i.e. they assess the same levels of the underlying trait), and they can be eliminated without consequences for the accuracy of assessment. Therefore, the advantages of applying the Rasch model include the reduction of items or response categories on a scale, which can prospectively reduce participant burden and facilitate large studies with multiple assessments (Gordon, 2015). Moreover, use of the model provides information on the degree of the underlying trait that the tool is centred around (Bond & Fox, 2015). To sum up, applying the Rasch model to the well-characterised scales of the CEBQ will provide some useful insights into the instrument facilitating the evaluation of child eating behaviours in the context of the ML study.

2. Aims

The aim of the present paper is twofold. The first objective is to apply the Rasch model for the validation of the CEBQ —the most widely used instrument for assessing child eating behaviours (Study I —Validation of the CEBQ using Rasch). The second objective is to evaluate changes in food approach and food avoidance behaviours in pre-schoolers over 12-month-follow-up in the ML study (Study II —Evaluation of CEBQ changes in the ML study).

3. Methods

3.1. Study I —Validation of the CEBQ using Rasch

3.1.1. Participants and recruitment

The study sample ($N_T = 1724$) consists of mother-child dyads in 1) a Swedish sample (N_s) and 2) an Australian sample (N_A).

1) The **Swedish sample ($N_S = 1336$)** is composed of three sub-samples from two urban areas, Malmö and Stockholm. In Malmö, **876** mothers completed the CEBQ questionnaires through a cross-sectional survey *(population sample)*. In Stockholm, data from two samples were used. First, a sample of 431 parents were recruited via 25 schools/preschools through a cross-sectional survey; from these **353** were mothers and theywere included in the analytical sample *(school sample)*. The second sample consists of baseline reports only from **107** mothers from the ML study *(clinical sample)*. A description

of the ML study (Ek et al., 2015, 2019) and the follow-up assessments, which were not included in Study I, is provided below.

2) The **Australian sample ($N_A = 388$)** consists of first-time mothers participating in the NOURISH RCT (Daniels et al., 2009, 2015; Daniels, Mallan, Nicholson, Battistutta, & Magarey, 2013; Magarey et al., 2016). The mothers were recruited from postnatal wards in two Australian cities, Brisbane and Adelaide, and were allocated to either control condition or intervention condition (focusing on responsive, non-controlling feeding practices). Data included in these analyses were collected when the children were 5 years of age. Both intervention and control conditions are included as the children presented similar changes in their eating behaviours between the ages of 2 and 5 years (no significant time-by-group interaction).

Ethical approval has been obtained for all samples: for the Malmö sample, by the Regional Ethical Board in Lund (approval number 2009/362), and for the Stockholm samples, by the Regional Ethical Board in Stockholm (approval numbers 2011/1329-31/4, 2012/1104-32, 2012/2005–32, 2013/486-32 and 2013/1628-31/2). The Australian sample (NOURISH study) has received approval by the Queensland University of Technology (ID0700000752).

3.1.2. Measurements

The instrument of interest for the present manuscript is the Child Eating Behaviour Questionnaire (CEBQ) comprising the food approach and food avoidance dimensions. These scales are Food Responsiveness (FR), Emotional Overeating (EOE), Enjoyment of Food (EF), and Desire to Drink (DD) clustering around food approach; and Satiety Responsiveness (SR), Slowness in Eating (SE), Emotional Undereating (EUE), and Food Fussiness (FF), clustering around food avoidance (Table 1).

Table 1
The items in the Child Eating Behaviour Questionnaire (CEBQ) according to eight scales describing unique obesity-related eating behaviours (Wardle et al. 2001).

FOOD APPROACH	FOOD AVOIDANCE
Food Responsiveness (FR)	Satiety Responsiveness (SR)
"My child is always asking for food"	"My child has a big appetite", reverse score
"If allowed to, my child would eat too much"	"My child leaves food on his/her plate at the end of a meal"
"Given the choice, my child would eat most of the time"	"My child gets full before his/her meal is finished"
"Even if my child is full up s/he finds room to eat his/her favourite food"	"My child gets full up easily"
"If given the chance, my child would always have food in his/her mouth"	"My child cannot eat a meal if s/he has had a snack just before"
Emotional Overeating (EOE)	Slowness in Eating (SE)
"My child eats more when worried"	"My child finishes his/her meal quickly", reverse score
"My child eats more when annoyed"	"My child eats slowly"
"My child eats more when anxious"	"My child takes more than 30 min to finish a meal"
"My child eats more when s/he has nothing else to do"	"My child eats more and more slowly during the course of a meal"
Enjoyment of Food (EF)	Emotional Undereating (EUE)
"My child loves food"	"My child eats less when angry"
"My child is interested in food"	"My child eats less when s/he is tired"
"My child looks forward to mealtimes"	"My child eats more when she is happy"
"My child enjoys eating"	"My child eats less when upset"
Desire to Drink (DD)	Food Fussiness (FF)
"My child is always asking for a drink"	"My child refuses new foods at first"
"If given the chance, my child would drink continuously throughout the day"	"My child enjoys tasting new foods", reverse score
"If given the chance, my child would always be having a drink"	"My child enjoys a wide variety of foods", reverse score
	"My child is interested in tasting food s/he hasn't tasted before", reverse score
	"My child is difficult to please with meals"
	"My child decides that s/he doesn't like a food, even without tasting it"

All items are measured on a 5-point Likert scale: 1 = "Never", 2 = "Rarely", 3 = "Sometimes", 4 = "Often", 5 = "Always".

For CEBQ, only questionnaires filled out by mothers were included in the analyses, in line with previous research including the development and validation of the CEBQ across the globe, which has overwhelmingly focused on maternal responses as regards child eating and feeding (Davison et al., 2016; Kininmonth, Smith, Llewellyn, & Fildes, 2020; Mallan et al., 2018; Morgan et al., 2017; Wardle et al., 2001). This is also reflected in the Swedish samples where over 80% of responses in relation to child eating behaviours were provided by mothers, while in the Australian sample data were almost exclusively provided by mothers. Questionnaires also included items related to child sex and age, and maternal height, weight, education and country of birth. Child height and weight were parent-reported in the Swedish population and school samples but measured in the Swedish clinical sample. Both child and maternal anthropometric data were measured by research staff in the Australian sample. The extended sex- and age-adjusted IOTF (International Obesity Task Force) criteria were applied to classify child weight status (Cole & Lobstein, 2012).

3.1.3. Statistical procedures

The Rasch model requires that clusters of items assumed to represent a certain behaviour, do indeed relate to one underlying trait only (assumption of unidimensionality). Thus, eight separate Principal Components Analyses (PCA) were performed for each eating behaviour scale in the CEBQ (Wardle et al., 2001). The assumption of unidimensionality was fulfilled for each scale (one single factor was identified each time with eigenvalue >1 and visual inspection of the scree plot). Moreover, the internal consistency reliability of all scales was acceptable (all Cronbach's alphas ≥0.73) (Field, 2009). PCA and reliability procedures were conducted using IBM SPSS Statistics version 24.

The Rasch model determined whether the empirical data conformed to the a priori hypotheses of the Rasch model for measurement validity. Higher measures corresponded to higher levels of the 'underlying trait'. The following diagnostics were examined (Bond & Fox, 2015; Linacre, 2020): 1) Item fit statistics (infit/outfit) to quantify the deviation of empirical data from the Rasch model (i.e. items with values between 0.5 and 1.5 are considered to be "productive of measurement" and are retained; values below/above these margins may imply that responses are too predictable or not predictable at all by the model, which interferes with interval measurement), 2) Person and item separation/reliability indexes to indicate whether the psychometric tool can discriminate between participants with high and low levels of the behaviour that the tool assesses (accuracy in placing participants and items relative to each other along the measure of the underlying trait; low person/item separation index below 2/3), and 3) Point-measure correlations to show how well responses to an item correlate with the levels of the underlying trait in the respondent (positive and noticeable correlations are required). Moreover, the following graphs were visually inspected (Bond & Fox, 2015; Linacre, 2020): 1) Wright maps, which illustrate both the items and participants along the same measure for each eating behaviour, 2) Item Characteristic Curves, which characterise each item and illustrate the probability of a respondent endorsing the item according to their own level of the underlying trait (i.e. increasing probability to endorse the item corresponds to monotonically increasing levels of the underlying trait in the respondent), and 3) Category Probability Curves, which illustrate the probability of respondents picking a certain response category according to their level of the underlying trait (e.g. mothers of children with high Food Responsiveness would have a high probability of picking the highest response category, while mothers of children with low Food Responsiveness would have the lowest probability). Winsteps Rasch Software, version 4.5.3, was used (Linacre, 2020).

Participants' logit measures for each scale (measures of the underlying trait according to the Rasch model) were computed in Winsteps and exported to SPSS. Logit measures were correlated to the mean scores for each scale based on the ordinal responses, which have been consistently used to distinguish between children with higher and lower weight status (Carnell & Wardle, 2008a; Kininmonth et al., 2021; Llewellyn & Fildes, 2017; Wardle et al., 2001). Construct validity was examined by comparing the logit measures and mean scores for each scale between children with and without obesity using independent samples *t*-test. Significance level was set at $p < 0.05$.

Descriptive statistics were applied for the total sample and separately for the Australian and Swedish sample. Differences between the two samples were examined using independent samples *t*-test for continuous variables and chi-squared test for categorical variables. Results are presents as mean (SD) and n (%) for continuous and categorical variables, respectively.

3.2. Study II —Evaluation of CEBQ changes in the ML study

3.2.1. Participants and recruitment

The ML study is an RCT, which evaluates the effectiveness of a parenting programme for obesity treatment among pre-schoolers in Sweden (Ek et al., 2015). Families of 4–6 year-old children with obesity (Cole, Bellizzi, Flegal, & Dietz, 2000; Cole & Lobstein, 2012) were eligible to participate if 1) the child did not have any condition or syndrome that could affect weight and height; 2) the child did not receive any other treatment for obesity; and 3) parents/caregivers had sufficient knowledge of the Swedish language to communicate during group sessions and fill out questionnaires in Swedish.

Families were randomized to one of three distinct treatment conditions:

1) Standard treatment (ST): usual care focused on lifestyle habits, i.e. eating and physical activity, according to the "Action plan for childhood obesity in Stockholm County" (Stockholm County Council, 2016). At least four visits were offered to families spanning 12 months follow-up, though the number of visits and the setup of treatment varied between clinics (Ek et al., 2019). During the first visit, families met with a paediatrician. In follow up visits, families met mainly with a paediatric nurse but also with other health care professionals as required.
2) Parenting programme with booster sessions (PGB): Parents attended 10 weekly sessions, each built around a parenting component along with a lifestyle component (Ek et al., 2015, 2019). After the end of the programme and up to 12 months post-baseline, parents received booster sessions via phone calls (every four to six weeks) emphasizing the content of the program.
3) Parenting programme without booster sessions (PGNB): Parents attended the 10 sessions of the parenting programme only.

3.2.2. Measurements

CEBQ was administered at baseline, 3-, 6-, and 12-months post-baseline. Only one parent filled out the CEBQ, the mother or the father, and all responses were considered. Child height and weight were measured at baseline and 3, 6, and 12 months post-baseline. Child height was measured by trained health care professionals to the nearest 0.1 cm using a fixed stadiometer. Children were weighed to the nearest 0.1 kg wearing underwear. BMI was calculated based on weight and height. Standardized BMI (BMI SDS) was computed according to age- and sex-specific reference data (Cole et al., 2000; Cole & Lobstein, 2012). Parents reported on background information regarding their height and weight, education level (university degree or not) and if they were of foreign (non-Swedish) background (two parents born abroad regardless of own country of birth). Mothers and fathers filled out the background questionnaires separately.

3.2.3. Statistical procedures

Background characteristics were compared across the treatment groups at baseline using one-way ANOVA (for continuous variables) and chi-squared test (for categorical variables). Linear mixed models were used to evaluate the difference in treatment effects changes in child eating behaviours across 12 months follow-up considering the four assessment points. These models included the following variables: time (in months), treatment group (PGB, PGNB and ST), and the treatment group-by-time interaction. The models included random intercept and a random slope for time. No additional procedures were applied to impute missing data. Estimated marginal means were computed based on the linear mixed models at baseline and 3-, 6- and 12-months follow-up.

4. Results

4.1. Study I —Validation of the CEBQ using Rasch

4.1.1. Descriptive characteristics

Table 2 shows characteristics of the 1724 mother-child dyads included. In the Swedish sample, six mothers (5 mothers from the population sample and 1 mother from the school sample) had not provided any data on CEBQ and were excluded. Children were on average 5 years old and 8% of them had obesity. The majority of mothers had a university degree and no migrant background, 64% and 73% respectively. The children in Sweden were slightly younger than the children in Australia (4.7 years old *vs.* 5 years old, $p < 0.001$). Moreover, the children in Australia were less likely to have obesity compared to the children in Sweden (1.3% *vs.* 10.5%, $p < 0.001$).

4.1.2. Validation of the CEBQ using the Rasch model

PCA and reliability statistics confirmed the suitability of all items in the CEBQ for the Rasch analysis (eigenvalues>1 and scree plots indicated the presence of a single factor linking all items in each scale according to Table 1). According to a first round of Rasch analysis, some modifications in the original 35-item CEBQ were made (a description follows) and the Rasch analysis was rerun. The findings shown are based on this second round. Overall, the 5-point response was appropriate to use for all scales, except for EOE where a 3-point response was enough), as illustrated in the Category Probability Curves included in Supplementary material I. Items describing EOE were rescored from original

Table 2
Descriptive characteristics of the total, Swedish and Australian samples.

Background characteristics	N [e]	Total sample (N_T=1724) [c]	Swedish sample (N_S=1336)	Australian sample (N_A=388)	p-value
			CHILD		
Age in years, mean (SD)	1681	4.9 (0.7)	4.7 (0.8)	5.0 (0.05)	*<0.001* [a]
Girl n (%)	1707	857 (50.2)	654 (49.6)	203 (52.3)	*0.36* [b]
Obesity n (%)	1530	126 (8.2)	121 (10.5)	5 (1.3)	*<0.001* [b]
			MOTHER		
Age in years, mean (SD)	1709	36.5 (5.2)	36.5 (5.2)	36.3 (5.1)	*0.44* [a]
Obesity n (%)	1608	168 (10.4)	107 (8.7)	61 (16.1)	*<0.001* [b]
University degree n (%)	1701	1092 (64.2)	825 (62.8)	267 (68.8)	*0.03* [b]
Migrant background [d] n (%)	1705	454 (26.6)	373 (28.3)	81 (21.0)	*0.004* [b]

[a] Independent samples t-test
[b] Chi-squared tests; Fisher's exact test significance level (2-sided)
[c] 6 mothers had not provided data on the CEBQ and they were excluded from the analyses
[d] Migrant background defined as *'born outside of the country/setting each sample was sourced from'* (i.e. born outside Sweden or Australia)
[e] The numbers vary due to missing data

response structure (upper categories 3, 4 and 5 could not discriminate between children of different levels of emotional overeating and floor effects were observed). Thus, categories 3, 4 and 5 were merged into one category.

Tables 3 and 4 provide the Rasch diagnostics for food approach and food avoidance behaviours respectively. Measures of eating behaviours are shown for each item in descending order. For example, in Table 3, the FR item *'If given the chance, my child would always have food in his/her mouth'* indicates the highest levels of the behaviour (i.e. mothers of highly food responsive children are more likely to endorse this item compared to mothers of less responsive children). By contrast, the FR item *'Even if my child is full up s/he finds room to eat his/her favourite food'* corresponds to the lowest levels of the behaviour (i.e. mothers of less and more food responsive children can relate to it). These findings are also illustrated in the Item Characteristic Curves, in Supplementary material I.

Among food avoidance behaviours, several items were shown to be redundant in discriminating between SR and FF levels (Supplementary material I, Wright maps). The two items *'My child gets full up easily'* and *'My child gets full before his/her meal is finished'* were equivalent with respect to describing SR. The latter was retained because it describes a specific situation that parents can visualize when filling out the questionnaire. Similarly, the four items describing food neophobia were found to be equivalent to each other in describing the Food Fussiness scale (i.e. *'My child refuses new foods at first'*, *'My child is interested in tasting foods s/he hasn't tasted before'*(reversed), *'My child decides that s/he doesn't like a food, even without tasting it'*, and *'My child enjoys tasting new foods'* (reversed)). The latter item was retained because of the positive wording and the short and straightforward statement describing the situation.

As a result of applying the Rasch model, four items from the original 35-item questionnaire were not retained for the evaluation of the ML study (Study II), and a modified 31-item CEBQ was supported.

The analyses with the new 31-item version found that mothers of children with obesity reported higher mean scores on food approach (Table 3) and lower food avoidance behaviours (Table 4) compared to mothers of children without obesity ($p < 0.001$). The findings held when logit measures were compared across child weight status ($p < 0.001$). In addition, both food approach and food avoidance behaviours were assigned an interval score according to the Rasch model measurement, which showed an almost perfect positive correlation ($r \geq 0.97$) with the ordinal scores based on the crude mean score (Tables 3 and 4).

4.2. Study II —Evaluation of CEBQ changes in the ML study

4.2.1. Descriptive characteristics

Table 5 shows background characteristics of the clinical sample with CEBQ data at baseline. Three children were diagnosed with conditions that affect physical development during the study and were excluded from the analyses. Children were on average 5 years old, BMI SDS was 2.9 and 52.2% were girls. Among mothers and fathers, 59% and 57% respectively, had a foreign background while about 40% of both parents had a university degree.

4.2.2. Evaluation of changes in child eating behaviours during obesity treatment using the modified 31-item CEBQ

Group-by-time interactions were not significant showing that parents randomized to either parenting programme (PGB or PGNB) did not report that their child's food approach (Fig. 1) or food avoidance (Fig. 2) behaviours changed more compared to parents in standard treatment (Supplementary material II). An exception was found for Satiety Responsiveness whereby parents in PGNB reported a greater increase (by 0.021, 95% CI 0.0009 to 0.041, on a 5-point scale) in their children's SR compared to parents in ST.

Significant time effects indicated similar trends in changes in child eating behaviours across treatment groups. While parents in general

Table 3
Item difficulty, item fit statistics, and validity testing of all food approach items clustering under four eating behaviours.

ITEM #	ITEM DESCRIPTION	DIFFICULTY [h] (ERROR)	ITEM FIT STATISTICS [g]	Validity testing Crude mean score (SD) [f]	
		Measure [c] (Model S.E)	Infit/Outfit Mean Square	No obesity	Obesity
Food Responsiveness [a] *r=0.97* [e]				1.87 (0.65)	2.96 (0.98)
34	If given the chance, my child would always have food in his/her mouth	1.27 (0.05)	0.89/0.76		
14	If allowed to, my child would eat too much	0.61 (0.04)	1.05/0.90		
19	Given the choice, my child would eat most of the time	0.28 (0.04)	0.95/0.89		
12	My child is always asking for food	-0.59 (0.04)	0.86/0.92		
28	Even if my child is full up s/he finds room to eat his/her favourite food	-1.57 (0.03)	1.32/1.35		
Emotional Overeating [b] *r=0.99* [e]				1.48 (0.48)	1.86 (0.64)
2	My child eats more when worried	1.04 (0.07)	0.97/1.00		
15	My child eats more when anxious	0.88 (0.07)	0.68/0.63		
13	My child eats more when annoyed	0.35 (0.06)	0.79/0.86		
27	My child eats more when s/he has nothing to do	-2.27 (0.06)	1.49/1.57 [d]		
Enjoyment of Food [a] *r=0.998* [e]				3.45 (0.72)	4.10 (0.68)
20	My child looks forward to mealtimes	0.89 (0.05)	1.13/1.13		
5	My child is interested in food	0.48 (0.05)	1.02/0.99		
1	My child loves food	-0.61 (0.05)	0.95/0.94		
22	My child enjoys eating	-0.76 (0.05)	0.82/0.79		
Desire to Drink [a] *r=0.99* [e]				2.23 (0.90)	2.63 (0.99)
31	If given the chance, my child would always be having a drink	1.51 (0.05)	0.83/0.73		
29	If given the chance, my child would drink continuously throughout the day	0.67 (0.05)	1.04/0.93		
6	My child is always asking for a drink	-2.17 (0.05)	1.09/1.28		

Person Separation/Reliability ranged between *0.88-2.25/0.44-0.83* (lowest values for EOE and highest for EF); relatively low (separation/reliability below 2/0.8) but there is still a capacity to discriminate between people endorsing at

least lower and higher levels of the behavior. Addition of a wider range of expressions/items of the respective behavior would be useful (Linacre, 2020).
Item Separation/Reliability ranged between *12.79-31.28/0.99-1.00* (lowest values for EF and highest for DD).
Point-measure correlations were acceptable (lowest was 0.71 for FR).
[a] Response categories (5): 1 'Never'; 2 'Rarely'; 3 'Sometimes'; 4 'Often'; 5 'Always'.
[b] Response categories (3): 1 'Never'; 2 'Rarely'; 3 'Sometimes/Often/Always'.
[c] A logit of 0 indicates a moderate amount of the latent trait.
[d] Outfit statistic is 1.57 (>1.5 according to the rule of thumb). Due to the small deviation and the relevance of the respective item (*"My child eats more when s/he has nothing to do"*), which points to eating out of boredom, and it is a relevant aspect of emotional overeating (Braden, Musher-Eizenman, Watford, & Emley, 2018; Havermans, Vancleef, Kalamatianos, & Nederkoorn, 2015; Koball, Meers, Storfer-Isser, Domoff, & Musher-Eizenman, 2012).
[e] Correlation coefficient describing the association between logit measures computed through Rasch model and the mean scores of ordinal responses by mothers (p-value<0.001).
[f] Crude mean scores (ordinal responses) were compared across child weight status (children with obesity and children without obesity) through independent samples t-tests (p-values<0.001).
[g] Values in the range 0.5-1.5 are *'productive of measurement'*, i.e. not too predictable and not too unpredictable patterns of measurement (Linacre, 2020).
[h] Difficulty of an item is defined by the measure of eating behaviour (in logits) whereby a higher measure, as reported by mothers, represents more frequent display of the behaviour by the child.

reported decreasing levels of child Food Responsiveness ($p = 0.057$) and Desire to Drink ($p = 0.027$), they reported increasing levels of Food Fussiness ($p = 0.047$).

5. Discussion

In the present paper, the Rasch model was applied to the original 35-item CEBQ and confirmed the validity of a 31-item version of this questionnaire as a parent-reported measure for child food approach and food avoidance behaviours. Changes in eating behaviours among preschoolers were assessed using the 31-item CEBQ during the 12-month follow-up period of the ML Study. The parenting programme was equally effective in improving food approach/food avoidance behaviours among children as compared to standard treatment —even though the parenting programme has been more effective in reducing weight status (Ek et al., 2019). Overall, obesity treatment (the parenting programme and standard treatment) had favourable effects on eating behaviours which promote a healthy weight status (decreased food approach and increased food avoidance behaviours).

The results from the validation of the questionnaire with an alternate method, Rasch, offers additional support to previous research. It confirms that the CEBQ assesses eight distinct eating behaviours, which can discriminate between children with higher and lower weight status (de Lauzon-Guillain et al., 2012; Ek et al., 2016). Moreover, it provides new insights into the CEBQ at the item level.

The item *'My child cannot eat a meal if s/he has had a snack just before'* ('snacking item') was found to indicate above average levels of child responsiveness to satiety cues, and was therefore a relevant aspect of Satiety Responsiveness. By contrast, in a factorial validation study of the CEBQ in Sweden, this item was dropped because it loaded weakly on the SR scale (Ek et al., 2016). This discrepancy may be due to floor effects in the study by Ek et al. (2016), whereby fewer parents of pre-schoolers endorsed the 'snacking item' (i.e. it was not common behaviour in the sample). Notably, a concrete definition for snacking is not provided in the CEBQ, and parents may find it challenging to define (Blaine, Kachurak, Davison, Klabunde, & Fisher, 2017). Yet, the 'snacking item' may be an important element of SR, which distinguishes between the different processes that bring any eating occasion to an end and those that prevent further eating, as defined by Blundell et al. (2010). In particular, the 'snacking item' may represent *inhibition of further eating/inter-meal satiety,* while the remaining items of the SR scale (e.g.

Table 4
Item difficulty, item fit statistics, and validity testing of included Food Avoidance items clustering under four eating behaviours.

ITEM #	ITEM DESCRIPTION	DIFFICULTY [f] (ERROR)	ITEM FIT STATISTICS [e]	Validity testing Crude mean score (SD) [d]	
		Measure [b] (Model S.E)	Infit/Outfit Mean Square	No obesity	Obesity
Satiety Responsiveness [a] *r=0.998* [c]				3.05 (0.59)	2.43 (0.70)
30	My child cannot eat a meal if s/he has had a snack just before	1.0 (0.04)	1.30/1.31		
3	My child has a big appetite *(reverse coding)*	0.13 (0.04)	1.02/1.02		
21	My child gets full before his/her meal is finished	-0.49 (0.04)	0.84/0.85		
17	My child leaves food on his/her plate at the end of a meal	-0.64 (0.04)	0.80/0.81		
Slowness in Eating [a] *r=0.99* [c]				2.99 (0.80)	2.25 (0.85)
18	My child takes more than 30 minutes to finish a meal	1.19 (0.04)	0.99/1.00		
35	My child eats more and more slowly during the course of a meal	1.02 (0.04)	1.33/1.36		
8	My child eats slowly	-0.89 (0.04)	0.69/0.70		
4	My child finishes his/her meal quickly *(reverse coding)*	-1.32 (0.04)	0.93/0.94		
Emotional Undereating [a] *r=0.99* [c]				2.89 (0.87)	2.52 (0.78)
25	My child eats less when upset	0.75 (0.03)	0.76/0.74		
9	My child eats less when angry	0.44 (0.03)	0.92/0.92		
23	My child eats more when she is happy	0.03 (0.03)	1.06/1.11		
11	My child eats less when s/he is tired	-1.23 (0.04)	1.14/1.15		
Food Fussiness [a] *r=0.998* [c]				2.71 (0.81)	2.36 (0.75)
24	My child is difficult to please with meals	0.98 (0.04)	1.11/1.12		
16	My child enjoys a wide variety of foods *(reverse coding)*	-0.01 (0.04)	0.98/0.98		
10	My child enjoys tasting new foods *(reverse coding)*	-0.97 (0.04)	0.87/0.87		

Person Separation/Reliability ranged between *1.32-1.72/0.63-0.75* (lowest values for SR and highest for SE); relatively low (separation/reliability below 2/0.8) but there is still a capacity to discriminate between people endorsing at least lower and higher levels of the behavior. Addition of a wider range of expressions/items of the respective behavior would be useful (Linacre, 2020).
Item Separation/Reliability ranged between 16.31-28.72/1.00-1.00 (lowest

values for SR and highest for SE).
Point-measure correlations were acceptable (lowest was 0.65 for SR)
[a] Response categories (5): 1 'Never'; 2 'Rarely'; 3 'Sometimes'; 4 'Often'; 5 'Always'
[b] A logit of 0 indicates a moderate amount of the latent trait
[c] Correlation coefficient describing the association between logit measures computed through Rasch model and the mean scores of ordinal responses by mothers (p-value<0.001).
[d] Crude mean scores (ordinal responses) were compared across child weight status (children with obesity and children without obesity) through independent samples t-tests (p-values<0.001).
[e] Values in the range 0.5-1.5 are *'productive of measurement'* i.e. not too predictable and not too unpredictable patterns of measurement (Linacre, 2020).
[f] Difficulty of an item is defined by the measure of eating behaviour (in logits) whereby a higher measure, as reported by mothers, represents more frequent display of the behaviour by the child.

Table 5
Descriptive characteristics of the clinical sample (total and across treatment conditions).

Background characteristics	N [e]	Total sample (N=134) [c]	PGB (N=31)	PGNB (N=36)	ST (N=67)	p-value [a,b]
			CHILD			
Age in years, mean (SD) [a]	134	5.3 (0.7)	5.2 (0.8)	5.2 (0.8)	5.3 (0.7)	*0.93*
Girl n (%) [b]	134	70 (52.2)	9 (29.0)	18 (50.0)	43 (64.2)	*<0.05*
BMI SDS, mean (SD) [a]	134	2.9 (0.6)	2.9 (0.6)	3.1 (0.7)	2.9 (0.6)	*0.13*
			MOTHER			
Age in years, mean (SD) [a]	130	36.6 (5.6)	38.1 (5.1)	36.1 (5.4)	36.1 (5.8)	*0.22*
Obesity n (%) [b]	129	42 (32.6)	10 (33.3)	13 (38.2)	19 (29.2)	*0.89*
University degree n (%) [b]	130	56 (43.1)	14 (45.2)	15 (44.1)	27 (41.5)	*0.94*
Foreign background n (%) [b]	131	78 (59.5)	20 (64.5)	20 (57.1)	38 (58.5)	*0.80*
			FATHER			
Age in years, mean (SD) [a]	117	39.9 (7.2)	43.1 (7.9)	38.7 (7.4)	39.0 (6.5)	*0.03*
Obesity n (%) [b]	117	46 (39.3)	9 (31.0)	13 (43.3)	24 (41.4)	*0.68*
University degree n (%) [b]	119	47 (39.5)	11 (39.3)	12 (38.7)	24 (40.0)	*0.99*
Foreign background [d] **n (%)** [b]	121	69 (57.0)	15 (51.7)	21 (65.6)	33 (55.0)	*0.50*

Abbreviations: PGB: Parenting program with boosters, PGNB: Parenting program without boosters, ST: Standard Treatment
[a] Independent samples t-test
[b] Chi-squared tests
[c] Out of 177 enrolled families, 42 families did not have data on CEBQ at baseline and 3 children were excluded due to receiving a diagnosis that affects their physical development.
[d] Foreign background: *'two parents born abroad regardless of own country of birth'*
[e] The numbers may vary due to missing data

'My child leaves food on his/her plate at the end of a meal') may describe the *termination of eating/intra-meal satiety* (Blundell et al., 2010). The items representing Food Fussiness suggest that both picky eating (e.g. *'My child is difficult to please with meals'*) and food neophobia (e.g. *'My child enjoys tasting new foods'* reversed scoring) are important aspects of the behaviour (Wardle et al., 2001). Interestingly, the four items for food neophobia (out of a total of six for FF) represented equivalent levels of the underlying trait, and, thus, only one of those was retained. While the definition for picky eating serves as an umbrella term to define rejection of both familiar and unfamiliar foods, food neophobia is specific to rejecting new (unfamiliar) foods (Brown, Vander Schaaf, Cohen, Irby, & Skelton, 2016; Taylor, Wernimont, Northstone, & Emmett, 2015). Notably, half of the parents in the Australian/Swedish sample were likely to endorse the 'neophobia item' (above average levels), which corresponds to earlier prevalence estimates for this (typical) child eating behaviour (Brown et al., 2016). However, overall rejection of foods (not enjoying meals and in particular a wide variety of foods) indicated higher levels of FF, and fewer parents endorsed the corresponding items. Future studies may need to explicitly distinguish between food neophobia and general food rejection, or at least maternal concerns in relation to food rejection.

In summary, the existing items of the widely used CEBQ hold relevance to assessing the eight subscales mapping onto the food approach and the food avoidance dimensions. However, certain items were superfluous, i.e. they assessed the same level of a certain underlying trait, overestimating this level's contribution to the assessment, without providing a holistic assessment along the continuum of the underlying trait (items tied to lower all the way up to higher levels of the behaviours). Based on these findings and an informed understanding of what type of behaviours the CEBQ assesses, we proceeded to the evaluation of child eating behaviours in the ML study.

Our evaluation of eating behaviours over 12 months follow-up in the ML study, are in contrast with Cohen, Hazell, Vanstone, Rodd, and Weiler (2018) who indeed demonstrated favourable effects on food approach behaviours (but not food avoidance behaviours) at 1-year post-baseline of family-based treatment. However, children in that study were older (mean age close to 8 years) and the control condition did not participate in any structured treatment regime until after the 1-year follow-up. On the contrary, all families in our sample received treatment, but of different set-up. Nevertheless, in our study child SR increased in the parenting programme without boosters. The SR scale comprises of items that capture not finishing/eating a meal and having a small appetite (Wardle et al., 2001). While these are measures of satiety, they may also depend on parental concerns around child eating (Jansen, Mallan, Nicholson, & Daniels, 2014). Parents, who have attended the parenting programme, but did not receive the boosters, might have increased their awareness around healthy eating without getting continuous support. Because fussy eating increased overall in our clinical sample, parents who did not receive boosters may have interpreted fussy eating behaviours as a sign of inadequate nutrition (Taylor et al., 2015). Nevertheless, Steinsbekk and Wichstrøm (2015) found that parental reports on SR did not influence child weight status between 6 and 8 years old. Thus, favourable effects on a single aspect of eating behaviour may not adequately explain child weight loss in preschool years, evident from the non-significant weight loss in the parent group without boosters.

The overall lack of differential changes across treatment groups should be discussed considering greater weight loss among children in the parenting programme with booster sessions (Ek et al., 2019). Recent cohorts from different settings have provided evidence that child weight status among young children (ages 4 to 7) prospectively relates to eating behaviours (Costa, Severo, Vilela, Fildes, & Oliveira, 2020; Derks et al., 2018; Steinsbekk, Llewellyn, Fildes, & Wichstrøm, 2017). In our sample, we could not confirm a mechanism of change in child eating behaviours in parallel with the clinically significant reduction in child weight status among children in the parenting programme with boosters (Ek et al., 2019). By contrast, our clinical sample benefited by treatment (parenting programme and standard treatment) and decreased aspects of food approach behaviours, which relate to a high weight status. Taken together, these findings indicate that treatment and support by health professionals, may promote less obesogenic behavioural profiles in the long term. Future research should examine the long-term effects of child

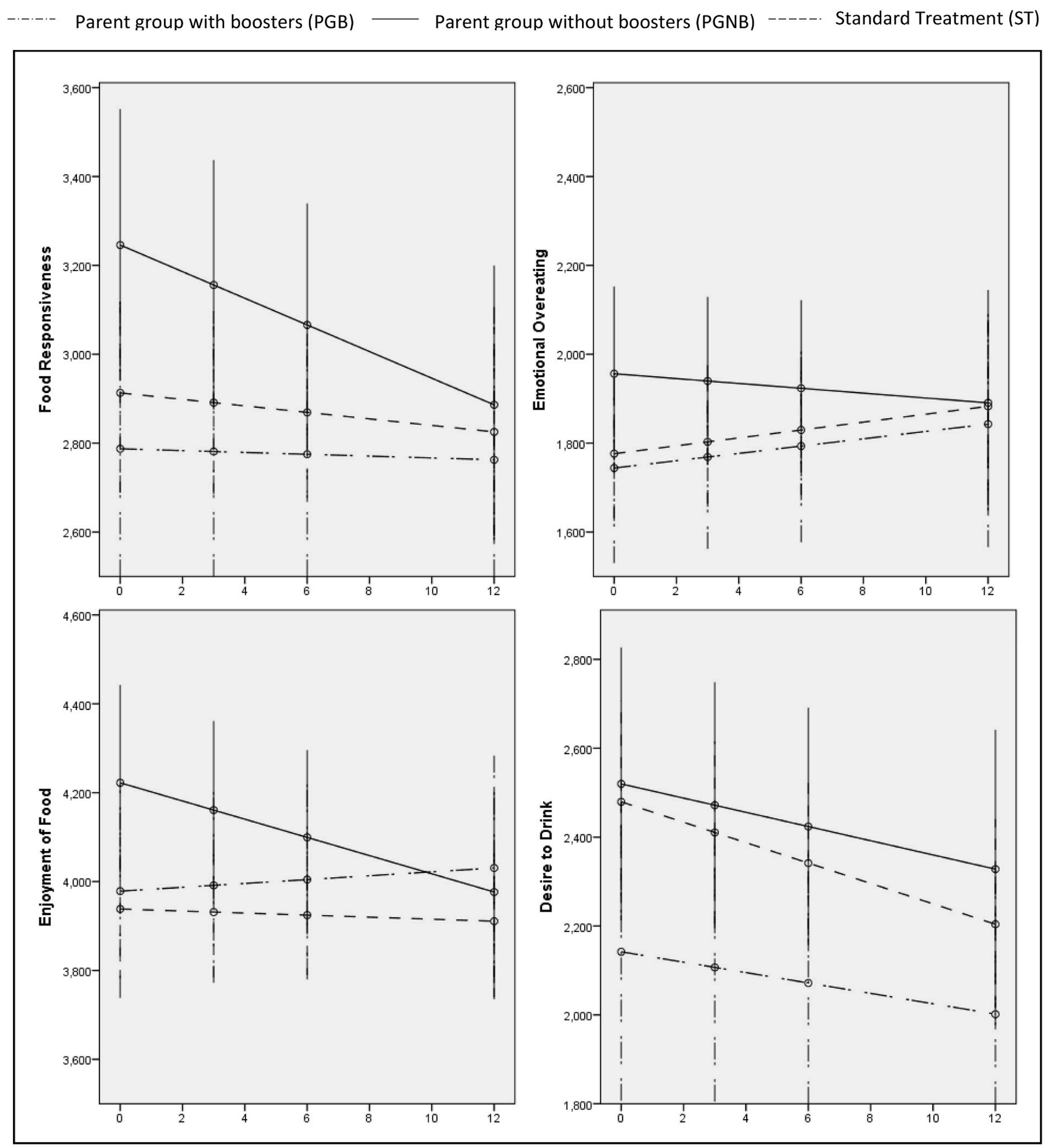

Fig. 1. Changes in food approach behaviours over the 1-year follow-up time. Graphs are based on Estimated Marginal Means holding time fixed at baseline, 3, 6 and 12 months (1 year).
FR: Group effect ($p = 0.105$), Time effect **($p = 0.057$)**, Group-by-Time ($p = 0.233$).
EOE: Group effect ($p = 0.258$), Time effect ($p = 0.451$), Group-by-Time ($p = 0.438$).
EF: Group effect ($p = 0.115$), Time effect ($p = 0.261$), Group-by-Time ($p = 0.191$).
DD: Group effect ($p = 0.189$), Time effect **($p = 0.025$)**, Group-by-Time ($p = 0.801$).

weight loss due to treatment on eating behaviours and potential hormonal mediators.

In our sample, children decreased their responsiveness to food and beverage cues and increased perceived fussy eating. These trajectories may favour early obesity treatment regardless of the approach by reversing/stabilising expected trajectories of increasing food and beverage consumption (Ashcroft, Semmler, Carnell, van Jaarsveld, & Wardle, 2008). On the contrary, increasing fussy eating behaviours may reflect developmental trajectories in this clinical sample of pre-schoolers (Taylor et al., 2015), though a similar trajectory was not identified during 12 months follow-up of the ML study when all 4 items for food neophobia in the original CEBQ were examined (Sandvik et al., 2019). Alternatively, families facing particular challenges around child eating, including fussy eating, may be more likely to seek treatment (Croker et al., 2011). More tailored advice regarding fussy eating may be relevant in the context of obesity treatment (Fernandez et al., 2020).

5.1. *Strengths and limitations*

The Rasch model has not been used previously to validate the CEBQ

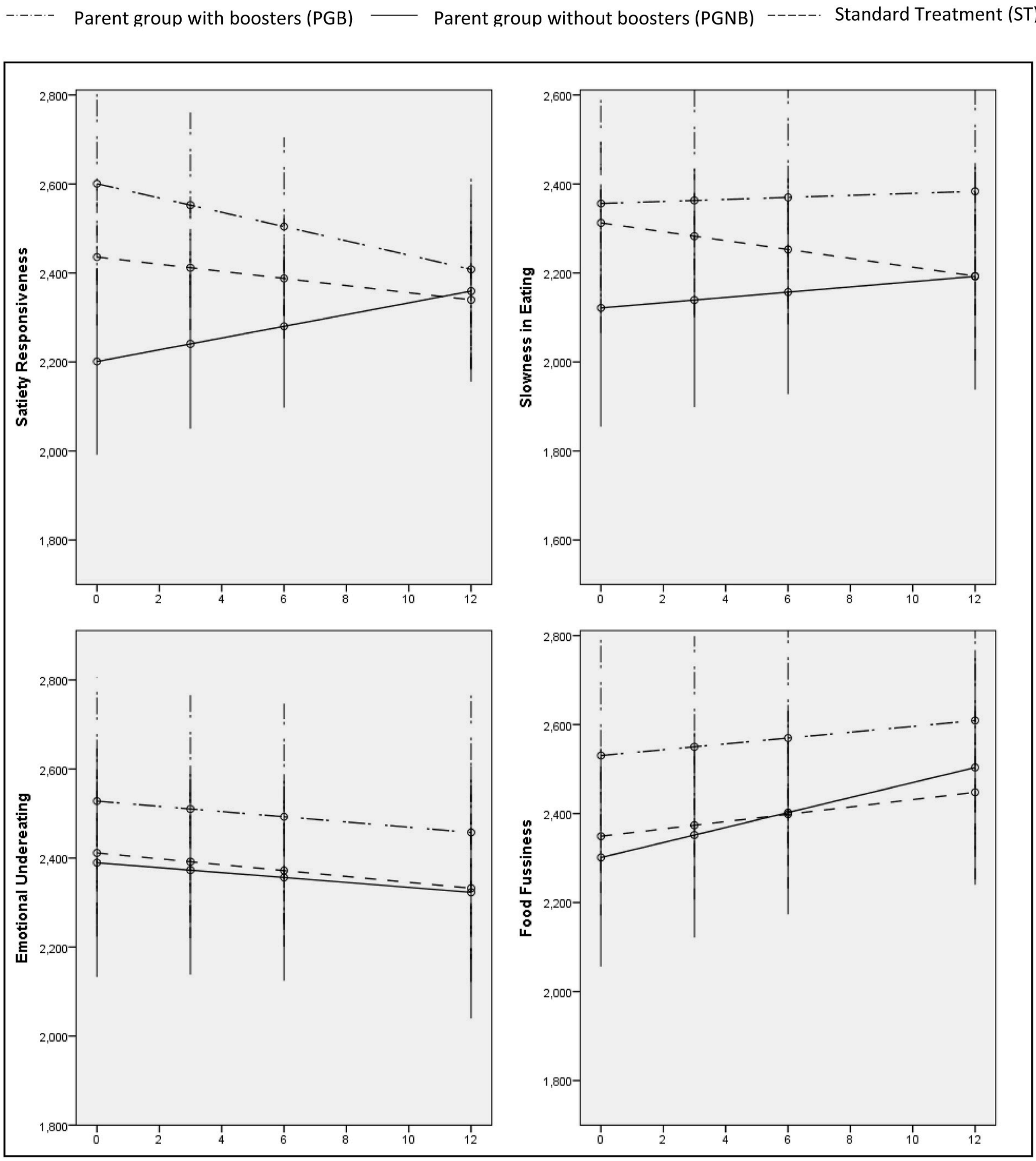

Fig. 2. Changes in food avoidance behaviours over the 1-year follow-up time. Graphs are based on Estimated Marginal Means holding time fixed at baseline, 3, 6 and 12 months (1 year).
SR: Group effect **($p = 0.038$)**, Time effect ($p = 0.424$), Group-by-Time **($p = 0.039$)**.
SE: Group effect ($p = 0.421$), Time effect ($p = 0.919$), Group-by-Time ($p = 0.427$).
EUE: Group effect ($p = 0.735$), Time effect ($p = 0.351$), Group-by-Time ($p = 0.997$).
FF: Group effect ($p = 0.412$), Time effect **($p = 0.047$)**, Group-by-Time ($p = 0.707$).

and this analysis provides a greater understanding of the items describing child eating behaviours. A particular strength was that the validation was performed in a merged sample from Australia and Sweden enhancing the range of the underlying traits being analyzed. In NOURISH the intervention group had presented favourable eating behaviours, but it followed similar trajectories as the control group in the time period spanning the end of intervention delivery and 3.5 years follow-up (Daniels et al., 2014; Magarey et al., 2016). Thus, we included both intervention and control of the NOURISH study at 5 years follow-up to further strengthen the sample and increase the range of responses.

Our findings should be interpreted considering some limitations. In Study I, the person separation/reliability indexes were relatively low, which shows the need for the development of new items in order to accurately assess the full range of each eating behaviour trait. However, our findings indicate that the items discarded did not necessarily offer additional information on the behaviour since they overlapped with other items. The addition of more items, which do not overlap with existing ones, may also prospectively facilitate the careful examination of the behaviours in the clinical setting and/or tailored groups in the population across countries. This can be further supported considering the presence of differential item functioning (DIF) across relevant groups in order to ensure measurement invariance, e.g. child sex/age or parent education/gender (Cheng, Chen, & Shih, 2020; Garratt, Coste, Rouquette, & Valderas, 2021). In Study II, the sample size computations were based on the primary outcome (changes in child weight status) (Ek et al., 2015). Thus, the present paper may have a limited capacity to identify differential effects on child eating behaviours across treatment groups. Moreover, 42 questionnaires on child eating behaviours were missing at baseline. However, we applied linear mixed models, which handles missing data well. Background characteristics of included families did not differ from those with missing data.

6. Conclusion

A modified 31-version of the CEBQ is a valid parent-reported tool for the assessment of eating behaviours among pre-schoolers, though future studies could consider what additional items are needed to adequately assess the full range of the underlying eating behaviour traits. Moreover, we provided evidence that early obesity treatment may support a decrease in food approach behaviours, which relate to a high weight status. Further research should investigate how changes in child weight status in response to treatment involving parents may influence child eating behaviours through middle childhood.

Authors' contributions

MS planned the study in collaboration with co-authors, participated in data entry, retrieved and processed questionnaire data, had the main responsibility for the statistical analyses and main responsibility for writing and revising the manuscript. AE and PS made a substantial contribution to the study design, data analysis, interpretation of findings, manuscript writing and critical revision of the manuscript. RB and PN conceptualized the study, coordinated and supervised the data collection and analysis, interpretation of findings, manuscript writing and critical revision of the manuscript.

Funding

The More and Less Study was funded by the Swedish Research Council (2014-02404), Karolinska Institutet Doctoral Funds, the Swedish Society of Medicine, VINNOVA (2011-03443), Jerring Foundation, Samariten Foundation, Magnus Bergvall Foundation, Ingrid and Fredrik Thuring Foundation, Helge Ax:son Foundation, Crown Princess Lovisa Foundation, Foundation Frimurare Barnhuset in Stockholm, Foundation Pediatric Care, Foundation Martin Rind, Jane and Dan Olsson Foundation, Sigurd and Elsa Golje Memory Foundation, and iShizu Matsumurais Donation. MS received funding from the Swedish Society for Medical Research and from the SYLFF (The Ryoichi Sasakawa Young Leaders Fellowship Fund). NOURISH was funded from 2008 through 2014 by 2 consecutive grants from the Australian National Health and Medical Research Council (426704, APP1021065). Additional funding was provided by Department of Health South Australia, Food Standards Australia New Zealand, Meat & Livestock Australia and Queensland University of Technology.

Ethical statement

Ethical approval has been obtained for all samples: for the Malmö sample, by the Regional Ethical Board in Lund (approval number 2009/362), and for the Stockholm samples, by the Regional Ethical Board in Stockholm (approval numbers 2011/1329-31/4, 2012/1104-32, 2012/2005–32, 2013/486-32 and 2013/1628-31/2). The Australian sample (NOURISH study) has received approval by the Queensland University of Technology (ID0700000752).

Acknowledgements

We thank all families participating to the ML study, child health care and school nurses, and all personnel involved in the standard treatment offered in the pediatric outpatient clinics. We also thank Kathryn Lewis Chamberlain, Lena Frenzel, Ola Eklund, Jan Ejderhamn, Marie Johannesson, Nilüfer Kayihan Kuru, Sofia Ljung, Mahnoush Etminan Malek, Jonna Nyman, Karin Nordin, JP Davis, Philip A. Fisher, Marion Forgatch, Claude Marcus, Stanley Ulijaszek and Patricia Chamberlain who were involved in design or in data collection in the ML study. We acknowledge the contribution of Professor Emeritus Lynne Daniels and the NOURISH research team and thank NOURISH participants who gave so generously of their time.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2021.105822.

References

Ashcroft, J., Semmler, C., Carnell, S., van Jaarsveld, C. H., & Wardle, J. (2008). Continuity and stability of eating behaviour traits in children. *European Journal of Clinical Nutrition, 62*(8), 985–990. https://doi.org/10.1038/sj.ejcn.1602855

Behar, A. I., Crespo, N. C., Garcia, M. L., Ayala, G. X., Campbell, N., Shadron, L. M., et al. (2018). Validation of a shortened version of the children's eating behavior questionnaire and associations with BMI in a clinical sample of latino children. *Journal of Nutrition Education and Behavior, 50*(4), 372–378. https://doi.org/10.1016/j.jneb.2017.08.013. e371.

Birch, L. L., & Fisher, J. O. (1998). Development of eating behaviors among children and adolescents. *Pediatrics, 101*(3 Pt 2), 539–549.

Blaine, R. E., Kachurak, A., Davison, K. K., Klabunde, R., & Fisher, J. O. (2017). Food parenting and child snacking: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 14*(1). https://doi.org/10.1186/s12966-017-0593-9, 146-123.

Blundell, J. E., Graaf, d. C., Hulshof, T., Jebb, S. A., Livingstone, B., Lluch, A., et al. (2010). Appetite control: Methodological aspects of the evaluation of foods. *Obesity Reviews, 11*(3), 251–270.

Bond, T. G., & Fox, C. M. (2015). *Applying the Rasch model: Fundamental measurement in the human sciences* (3rd ed.). New York;London: Routledge, Taylor and Francis Group.

Braden, A., Musher-Eizenman, D., Watford, T., & Emley, E. (2018). Eating when depressed, anxious, bored, or happy: Are emotional eating types associated with unique psychological and physical health correlates? *Appetite, 125*, 410–417. https://doi.org/10.1016/j.appet.2018.02.022

Brown, C. L., Vander Schaaf, E. B., Cohen, G. M., Irby, M. B., & Skelton, J. A. (2016). Association of picky eating and food neophobia with weight: A systematic review. *Childhood Obesity, 12*(4), 247–262. https://doi.org/10.1089/chi.2015.0189

Cao, Y. T., Svensson, V., Marcus, C., Zhang, J., Zhang, J. D., & Sobko, T. (2012). Eating behaviour patterns in Chinese children aged 12-18 months and association with relative weight–factorial validation of the Children's Eating Behaviour Questionnaire. *International Journal of Behavioral Nutrition and Physical Activity, 9*, 5. https://doi.org/10.1186/1479-5868-9-5

Carnell, S., Pryor, K., Mais, L. A., Warkentin, S., Benson, L., & Cheng, R. (2016). Lunch-time food choices in preschoolers: Relationships between absolute and relative intakes of different food categories, and appetitive characteristics and weight. *Physiology & Behavior, 162*, 151–160. https://doi.org/10.1016/j.physbeh.2016.03.028

Carnell, S., & Wardle, J. (2007). Measuring behavioural susceptibility to obesity: Validation of the child eating behaviour questionnaire. *Appetite, 48*(1), 104–113. https://doi.org/10.1016/j.appet.2006.07.075

Carnell, S., & Wardle, J. (2008a). Appetite and adiposity in children: Evidence for a behavioral susceptibility theory of obesity. *American Journal of Clinical Nutrition, 88*(1), 22–29.

Carnell, S., & Wardle, J. (2008b). Appetitive traits and child obesity: Measurement, origins and implications for intervention. *Proceedings of the Nutrition Society, 67*(4), 343–355. https://doi.org/10.1017/s0029665108008641

Cheng, C. P., Chen, C. C., & Shih, C. L. (2020). An exploratory strategy to identify and define sources of differential item functioning. *Applied Psychological Measurement, 44*(7–8), 548–560. https://doi.org/10.1177/0146621620931190

Cohen, T. R., Hazell, T. J., Vanstone, C. A., Rodd, C., & Weiler, H. A. (2018). Changes in eating behavior and plasma leptin in children with obesity participating in a family-centered lifestyle intervention. *Appetite, 125*, 81–89. https://doi.org/10.1016/j.appet.2018.01.017

Cole, T. J., Bellizzi, M. C., Flegal, K. M., & Dietz, W. H. (2000). Establishing a standard definition for child overweight and obesity worldwide: International survey. *BMJ, 320*(7244), 1240–1243.

Cole, T. J., & Lobstein, T. (2012). Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. *Pediatr Obes, 7*(4), 284–294. https://doi.org/10.1111/j.2047-6310.2012.00064.x

Costa, A., Severo, M., Vilela, S., Fildes, A., & Oliveira, A. (2020). Bidirectional relationships between appetitive behaviours and body mass index in childhood: A cross-lagged analysis in the generation XXI birth cohort. *European Journal of Nutrition*. https://doi.org/10.1007/s00394-020-02238-9

Croker, H., Cooke, L., & Wardle, J. (2011). Appetitive behaviours of children attending obesity treatment. *Appetite, 57*(2), 525–529. https://doi.org/10.1016/j.appet.2011.05.320

Daniels, L. A., Magarey, A., Battistutta, D., Nicholson, J. M., Farrell, A., Davidson, G., et al. (2009). The NOURISH randomised control trial: Positive feeding practices and food preferences in early childhood - a primary prevention program for childhood obesity. *BMC Public Health, 9*(1), 387. https://doi.org/10.1186/1471-2458-9-387

Daniels, L. A., Mallan, K. M., Battistutta, D., Nicholson, J. M., Meedeniya, J. E., Bayer, J. K., et al. (2014). Child eating behavior outcomes of an early feeding intervention to reduce risk indicators for child obesity: The NOURISH RCT. *Obesity, 22*(5), E104–E111. https://doi.org/10.1002/oby.20693

Daniels, L. A., Mallan, K. M., Nicholson, J. M., Battistutta, D., & Magarey, A. (2013). Outcomes of an early feeding practices intervention to prevent childhood obesity. *Pediatrics, 132*(1), e109–118. https://doi.org/10.1542/peds.2012-2882

Daniels, L. A., Mallan, K. M., Nicholson, J. M., Thorpe, K., Nambiar, S., Mauch, C. E., et al. (2015). An early feeding practices intervention for obesity prevention. *Pediatrics, 136*(1), e40–49. https://doi.org/10.1542/peds.2014-4108

Davison, K. K., Gicevic, S., Aftosmes-Tobio, A., Ganter, C., Simon, C. L., Newlan, S., et al. (2016). Fathers' representation in observational studies on parenting and childhood obesity: A systematic review and content analysis. *American Journal of Public Health, 106*(11), e14–e21. https://doi.org/10.2105/ajph.2016.303391

Derks, I. P. M., Sijbrands, E. J. G., Wake, M., Qureshi, F., van der Ende, J., Hillegers, M. H. J., et al. (2018). Eating behavior and body composition across childhood: A prospective cohort study. *International Journal of Behavioral Nutrition and Physical Activity, 15*(1), 96. https://doi.org/10.1186/s12966-018-0725-x

Domoff, S. E., Miller, A. L., Kaciroti, N., & Lumeng, J. C. (2015). Validation of the children's eating behaviour questionnaire in a low-income preschool-aged sample in the United States. *Appetite, 95*, 415–420. https://doi.org/10.1016/j.appet.2015.08.002

Ek, A., Chamberlain, K. L., Ejderhamn, J., Fisher, P. A., Marcus, C., Chamberlain, P., et al. (2015). The more and less study: A randomized controlled trial testing different approaches to treat obesity in preschoolers. *BMC Public Health, 15*, 735. https://doi.org/10.1186/s12889-015-1912-1

Ek, A., Lewis Chamberlain, K., Sorjonen, K., Hammar, U., Etminan Malek, M., Sandvik, P., et al. (2019). A parent treatment program for preschoolers with obesity: A randomized controlled trial. *Pediatrics, 144*(2). https://doi.org/10.1542/peds.2018-3457

Ek, A., Sorjonen, K., Eli, K., Lindberg, L., Nyman, J., Marcus, C., et al. (2016). Associations between parental concerns about preschoolers' weight and eating and parental feeding practices: Results from analyses of the child eating behavior questionnaire, the child feeding questionnaire, and the lifestyle behavior checklist. *PLoS One, 11*(1), Article e0147257. https://doi.org/10.1371/journal.pone.0147257

Ells, L. J., Rees, K., Brown, T., Mead, E., Al-Khudairy, L., Azevedo, L., et al. (2018). Interventions for treating children and adolescents with overweight and obesity: An overview of cochrane reviews. *International Journal of Obesity, 42*(11), 1823–1833. https://doi.org/10.1038/s41366-018-0230-y

Fernandez, C., McCaffery, H., Miller, A. L., Kaciroti, N., Lumeng, J. C., & Pesch, M. H. (2020). Trajectories of picky eating in low-income US children. *Pediatrics (Evanston), 145*(6), Article e20192018. https://doi.org/10.1542/peds.2019-2018

Fildes, A., Mallan, K. M., Cooke, L., van Jaarsveld, C. H., Llewellyn, C. H., Fisher, A., et al. (2015). The relationship between appetite and food preferences in British and Australian children. *International Journal of Behavioral Nutrition and Physical Activity, 12*, 116. https://doi.org/10.1186/s12966-015-0275-4

Freitas, A., Albuquerque, G., Silva, C., & Oliveira, A. (2018). Appetite-related eating behaviours: An overview of assessment methods, determinants and effects on children's weight. *Annals of Nutrition and Metabolism, 73*(1), 19–29. https://doi.org/10.1159/000489824

Garratt, A. M., Coste, J., Rouquette, A., & Valderas, J. M. (2021). The Norwegian PROMIS-29: Psychometric validation in the general population for Norway. *J Patient Rep Outcomes, 5*(1), 86. https://doi.org/10.1186/s41687-021-00357-3

Golan, M., & Weizman, A. (2001). Familial approach to the treatment of childhood obesity: Conceptual model. *Journal of Nutrition Education, 33*(2), 102–107. https://doi.org/10.1016/S1499-4046(06)60173-5

Gordon, R. A. (2015). Measuring constructs in family science: How can item response theory improve precision and validity? *Journal of Marriage and Family, 77*(1), 147–176. https://doi.org/10.1111/jomf.12157

Grossman, D. C., Bibbins-Domingo, K., Curry, S. J., Barry, M. J., Davidson, K. W., Doubeni, C. A., et al. (2017). Screening for obesity in children and adolescents: US preventive services Task Force recommendation statement. *Jama, 317*(23), 2417–2426. https://doi.org/10.1001/jama.2017.6803

Havermans, R. C., Vancleef, L., Kalamatianos, A., & Nederkoorn, C. (2015). Eating and inflicting pain out of boredom. *Appetite, 85*, 52–57. https://doi.org/10.1016/j.appet.2014.11.007

van Jaarsveld, C. H., Boniface, D., Llewellyn, C. H., & Wardle, J. (2014). Appetite and growth: A longitudinal sibling analysis. *JAMA Pediatr, 168*(4), 345–350. https://doi.org/10.1001/jamapediatrics.2013.4951

Jackson, R., Haszard, J. J., Morrison, S., Galland, B. C., McIntosh, D., Ward, A. L., et al. (2021). Measuring short-term eating behaviour and desire to eat: Validation of the child eating behaviour questionnaire and a computerized 'desire to eat' computerized questionnaire. *Appetite, 167*, 105661. https://doi.org/10.1016/j.appet.2021.105661

Jansen, E., Mallan, K. M., Nicholson, J. M., & Daniels, L. A. (2014). The feeding practices and structure questionnaire: Construction and initial validation in a sample of Australian first-time mothers and their 2-year olds. *International Journal of Behavioral Nutrition and Physical Activity, 11*, 72. https://doi.org/10.1186/1479-5868-11-72

Jansen, P. W., Roza, S. J., Jaddoe, V. W., Mackenbach, J. D., Raat, H., Hofman, A., et al. (2012). Children's eating behavior, feeding practices of parents and weight problems in early childhood: Results from the population-based generation R study. *International Journal of Behavioral Nutrition and Physical Activity, 9*, 130. https://doi.org/10.1186/1479-5868-9-130

Kininmonth, A., Smith, A., Carnell, S., Steinsbekk, S., Fildes, A., & Llewellyn, C. (2021). The association between childhood adiposity and appetite assessed using the child eating behavior questionnaire and baby eating behavior questionnaire: A systematic review and meta-analysis. *Obesity Reviews, 22*(5), Article e13169. https://doi.org/10.1111/obr.13169

Kininmonth, A. R., Smith, A. D., Llewellyn, C. H., & Fildes, A. (2020). Socioeconomic status and changes in appetite from toddlerhood to early childhood. *Appetite, 146*, 104517. https://doi.org/10.1016/j.appet.2019.104517

Koball, A. M., Meers, M. R., Storfer-Isser, A., Domoff, S. E., & Musher-Eizenman, D. R. (2012). Eating when bored: Revision of the emotional eating scale with a focus on boredom. *Health Psychology, 31*(4), 521–524. https://doi.org/10.1037/a0025893

Kral, T. V. E., Moore, R. H., Chittams, J., Jones, E., O'Malley, L., & Fisher, J. O. (2018). Identifying behavioral phenotypes for childhood obesity. *Appetite, 127*, 87–96. https://doi.org/10.1016/j.appet.2018.04.021

de Lauzon-Guillain, B., Oliveira, A., Charles, M. A., Grammatikaki, E., Jones, L., Rigal, N., et al. (2012). A review of methods to assess parental feeding practices and preschool children's eating behavior: The need for further development of tools. *Journal of the Academy of Nutrition and Dietetics, 112*(10), 1578–1602. https://doi.org/10.1016/j.jand.2012.06.356, 1602.e1571-1578.

Linacre, J. M. (2020). *Winsteps® Rasch measurement computer program User's Guide*. Retrieved from Beaverton, Oregon.

Llabre, M. M., Ard, J. D., Bennett, G., Brantley, P. J., Fiese, B., Gray, J., et al. (2020). Summary of the clinical practice guideline for multicomponent behavioral treatment of obesity and overweight in children and adolescents. *American Psychologist, 75*(2), 178–188. https://doi.org/10.1037/amp0000530

Llewellyn, C. H., & Fildes, A. (2017). Behavioural susceptibility theory: Professor Jane Wardle and the role of appetite in genetic risk of obesity. *Current Obesity Reports, 6*(1), 38–45. https://doi.org/10.1007/s13679-017-0247-x

Llewellyn, C. H., Trzaskowski, M., van Jaarsveld, C. H. M., Plomin, R., & Wardle, J. (2014). Satiety mechanisms in genetic risk of obesity. *JAMA Pediatr, 168*(4), 338–344. https://doi.org/10.1001/jamapediatrics.2013.4944

Loh, D. A., Moy, F. M., Zaharan, N. L., & Mohamed, Z. (2013). Eating behaviour among multi-ethnic adolescents in a middle-income country as measured by the self-reported Children's Eating Behaviour Questionnaire. *PLoS One, 8*(12), Article e82885. https://doi.org/10.1371/journal.pone.0082885

Loveman, E., Al-Khudairy, L., Johnson, R. E., Robertson, W., Colquitt, J. L., Mead, E. L., et al. (2015). Parent-only interventions for childhood overweight or obesity in children aged 5 to 11 years. *Cochrane Database of Systematic Reviews, 12*, Article Cd012008. https://doi.org/10.1002/14651858.cd012008

Magarey, A., Mauch, C., Mallan, K., Perry, R., Elovaris, R., Meedeniya, J., et al. (2016). Child dietary and eating behavior outcomes up to 3.5 years after an early feeding intervention: The NOURISH RCT. *Obesity, 24*(7), 1537–1545. https://doi.org/10.1002/oby.21498

Mallan, K. M., Jansen, E., Harris, H., Llewellyn, C., Fildes, A., & Daniels, L. A. (2018). Feeding a fussy eater: Examining longitudinal bidirectional relationships between child fussy eating and maternal feeding practices. *Journal of Pediatric Psychology, 43*(10), 1138–1146. https://doi.org/10.1093/jpepsy/jsy053

Mallan, K. M., Liu, W. H., Mehta, R. J., Daniels, L. A., Magarey, A., & Battistutta, D. (2013). Maternal report of young children's eating styles. Validation of the Children's Eating Behaviour Questionnaire in three ethnically diverse Australian samples. *Appetite, 64*, 48–55. https://doi.org/10.1016/j.appet.2013.01.003

McCarthy, E. K., Chaoimh, C., Murray, D. M., Hourihane, J. O., Kenny, L. C., & Kiely, M. (2015). Eating behaviour and weight status at 2 years of age: Data from the cork BASELINE birth cohort study. *European Journal of Clinical Nutrition, 69*(12), 1356–1359. https://doi.org/10.1038/ejcn.2015.130

Morgan, E. H., Schoonees, A., Sriram, U., Faure, M., & Seguin-Fowler, R. A. (2020). Caregiver involvement in interventions for improving children's dietary intake and physical activity behaviors. *Cochrane Database of Systematic Reviews, 1*(1), Article Cd012547. https://doi.org/10.1002/14651858.CD012547.pub2

Morgan, P. J., Young, M. D., Lloyd, A. B., Wang, M. L., Eather, N., Miller, A., et al. (2017). Involvement of fathers in pediatric obesity treatment and prevention trials: A systematic review. *Pediatrics, 139*(2). https://doi.org/10.1542/peds.2016-2635

Purwaningrum, D. N., Arcot, J., Hadi, H., Hasnawati, R. A., Rahmita, R. S., & Jayasuriya, R. (2020). A cultural adaptation and validation of a child eating behaviour measure in a low- and middle-income country. *Public Health Nutrition, 23*(11), 1931–1938. https://doi.org/10.1017/s136898001900510x

Quah, P. L., Cheung, Y. B., Pang, W. W., Toh, J. Y., Saw, S. M., Godfrey, K. M., et al. (2017). Validation of the Children's Eating Behavior Questionnaire in 3 year old children of a multi-ethnic Asian population: The GUSTO cohort study. *Appetite, 113*, 100–105. https://doi.org/10.1016/j.appet.2017.02.024

Quah, P. L., Fries, L. R., Chan, M. J., Fogel, A., McCrickerd, K., Goh, A. T., et al. (2019). Validation of the children's eating behavior questionnaire in 5 and 6 Year-old children: The GUSTO cohort study. *Frontiers in Psychology, 10*(824). https://doi.org/10.3389/fpsyg.2019.00824

Reinehr, T., Kleber, M., Lass, N., & Toschke, A. M. (2010). Body mass index patterns over 5 y in obese children motivated to participate in a 1-y lifestyle intervention: Age as a predictor of long-term success. *American Journal of Clinical Nutrition, 91*(5), 1165–1171. https://doi.org/10.3945/ajcn.2009.28705

Rendall, S., Dodd, H., & Harvey, K. (2020). Behavioural validation of a parent-report measure of child food fussiness. *Appetite, 154*, 104796. https://doi.org/10.1016/j.appet.2020.104796

Sandvik, P., Ek, A., Eli, K., Somaraki, M., Bottai, M., & Nowicka, P. (2019). Picky eating in an obesity intervention for preschool-aged children – what role does it play, and does the measurement instrument matter? *International Journal of Behavioral Nutrition and Physical Activity, 16*(1), 76. https://doi.org/10.1186/s12966-019-0845-y

Sandvik, P., Ek, A., Somaraki, M., Hammar, U., Eli, K., & Nowicka, P. (2018). Picky eating in Swedish preschoolers of different weight status: Application of two new screening cut-offs. *International Journal of Behavioral Nutrition and Physical Activity, 15*(1), 74. https://doi.org/10.1186/s12966-018-0706-0

Sleddens, E. F., Kremers, S. P., & Thijs, C. (2008). The children's eating behaviour questionnaire: Factorial validity and association with body mass index in Dutch children aged 6-7. *International Journal of Behavioral Nutrition and Physical Activity, 5*, 49. https://doi.org/10.1186/1479-5868-5-49

Somaraki, M., Eli, K., Sorjonen, K., Flodmark, C. E., Marcus, C., Faith, M. S., et al. (2018). Perceived child eating behaviours and maternal migrant background. *Appetite, 125*, 302–313. https://doi.org/10.1016/j.appet.2018.02.010

Sparks, M. A., & Radnitz, C. L. (2012). Confirmatory factor analysis of the Children's Eating Behaviour Questionnaire in a low-income sample. *Eating Behaviors, 13*(3), 267–270. https://doi.org/10.1016/j.eatbeh.2012.03.002

Stark, L. J., Spear Filigno, S., Bolling, C., Ratcliff, M. B., Kichler, J. C., Robson, S. M., et al. (2018). Clinic and Home-based behavioral intervention for obesity in preschoolers: A randomized trial. *The Journal of Pediatrics, 192*, 115–121. https://doi.org/10.1016/j.jpeds.2017.09.063. e111.

Steinsbekk, S., Llewellyn, C. H., Fildes, A., & Wichstrøm, L. (2017). Body composition impacts appetite regulation in middle childhood. A prospective study of Norwegian community children. *International Journal of Behavioral Nutrition and Physical Activity, 14*(1), 70. https://doi.org/10.1186/s12966-017-0528-5

Steinsbekk, S., & Wichstrøm, L. (2015). Predictors of change in BMI from the age of 4 to 8. *Journal of Pediatric Psychology, 40*(10), 1056–1064. https://doi.org/10.1093/jpepsy/jsv052

Stockholm County Council. (2016). *Handlingsprogram mot övervikt och fetma 2016-2020*. Retrieved from Stockholm.

Svensson, V., Lundborg, L., Cao, Y., Nowicka, P., Marcus, C., & Sobko, T. (2011). Obesity related eating behaviour patterns in Swedish preschool children and association with age, gender, relative weight and parental weight–factorial validation of the Children's Eating Behaviour Questionnaire. *International Journal of Behavioral Nutrition and Physical Activity, 8*, 134. https://doi.org/10.1186/1479-5868-8-134

Syrad, H., Johnson, L., Wardle, J., & Llewellyn, C. H. (2016). Appetitive traits and food intake patterns in early life. *American Journal of Clinical Nutrition, 103*(1), 231–235. https://doi.org/10.3945/ajcn.115.117382

Taylor, C. M., Wernimont, S. M., Northstone, K., & Emmett, P. M. (2015). Picky/fussy eating in children: Review of definitions, assessment, prevalence and dietary intakes. *Appetite, 95*, 349–359. https://doi.org/10.1016/j.appet.2015.07.026

Viana, V., Sinde, S., & Saxton, J. C. (2008). Children's eating behaviour questionnaire: Associations with BMI in Portuguese children. *British Journal of Nutrition, 100*(2), 445–450. https://doi.org/10.1017/s0007114508894391

Wardle, J., Guthrie, C. A., Sanderson, S., & Rapoport, L. (2001). Development of the children's eating behaviour questionnaire. *Journal of Child Psychology and Psychiatry, 42*(7), 963–970.

Yavuz, H. M., van Ijzendoorn, M. H., Mesman, J., & van der Veek, S. (2015). Interventions aimed at reducing obesity in early childhood: A meta-analysis of programs that involve parents. *Journal of Child Psychology and Psychiatry, 56*(6), 677–692. https://doi.org/10.1111/jcpp.12330

Yee, A. Z., Lwin, M. O., & Ho, S. S. (2017). The influence of parental practices on child promotive and preventive food consumption behaviors: A systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity, 14*(1), 47. https://doi.org/10.1186/s12966-017-0501-3