Published in final edited form as:

Int J Eat Disord. 2019 June ; 52(6): 669–680. doi:10.1002/eat.23062.

Assessment of eating attitudes and dieting behaviors in healthy children: Confirmatory factor analysis of the Children's Eating Attitudes Test

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Abstract

Objective: The Children's Eating Attitudes Test (ChEAT) is a self-report questionnaire that is conventionally summarised with a single score to identify 'problematic' eating attitudes, masking informative variability in different eating attitude domains. This study evaluated the empirical support for single-versus multifactor models of the ChEAT. For validation, we compared how well the single- versus multifactor-based scores predicted BMI.

Method: Using data from 13,674 participants of the 11.5 year-follow-up of the Promotion of Breastfeeding Intervention Trial (PROBIT) in the Republic of Belarus, we conducted confirmatory factor analysis to evaluate the performance of 3- and 5-factor models, which were based on past studies, to a single-factor model representing the conventional summary of the ChEAT. We used cross-validated linear regression models and the reduction in mean squared error (MSE) to compare the prediction of BMI at 11.5y and 16y by the conventional and confirmed factor-based ChEAT scores.

Results: The 5-factor model, based on 14 of the original 26 ChEAT items, had good fit to the data whereas the 3- and single-factor models did not. The MSE for concurrent (11.5y) BMI regressed on the 5-factor ChEAT summary was 35% lower than that of the single-score models, which reduced the MSE from the null model by only 1–5%. The MSE for BMI at 16y was 20% lower.

Discussion: We found that a parsimonious 5-factor model of the ChEAT explained the data collected from healthy Belarusian children better than the conventional summary score and thus provides a more discriminating measure of eating attitudes.

Keywords

Factor Analysis; Statistical; Republic of Belarus; Child; Eating; psychology; Attitude; Adiposity

Introduction

A child's attitude toward eating is a major determinant of his or her food consumption, and hence nutrition. However, the emotional and social causes and consequences of eating attitudes are not fully understood (Gahagan, 2012). Sensitive and reliable measures of eating attitudes are prerequisites to understanding their role in childhood health and well-being.

The Children's Eating Attitudes Test (ChEAT) (Maloney, Bell McGuire, & Daniels, 1988) is a questionnaire-based instrument that is widely used in children 8–14 years (Micali & House, 2011). Adapted from the EAT for adults (Garner, Olmsted, Bohr, & Garfinkel, 1982), the ChEAT consists of 26 items on a wide range of eating-related feelings and behaviors. The ChEAT has been used in a variety of study types in English and non-English speaking countries. It has also been used to establish national age- and sex-specific norms for the prevalence of "eating disturbances which interfere with normal psycho-social functioning" (Garfinkel & Newman, 2001, p.13). The conventional scoring method is the unweighted sum of the points assigned to the items. That sum is a continuous score that can range from 0 to about 70 (depending on the version used), where higher scores represent more 'problematic' eating attitudes and behaviors. The score is often dichotomized at 20.

A single summed score, however, may mask different eating-attitude domains with different eating-related pathways to health outcomes (Koslowsky et al., 1992; Ocker, Lam, Jensen, & Zhang, 2007). The three original subscales for the EAT— 'dieting,' 'food preoccupation and bulimia,' and 'oral control'—were differentially associated with body mass (Garner et al., 1982) and age (Wood, Waller, Miller, & Slade, 1992). Although some researchers have endorsed the three factors as a sound, albeit partial, reflection of the theory on problematic eating attitudes in children, they found little empirical support for a 3-factor latent structure for the ChEAT (Anton et al., 2006; Lynch & Eppers-Reynolds, 2005). Smolak and Levine (1994) conducted the first factor analysis of the ChEAT in a small sample of girls and proposed a 4-factor structure, but several large psychometric studies have since proposed different structural models, mainly with four to six factors nested within the original three factors (see eTable 1 for summary). Although all the proposed factor structures share similarities, the evidence for which of the ChEAT subscales, if any, are reliable across multiple populations has not been rigorously evaluated.

Our aim, therefore, was to evaluate the empirical support for single-versus multifactor models of the ChEAT in healthy children. More specifically, we conducted confirmatory factor analysis (CFA) in a large birth cohort of healthy Belarusian children to evaluate the best-supported factor structures of the ChEAT based on previous studies and compared those structures to a single factor model of the ChEAT. As an indirect validation of the different

factor models, we compared the extent to which the single summed score and each factor-based ChEAT summary explained the variance in adiposity that has shown associations with eating attitudes (Anton et al., 2006b). We hypothesize that (1) there is at least one multifactor model with widespread support in the literature that will fit the collected ChEAT data better than a single-factor model, and (2) the multifactor-based subscales will explain more of the variance in adiposity between children than does the single-factor model or conventional unweighted summed ChEAT score.

Methods

Participants

Participants in this study were Belarusian children who attended the 11.5-year follow-up visit of the Promotion of Breastfeeding Intervention Trial (PROBIT), which has been described in detail elsewhere (Patel et al., 2014). In brief, 17,046 mother-infant pairs were recruited at birth during their postpartum stay at maternity hospitals. Infants were eligible if they were born full-term and healthy (i.e., no serious morbidity at birth; birth weight ≥ 2500 g; 5-minute Apgar ≥ 5), and if they had initiated breastfeeding. They were assessed seven times during the first year, and at ages 6.5, 11.5, and 16 years at the polyclinics affiliated with the maternity hospitals. The ChEAT was administered at the 11.5-year visits conducted between January 2008 and December 2010. The response rate was 80.6% (13,751 of the original 17,046 children). Children with diabetes ($n=43$) or children with missing diabetes status ($n=34$) were excluded from our study because diabetes management may change eating attitudes and has been associated with disease-specific weight control behaviors (Conviser, Fisher, & McColley, 2018). We did not have data for other diagnoses that may be associated with eating attitudes or eating disorders.

The study was approved by the McGill University Children's Hospital Research Ethics Board, the Institutional Review Board at Harvard Pilgrim Health Care, and the Avon Longitudinal Study of Parents and Children Law and Ethics Committee.

Measures

The ChEAT questionnaire administered in PROBIT had been translated into Russian and back-translated to English by independent translators. The data included 24 of the original 26 items (Table 1, columns 1–2). Item 19 was not collected because past studies found it had a low, negative correlation with the total score (Maloney et al., 1988; Smolak & Levine, 1994); item 25 was collected, but then dropped for the same reason (R. M. Martin et al., 2013). To further improve comprehension and reduce questionnaire burden for the PROBIT participants, each ChEAT item response was a 3-point Likert scale, instead of the original 6-point scale. Usually, the 6-point scale is reduced to four levels. The three lowest-frequency choices are scored as 0, and the next three are scored 1, 2, and 3 (Garner and Garfinkel, 1979), which sums to a maximum of 78 if all 26 items are used. In PROBIT, the responses 'never,' 'sometimes,' and 'often' were scored as 0, 1.5, and 3 points, respectively. The lowest (0) and highest (3) scores were chosen to approximate the range of the original scale (Wade et al., 2014). The mid-level score of 1.5 gives the difference between 'never' and 'sometimes' equal weight as the difference between 'sometimes' and 'often.'

BMI was derived from weight (kg)/height² (m), which were measured by trained interviewers at each visit. BMI was then converted to age- and sex-standardized z-scores (Centers for Disease Control and Prevention, 2016). Also, fat mass, as a percent of total body mass, was measured by foot-to-foot bioelectrical impedance (Tanita TBF 300GS body fat analyzer) at 11.5y and 16y.

Confirmatory factor analysis (CFA) model-building

Candidate multifactor models for CFA of the ChEAT were identified from the literature. Anton et al. (2006) and Lynch & Eppers-Reynolds (2005) evaluated factor analysis studies that were published before 2005. Both Lynch and Eppers-Reynolds (2005) and Anton et al. (2006) concluded that neither the models based on studies of adults, including Garner et al. (1982), nor the models based on studies of children, including Smolak and Levine (1994), had a good fit to new data they collected from non-clinical samples of children; therefore, they proposed new models.

We searched PubMed, PsychInfo, and Scopus on August 30, 2018 to capture additional factor models from studies published in 2005 or later. We used the following search strategy: (TITLE-ABS-KEY (“eating attitudes test” AND “children”)) AND (“factor analysis” OR “psychometric” OR “IRT”))). We found thirteen studies that included factor analysis results for children between the ages of 8 and 14 (Ambrosi-Randi & Pokrajac-Bulian, 2005; Chiba et al., 2016; Elizathe, Murawski, Arana, & Rutsztein, 2012; Escoto Ponce De León & Camacho Ruiz, 2008; Maïano, Morin, Lanfranchi, & Therme, 2013; McEnery, Fitzgerald, McNicholas, & Dooley, 2016; Pilecki, Kowal, Woronkiewicz, Kryst, & Sobiecki, 2013; Ranzenhofer et al., 2008; Rojo-Moreno et al., 2011; Sancho, Asorey, Arija, & Canals, 2005; Senra, Seoane, Vilas, & Sánchez-Cao, 2007; Teixeira et al., 2012; Theuwis, Moens, & Braet, 2009). Study characteristics and principal components analysis (PCA) or factor analysis (FA) results from Anton et al. (2006), Lynch and Eppers-Reynolds (2005), and the thirteen new studies are summarized in eTable 1, alongside the seminal Garner et al. (1982) and Smolak and Levine (1994) studies of the (Ch)EAT.

Skugarevsky et al. (2014) conducted a PCA for the ChEAT on the same PROBIT sample; therefore, we did not consider those results in CFA model building. However, for the reasons explained below, we examined the CFA fit of the Skugarevsky model in sensitivity analyses.

Factor constructs from early studies were often supported by later studies, but the specific items loading on each factor varied considerably among studies (eTable 1). Occasionally, a study did not test one or more items. The vomiting items, 9 and 26, were the items most often excluded from analyses, either because authors believed they were not appropriate for the age group (Sancho et al., 2005; Senra et al., 2007) or participants uniformly scored zero (Elizathe et al., 2012; Pilecki et al., 2013). Therefore, the number of studies with an estimated factor loading for an item varied. We based selection of factor-item pairings on the following criteria: (1) in more than one third of studies that analyzed the item, the item loaded on the same (or a synonymous) factor with a factor loading >0.70, or (2) in more than two thirds of studies that analyzed the item, the item loaded on the same (or a synonymous) factor with a factor loading >0.30. According to those selection criteria, we found support for a 5-factor model, although support for the vomiting factor was tenuous. We labelled the

factors as ‘weight preoccupation’ (**WP**), ‘dieting’ (**D5**), ‘food preoccupation’ (**FP**), ‘social pressure [to eat or gain weight]’ (**SP**), and ‘vomiting [and purging]’ (**VP**). Box 1 lists the factor label abbreviations and other labels that we considered to be synonyms.

Three studies (Anton et al., 2006; Lynch & Eppers-Reynolds, 2005; Mañano et al., 2013) proposed models that grouped Garner’s dieting items into three distinct factors instead of two, resulting in six factors. Those studies used the full 6-point scale for each item, which may be more sensitive to variation in relatively healthy children, and an adequate sample size for the potential number of model parameters, which is large given the ChEAT’s 26 items. We tried to use their results to identify a 6-factor model, but only the factor-item pairings for WP were similar across the studies; the remaining dieting-related items (those that did not load onto WP) did not load onto synonymous factors across the three studies. Moreover, none of the other twelve studies replicated the extra dieting-related factor. Therefore, we compared only a 5-factor model to a single-factor model as a latent-trait analog to the univariate summed ChEAT score and to the original 3-factor model (Garner et al., 1982) (using the 24 available items). Table 1 shows the factor-item pairings and the item wordings.

Statistical analysis

CONFIRMATORY FACTOR ANALYSIS—The CFA model parameters were estimated using polychoric correlations and the diagonally-weighted least squares (DWLS) method to reflect the ordinal nature of the items (Brown, 2015; Holgado-Tello, Chacón-Moscoso, Barbero-García, Enrique Abad, & Vila-Abad, 2010). This ‘underlying variable’ model assumes that the observed Likert scale responses represent values that lay between *thresholds* on a continuous latent item. For the ChEAT item responses, each threshold represents the frequency of the given feeling or behavior that triggered a response of ‘sometimes’ rather than ‘never,’ or ‘often’ rather than ‘sometimes’ (eFigure 1). Each latent item and factor was assumed to follow a standard normal distribution (mean = 0, standard deviation = 1), leaving the latent item thresholds, the factor loadings, and between-factor correlations as parameters to be estimated from the data. See Figure 1 for the path diagram for the 5-factor model.

The main criteria we used for comparing models were the robust-standard-error (or ‘scaled’) versions of global fit statistics that are not biased by large sample size, and conventional guidelines for acceptable fit (Brown, 2015). Specifically, we examined the scaled comparative fit index (CFI, >0.95 represents good fit), the non-normed fit index (NNFI, >0.95 is good; also known as the Tucker-Lewis index), the root mean squared error of approximation (RMSEA, <0.05 is good), and the standardized root mean square residual (SRMR, <0.08 is good) (Brown, 2015; Rosseel, 2012). We also assessed the discriminant validity (Brown, 2015) of the multifactor models. Poor discriminant validity would indicate that factors we assumed were distinct in children, based on the literature, may be more parsimoniously represented by fewer factors. The division of Garner’s original dieting factor into a WP factor and a narrower dieting factor was of particular interest. We considered a model to have poor discriminant validity if, in any pair of factors, the average variance extracted (AVE) for either factor was smaller than their squared correlation (Farrell, 2010).

Finally, we estimated the internal consistency of the factors, as measured with the omega-3 statistic that is suitable for models with ordinal items (Green & Yang, 2015).

PREDICTION OF ADIPOSITY—To compare how well the multifactor models and the single-variable ChEAT scores explained adiposity, we estimated the decrease in unexplained variance of BMI z-scores (at ages 11.5 and 16 years) when regressed on each of the following:

- *Conventional single-variable summaries:* a) total summed score, and b) high ChEAT score indicator (total summed score ≥ 20).
- *Factor-based ChEAT summaries (c-e):* individual factor scores obtained from the model-based predicted scores for each model tested in the CFA (single-, 3-, 5-factor models). The factor scores were predicted with R's lavaan:: lavPredict() function, which used the 'empirical Bayes model' method for categorical items (Rosseel, 2012).

Our 'null' model, an intercept-only model, included no ChEAT variables. Each of the six linear regression models (a–e and the null model) was estimated with 10-fold cross-validation to guard against over-fitting. That is, the sample was randomly divided into ten data sets, and the regression model was fit to each. We then calculated the *mean* mean squared error (mMSE) of the ten cross-validations for each ChEAT summary (a–e) and its percent decrease from the null model's mMSE.

For the cross-sectional (11.5y) regression models, 15 children were excluded because of missing or biologically implausible BMI z-scores (<-5.0 SD or $>+6.0$ SD, as per Centers for Disease Control and Prevention, 2016). For the longitudinal models of BMI z-score at 16y regressed on ChEAT summaries at 11.5y, children were excluded if they had not attended the 11.5y visit or did not complete the ChEAT questionnaire (n=913), had attended one polyclinic that had had major deviations from the protocol for data collection at the 16y visit (n=267) (Wade et al., 2017), or had missing or implausible BMI z-scores (n=20).

To facilitate cross-study comparisons, we report BMI z-score as the main validation outcome (i.e., a proxy for adiposity), but we repeated the cross-validated regression analysis with fat mass percent, a more direct measure of adiposity.

SENSITIVITY ANALYSES—We compared CFA model parameter estimates from the main, literature-based models to those from several alternative analyses. First, to compare the fit of the model from our main analysis to what we would have obtained from the exploratory approaches used by past studies, we conducted a CFA of a) the Skugarevsky et al. (2014) PCA-identified orthogonal factors; and b) the best-fit 5- and 6-factor models from an exploratory factor analysis (EFA) with oblique rotation. For (b), we performed EFA in a random half of our study sample and CFA in the remaining half. Second, to examine the sensitivity of the CFA results to distributional assumptions for the items, we repeated the CFA treating the 3-point Likert items as continuous and used Pearson correlation and maximum likelihood-based methods, instead of polychoric correlations plus the DWLS algorithm. Third, we explored measurement invariance, specifically for equal form and equal

factor loadings (Brown, 2015), across sex and urban-rural strata by comparing factor loadings and correlations, and their SEs, CFI, and RMSEAs (Maïano et al., 2013). The objective was to estimate whether the same measurement model suited each stratum, but not to examine differences in mean factor scores across strata. Finally, we repeated the primary analysis after a) excluding data from one polyclinic (n=920) where most total ChEAT scores were zero (Richmond et al., 2014), and b) including children with diabetes (n=43).

R statistical software (R Core Team, 2018) v.3.5.1 was used for all analyses. CFA was performed with R's lavaan package (Rosseel, 2012) v.0.6–2. Linear regression with cross-validation was performed with R's daag package (Maindonald & Braun, 2015) v.1.22.

Results

The main analysis, the CFA, included 13,674 children (80.2% of original cohort). At the 11.5y study visit, most of the children (75.4%) were in their 12th year, but the participants ranged in age from 10.2 to 14.5 years; 51.3% were male. Table 2 shows demographic and body composition measures of the participants.

Confirmatory Factor Analysis

The median ChEAT total score was 12.0 (IQR: 6.0–19.5). Figure 2 and eTable 2A show the distribution of responses to each ChEAT item. As expected from other non-clinical study populations, low scores were common. A response other than 'never' on the items regarding vomiting (Q09, Q26) was rare (5–6%) but frequent enough to estimate the parameters precisely. The threshold estimates are listed in the supplementary materials, eTable 2B.

Table 3 shows the factor loading point estimates and global fit indices for each of the CFA models. All factor loadings were greater than 0.3 in all models. On average, factor loadings were higher in the multifactor models than in the single-factor model, and lower bounds of all the 95% confidence intervals for the 5-factor model were greater than 0.50 (eTable 2C). Items that had been excluded from the 5-factor model, owing to a lack of support in previous studies, were also more likely to have lower factor loadings in the 3-factor model. For example, the three items with the lowest loadings (Q02, Q05, Q15: 0.40–0.49) for OC in the 3-factor model were not selected for the SP factor in the 5-factor model. However, some items loaded on the D3 factor in the 3-factor model but not selected for the 5-factor model (Q07, 10, 12, 22, 23, 24) had moderately high loadings (0.51–0.66). Nevertheless, the fit indices indicated improved fit with the 5-factor model (NNFI > 0.95, SRMR < 0.08, and RMSEA < 0.05) versus the single and 3- factor models.

Table 4 presents the between-factor correlations, internal consistency, and AVE estimates for each factor and model. The 3- and 5-factor models had weak to moderate positive correlations between most factor pairs (Pearson's $r = 0.10$ – 0.57), except for a weak negative correlation between SP and WP in the 5-factor model (Pearson's $r = -0.19$). The largest correlation in the 5- factor model was between D5 and WP ($r=0.47$), but its square (0.22) was less than the AVE for D5 (0.45) and WP (0.71). For all other pairs, the squared correlations were even smaller than each factor's AVE. Hence, the discriminant validity of the 5-factor model was supported. The estimates for the internal consistency of each

multifactor model were good but lower than that of the single-factor model (omega-3: 0.83 versus 0.94). Except for the D5 factor in the 5-factor model (omega-3: 0.57), all estimates for within-factor consistency were acceptable (>0.65). (For comparison of omega-3 and Cronbach's alpha, see eTable3B.)

Prediction of adiposity

Children had a mean BMI of 18.2 (SD=3.1, $n=13,659$) at 11.5 years and 21.4 (SD=3.4, $n=12,624$) at 16 years (Table 2). Overall, more of the variance in adiposity was explained (smaller mMSEs) by models using the multifactor-based ChEAT summaries (Table 5, d-e) than those using single-variable summaries (Table 5, a-c). The mMSE of the null model for concurrent BMI z-score (1.06) was reduced 36% by using the 3-factor summary and 38% by the 5-factor summary, whereas the single-variable summaries reduced mMSE by only 1–5%. In the longitudinal model of adiposity at 16y regressed on each 11.5y ChEAT summary, the percent reductions in mMSEs from the null model followed the same pattern as in the concurrent models but were smaller. The multifactor-based ChEAT summaries (d-e) had 20–21% reductions compared to 1–3% reductions in the single-variable summaries. The differences between the mMSEs of the 3- and 5-factor models were close to the cross-validation sampling error ($SD \cong 0.029$) meaning they not statistically different.

The results for fat mass percent as the measure of adiposity showed similar results (eTable 4 A–C). Compared to the total ChEAT score, the 5-factor-based ChEAT summary further reduced the mMSE of fat mass percent by 32% at 11.5y and by 13% at 16y.

Sensitivity analyses

We tested factor models generated with exploratory methods. In the 5-factor EFA model, some items that were not included in the literature-based CFA model (Q02, Q05, Q07, Q12, and Q24) loaded onto the first factor (D5 in the CFA) (eTable 5A.ii). Also, Q10 loaded onto the fifth factor (WP in the CFA). However, the global fit of the EFA-based 5-factor model was slightly worse than that of the literature-based model in our main analysis (eTable 6A). On the other hand, the internal consistency for the D5-like factor was much better (omega-3: 0.73; eTable 6D). The 6-factor EFA-based model also had a slightly worse global fit (eTable 6A) and the correlation between the dieting-related factors was exceptionally strong (Pearson's $r = 0.87$; eTable 6C.ii). The 6-factor model that was previously estimated with PCA in these data (Skugarevsky et al., 2014) also did not confer any advantage (eTable 7).

We also examined the stability of the confirmed 5-factor model under different model assumptions (eTable 8). First, as expected, the factor loadings tended to be smaller when estimated using Pearson correlation-based methods (eTable 8B) compared to DWLS. Second, urban-rural and sex-specific factor loadings and correlations were very similar to each other, although the 5-factor model showed slightly better fit statistics in boys than in girls (eTable 8A, C). Finally, factor loadings and fit indices remained unchanged when we excluded one polyclinic with unusual response data and when we included children with diabetes, (eTables 8A–B).

Discussion

To better understand the latent structure of eating attitudes measured in the ChEAT, we evaluated different models suggested by past factor analytic studies using CFA in a large sample of healthy children. We found the 5-factor model had a good global fit that was better than that of the single- or 3-factor model, and these results were robust to multiple sensitivity analyses. The factor loadings for each item were moderate to strong in the 5-factor model (0.64–0.97). Finally, the 5-factor model is statistically parsimonious (14 versus 24+ items). The 5-factor model, therefore, appears to be superior for developing standardized ChEAT subscales for eating attitudes in children.

Our results also show how distinct ChEAT subscales would be useful for research into the role of eating attitudes on relevant health outcomes. We found that the factor-based ChEAT summaries derived from models with >1 factor explained approximately 30% more of the variance in concurrent adiposity than did the conventional summed total, the high ChEAT score (> 20), or the single-factor-based score, each of which explained little. The multifactor-based summaries were also superior predictors of adiposity five years later.

The confirmed 5-factor model seems to identify eating attitude domains consistently measured by the ChEAT. However, to account for the variety of statistical methods used in past studies (eTable 1), we distilled the evidence using simple, arbitrary criteria in the CFA model-building step. Our selection criteria for factor-item pairings excluded some items (e.g., Q07, Q12, and Q23) that loaded strongly onto factors in some studies. Indeed, in the sensitivity analysis, PCA- and EFA-based models included some items that fell short of our selection threshold. However, neither the EFA-based nor the PCA-based 6-component model by Skugarevsky et al. (2014) showed substantially better fit than the literature-based 5-factor model. Those models also did not explain more of the variance in adiposity.

In addition to its good global fit, none of the factor loadings of the 5-factor model were weak (e.g., <0.6) meaning our data did not dispute the importance of any of the selected factor-item pairs. On average, the factor loadings in our 5-factor model were slightly higher than in past studies, which may be partially explained by how the items were modeled. We modeled the 3-level item responses used in the PROBIT study questionnaires as ordinal variables, whereas past studies have mainly used 4- or 6-level item responses as continuous, normally-distributed variables. Modeling ordinal items as continuous variables can lead to attenuated factor loading estimates (Holgado-Tello et al., 2010). We found that using polychoric correlation methods yielded slightly higher factor loadings in our data than Pearson correlation-based methods. The use of the polychoric correlation technique may also have mitigated the differences between the Likert scales used in our study and others' by estimating an intermediate latent continuous response. However, our questionnaire with 3-point Likert scales would have probably captured less variation in eating attitudes than if we had used the original 6-point scales. We suspect this introduced extra, but random, measurement error.

The small number of studies, using a relatively wide variety of methods, prevent systematic inferences about the cause of the slight differences between our results and those of past

studies, but sample size or composition may partly explain variations in the latent structure advanced by past studies. Some studies that found unique structures had small samples sizes (e.g., Elizathe et al., 2012; Theuwis et al., 2010) or included only girls (Ambrosi-Randi and Pokrajac-Bulian, 2005; Lynch and Eppers-Reynolds, 2005). However, sex differences are not a likely explanation; we fit the 5-factor model in boys and girls separately and found the global fit and factor loadings were very similar. Other studies also found only trivial differences in their measurement models when estimated separately for girls and boys (e.g., Teixeira et al., 2012). Another possible explanation for those differences is the age range of the samples. Most studies that included older adolescents (>14y) did not report whether the measurement model fit equally well in younger and older adolescents, but Maïano et al. (2013) found evidence for strong measurement invariance in participants aged 11–14 y versus 15–18 y. However, Rogoza, Brytek-Matera, and Garner (2016) conducted a CFA synthesizing studies of older adolescents and adults, and their model did not include a weight preoccupation factor, which was the most consistent factor among the ChEAT studies (in children and adolescents).

Measurement invariance, or generalizability, across nationalities or cultures is harder to test in a single study. Although the 5-factor model had widespread support from studies from three continents, the reasons for youth dieting and preferred body image are known to differ by culture (e.g., Levinson & Brosof, 2016; Shekriladze & Tchanturia, 2017). Cultural norms and trends might predict differences in the ChEAT responses across studies. For instance, many Japanese youths diet not for fear of fatness, but out of a desire to delay adolescence (Levinson & Brosof, 2016)—an attitude not captured by the ChEAT. However, a Japanese study by Chiba et al. (2016) found strong evidence for a weight preoccupation factor and most of the same items loaded onto it as in other studies. Urbanization is one of the hypothesized drivers of changes in eating disorders and obesity (Levinson & Brosof, 2016) and it was associated with measurement model differences in the EAT (Szabo & Allwood, 2004). However, we found the fit statistics and loadings were similar in our urban and rural subsamples. Thus, cultural differences may not affect the factor structure of the ChEAT but may simply cause the mean scores of specific factors to vary by culture.

By the same logic as for sex, age, or local culture, disease-specific models may measure eating attitudes more accurately if the disease affects eating attitudes and behaviors. However, we could not estimate separate models for children with chronic diseases because few diagnoses were collected and, for collected diagnoses, there were few cases. We excluded children with diabetes (n=43) from the main analysis but including them in the analysis did not change the results. Likewise, we believe the number of children with other chronic diseases that plausibly affect eating attitudes—that is, misclassified as healthy in our study—would be too small to influence our results.

The large, non-clinical sample of children is one of the strengths of this study because it provides reliable estimates and a normative latent structure of eating attitudes in children. Our study has several other methodologic strengths: 1) a transparent CFA model-building procedure synthesizing past studies, 2) appropriate methods for ordinal items, and 3) assessment of multiple aspects of model fit using fit statistics not biased by the large sample size. We judged that the literature-based 5-factor model had a good fit to our data in the CFA

based on robust-variance versions of CFI, NNFI, SRMR, and RMSEA, not chi-square tests. The factor loadings for each item retained in the literature-based 5-factor model were moderate to strong (11 of the 14 estimates were >0.70). We found all the internal consistency estimates for the 5-factor model to be well above 0.5, whether using Cronbach's alpha or the omega-3 statistic appropriate for ordinal items (Green & Yang, 2015).

Finally, our adiposity analysis shows how the multifactor models explain the distribution of an associated health outcome better than the conventional single-variable ChEAT summaries. From a methodological point of view, these results show that predictive value and statistical significance do not provide equivalent information—a well-understood fact in statistics that is often overlooked in applied research. Although the regression coefficients for all single-variable summaries were statistically significant (p -values $<.0001$), the multifactor-based summaries had much better predictive value in terms of explaining the variance in adiposity outcomes. When the sample size is large, coefficients with both small p -values and poor predictive value can occur, and associations that are small relative to the total variability in the outcome can be detected. From a scientific point of view, these results suggest that research into the prevention of obesity or undernutrition may benefit from using measures of distinct unhealthy eating attitudes instead of a total score for 'problematic' eating attitudes.

In summary, our study confirms that the ChEAT captures the multi-dimensional nature of eating attitudes in a large sample of Belarusian children. It also corroborates past studies, suggesting that diverse populations share a common measurement model. The 5-factor model based on fourteen items parsimoniously summarizes eating attitudes related to weight preoccupation, dieting, food preoccupation, experiencing social pressure to eat or gain weight, and possibly purging. In addition, the 5-factor-based model explained 13–35% more of the variability in adiposity between children than the conventional total score or the binary indicator of 'problematic' eating attitudes. Further research is needed to answer outstanding questions about measurement invariance and to propose standardized scoring for the subscales. Studies relating health outcomes to the ChEAT subscales, rather than the conventional unidimensional scores, would better elucidate the distinct roles of children's eating attitudes in their health.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Box 1.**Abbreviations***Factors*

D3	Dieting as specified in Garner et al. (1982)
BN&FP	Bulimia nervosa and food preoccupation (Garner et al., 1982)
OC	Oral control
D5	Dieting as specified in the 5-factor model (without WP items); fatty food avoidance; eating-related control; restriction and control; food restriction; awareness of food contents; caloric awareness
FP	Food preoccupation
SP	Social pressure (to eat or to gain weight)
VP	Vomiting (or purging)
WP	Weight preoccupation; body image; fear of getting fat

Other model terms

Total	Unweighted sum of the points of the 24 items
ChEAT	
High-ChEAT indicator	Total ChEAT ≥ 20

Figure 1.
Structural model for the 5-factor ChEAT model.

Figure 2.
Frequency (%) of responses to CHEAT items.

Table 1.

Item-factor pairings for the confirmatory factor analysis models estimated in this study. Abbreviations: D[3, 5, 6]=dieting [as specified in the 3-, 5-, or 6-factor models]; AFC=awareness of food contents (or calories); WP=weight preoccupation; OC=oral control; SP=social pressure (to eat or gain weight).BN=Bulimia nervosa; FP=food preoccupation; VP=vomiting (or purging); SP=social pressure (to eat or gain weight).

Item	Wording	Single-factor	3-factor	5-factor
			<u>D3</u>	<u>WP</u>
Q01	I am scared about being overweight	✓	✓	✓
Q11	I think a lot about wanting to be thinner	✓	✓	✓
Q14	I think a lot about having fat on my body	✓	✓	✓
				<u>D5</u>
Q06	I am aware of the energy (calorie) content in foods that I eat	✓	✓	✓
Q16	I stay away from foods with sugar in them	✓	✓	✓
Q17	I eat diet foods	✓	✓	✓
Q07	I try to stay away from foods such as breads, potatoes, and rice	✓	✓	
Q10	I feel very guilty after eating	✓	✓	
Q12	I think about burning up energy (calories) when I exercise	✓	✓	
Q22	I feel uncomfortable after eating sweets	✓	✓	
Q23	I have been dieting	✓	✓	
Q24	I like my stomach to be empty	✓	✓	
			<u>BN&FP</u>	<u>FP</u>
Q03	I think about food a lot of the time	✓	✓	✓
Q04	I have gone on eating binges where I feel that I might not be able to stop	✓	✓	✓
Q21	I give too much time and thought to food	✓	✓	✓
Q18	I think that food controls my life	✓	✓	
				<u>VP</u>
Q09	I vomit after I have eaten	✓	✓	✓
Q26	I have the urge to vomit after eating	✓	✓	✓
			<u>OC</u>	<u>SP</u>
Q08	I feel that others would like me to eat more	✓	✓	✓
Q13	Other people think I am too thin	✓	✓	✓
Q20	I feel that others pressure me to eat	✓	✓	✓
Q02	I stay away from eating when I am hungry	✓	✓	
Q05	I cut my food into small pieces	✓	✓	
Q15	I take longer than others to eat my meals	✓	✓	

Table 2.

Study participants' characteristics by study visit

	11.5-year visit	16-year visit
n	13,674	12,644
Sex, girl (%)	48.6%	49.0%
Mean age in years (SD)	11.6 (0.5)	16.2 (0.5)
Region (%)		
East, urban	31.9%	30.8%
East, rural	15.4%	15.6%
West, urban	25.9%	25.6%
West, rural	26.8%	28.1%
Mean body mass index (SD) [†]	18.2 (3.1)	21.4 (3.4)
BMI categories (%)		
Under-nourished	6.0%	3.6%
Over-nourished	10.1%	9.5%
Obese	5.1%	4.4%
Mean fat mass % (SD) [‡]	17.1 (7.7)	(8.9)

[†]Weight or height measure was missing or biologically implausible for 15 participants at 11.5y and 20 participants at 16y.

[‡]Fat mass percent measure missing or biologically implausible for 224 participants at 11.5y and 45 participants at 16y.

Table 3.

Factor loadings and goodness-of-fit measures for single and multifactor CFA models of ChEAT.

Abbreviations: D[3, 5]=dieting [as specified in the 3-, 5-factor models]; OC=oral control; BN=Bulimia nervosa; FP=food preoccupation; WP=weight preoccupation; VP=vomiting (or purging); SP=social pressure (to eat or gain weight); CFI=comparative fit index; NNFI=non-normed fit index; RMSEA=root mean squared error of approximation; SRMR=standardized root mean square residual.

Item	Single-factor	3-factor	5-factor
		<u>D3</u>	<u>WP</u>
Q01	.58	.64	.70
Q11	.77	.85	.97
Q14	.71	.77	.83
			<u>D5</u>
Q06	.53	.55	.64
Q16	.63	.65	.65
Q17	.54	.56	.64
Q07	.58	.59	
Q10	.52	.57	
Q12	.62	.66	
Q22	.51	.51	
Q23	.57	.62	
Q24	.53	.55	
		<u>BN&FP</u>	<u>FP</u>
Q03	.47	.63	.73
Q04	.48	.61	.65
Q21	.55	.75	.85
Q18	.48	.60	
			<u>VP</u>
Q09	.56	.71	.82
Q26	.60	.75	.97
		<u>OC</u>	<u>SP</u>
Q08	.40	.83	.88
Q13	.30	.70	.77
Q20	.43	.84	.86
Q02	.58	.41	
Q05	.42	.40	
Q15	.35	.49	
<i>Global fit statistics</i>			
CFI	.487	.711	.977
NNFI	.439	.679	.969
SRMR	.144	.139	.048
RMSEA (90% CI)	.133 (.132, .134)	.101 (.100, .101)	.045 (.043, .047)

Table 4.

ChEAT CFA: Between-factor correlations and internal consistency. The correlations between factors (within a model) are represented by the Pearson's r coefficient. The internal consistency of each factor (and the model, overall) is represented by the omega-3 coefficient. All correlation coefficients are bounded by 0 and 1. Abbreviations: D[3, 5]=dieting [as specified in the 3-, 5-factor models]; OC=oral control; BN=Bulimia nervosa; FP=food preoccupation; WP=weight preoccupation; AFC=awareness of food contents (or calories); VP=vomiting (or purging); SP=social pressure (to eat or gain weight); AVE=Average variance explained.

Correlation coefficients							
	Between-factor (Pearson's r)			Within-factor (omega-3)		AVE	
3-factor model	OC	FP	D3	overall = .83		.42	
	OC	1	.39	.19	.69	.41	
	FP		1	.57	.87	.46	
	D3			1	.86	.40	
5-factor model	SP	FP	VP	D5	WP	overall = .83	.63
	SP	1	.18	.21	.10	-.19	.71
	FP		1	.38	.45	.37	.56
	VP			1	.37	.25	.80
	D5				1	.47	.45
	WP					1	.71

Table 5.

Between-subject variation in 11.5y and 16y BMI z-scores explained by ChEAT scores. Unexplained variance is measured by mean squared error (MSE) of the linear regression of BMI z-score on conventional and factor-based ChEAT scores. The table lists the mean MSE $\pm$ SD of 10 cross-validation folds for each model. ChEAT factors that explain more of the variance in adiposity have a lower mMSE.

Model	Unexplained variance in 11.5y adiposity (n=13,659)		Unexplained variance in 16y adiposity (n=12,624)	
	mMSE $\pm$ SD	% change from Null	mMSE $\pm$ SD	% change from Null
Null (no ChEAT scores)	1.06 $\pm$ 0.042		0.86 $\pm$ 0.039	
a) Total score	1.05 $\pm$ 0.044	1	0.85 $\pm$ 0.037	1
b) High ChEAT (total 20)	1.05 $\pm$ 0.042	1	0.85 $\pm$ 0.037	1
c) Single-factor	1.01 $\pm$ 0.042	5	0.83 $\pm$ 0.034	3
d) 3-factor	0.68 $\pm$ 0.026	36	0.68 $\pm$ 0.032	20
e) 5-factor	0.65 $\pm$ 0.029	38	0.68 $\pm$ 0.035	21