Validation of a Child Version of the Three-Factor Eating Questionnaire in a Canadian Sample – A Psychometric Tool for the Evaluation of Eating Behaviour

Short title: Validation of a Child Version of the Three-Factor Eating Questionnaire

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The authors' responsibilities were as follows: JY, KEG, EJB, VD, DT, KBA and JPC designed the research; JY conducted the research; JY and KG analyzed the data; JY and JPC wrote the manuscript; and JPC had primary responsibility for the final content. Ryan Featherstone, a student with the Healthy Active Living and Obesity (HALO) research group at the Children's Hospital of Eastern Ontario Research Institute, also helped with data collection. All authors read and approved the final manuscript.

Ethical Standards Disclosure

This study was conducted according to the guidelines laid down in the declaration of Helsinki. The Research Ethics Board of the Children's Hospital of Eastern Ontario, the Research Ethics Board of the University of Ottawa, and The Ottawa Carleton Research and Evaluation Advisory Committee approved the CTFEQ-R21 validation study. After being provided with full details of the study, written informed consent was obtained from the parent or legal guardian. Children gave their written assent and ongoing verbal assent.

Abstract

Objective: To examine score validity and reliability of a Child version of the 21-item Three-Factor Eating Questionnaire (CTFEQ-R21) in a sample of Canadian children and adolescents and its relationship with body mass index (BMI) z-scores and food/taste preferences.

Design: Cross-sectional study.

Setting: School-based.

Subjects: 158 children, 63 boys (11.5±1.6 years) and 95 girls (11.9±1.9 years).

Results: The exploratory factor analysis revealed that the CTFEQ-R21 was best represented by four factors with item 17 removed (CFFEQ-R20) representing Cognitive Restraint (CR), Cognitive Uncontrolled Eating (UE 1), External Uncontrolled Eating (UE 2), and Emotional Eating (EE) and accounted for 41.2% of the total common variance, with good scale reliability. ANOVAs revealed that younger children reported higher UE 1 scores and CR scores compared to older children, and boys who reported high UE 1 scores had significantly higher BMI Z-scores. Children with high UE 1 scores reported a greater preference for high protein and fat foods, and high-fat savoury (HFSA) and high-fat sweet (HFSW) foods. Higher preference for high protein, fat, and carbohydrate foods, and HFSA, HFSW, and low-fat savoury foods was found in children with high UE 2 scores.

Conclusions: This study suggests that the CFFEQ-R20 can be used to measure eating behaviour traits and associations with BMI z-scores and food/taste preferences in Canadian children and adolescents. Future research is needed to examine the validity of the questionnaire in larger samples and in other geographical locations, as well as the inclusion of extraneous variables such as parental eating or socio-economic status.

Keywords: children; eating behaviours; overweight; obesity, psychometric properties; food preferences; taste preferences

Introduction

The percentage of Canadian children with overweight and obesity has increased significantly over the past decade[1], with currently 1 in 7 children between the ages of 2-17 having obesity[2]. Excess weight in children and adolscents is a risk factor for a variety of chronic diseases, including hypertension, type 2 diabetes mellitus, cardiovascular disease, and certain types of cancer[2] and is linked to emotional health issues, low self-esteem[3], stigmatization[4], poor academic performance, and lower quality of life in children and adolescents[5], which may increase the risk of presenting altered eating behaviours. Although the health consequences of obesity are well established, obesity is a multi-factorial condition with a paucity of successful treatment or prevention strategies[1].

Dietary intake, eating behaviours, appetite, and physical inactivity in the pediatric population are linked to the obesogenic environment, which imposes factors that encourage overeating or increased energy intake in the form of energy and sugar-dense foods, increasing passive overconsumption[6, 7]. As eating behaviour traits are one factor affecting weight gain, part of the solution to overcoming the high rates of obesity is to understand the link between eating behaviour traits and excess weight. Specific eating behaviour traits have been linked to excess weight in children and adolescents[8, 9, 10]; however, the ability to accurately and conveniently measure these eating behaviour traits, especially in Canada, remains an important understudied research area.

One widely used tool to measure eating behaviour traits is the Three-Factor Eating Questionnaire (TFEQ) developed by Stunkard and Messick[11]. The TFEQ is a self-assessment scale based on the Restraint Theory (RS)[12], and the Latent Obesity Theory proposed by Meyer and Pudel[13]. The TFEQ measures eating behaviour traits in response to social, environmental, and emotional factors, such as (1) Dietary Restraint (restriction of food intake to control weight), (2) Disinhibition (tendency to

overeat opportunistically), and (3) Hunger (responsiveness to internal and external hunger sensations)[11].

The TFEQ has recently been revised into a psychometrically robust shortened version of the 21-item questionnaire (TFEQ-R21) utilizing the same items as the original TFEQ but assessing slightly different factors: (1) Cognitive Restraint (CR; unchanged), (2) Uncontrolled Eating (UE; eating in response to food palatability and likelihood of overeating), and (3) Emotional Eating (EE; eating in response to negative moods)[14]. The UE and EE subscales of the TFEQ-R21 were shown to have utility in predicting weight gain and weight loss success in obese and non-obese adult samples, while EE was also found to be associated with overweight and obesity[14]. Until recently, research on the utility of the TFEQ has focused on varied adult populations[11,14,15,16,17,18,19,20], including university students[15, 21,22,23], participants of weight loss interventions[24,25,26,27] and adolescents[16,28,29].

Associations between BMI and CR[9,16,28,29,30,31,32,33,34], EE[29,35,36,37], and UE[8,29,38] currently exist in the literature in children and adolscents. However, the eating behaviour traits measured in these studies were based on the adult TFEQ and not on a TFEQ version that had been developed for children and adolescents. A Spanish version of the TFEQ-R21 tailored to children and adolescents was recently developed; the subsequent analysis confirmed the three-factor structure and good subscale internal consistency of the questionnaire[10]. Furthermore, researchers found that children who scored low on all three subscales of the TFEQ-R21 C were found to have lower BMI and weight[10]. More recently, an English Child version of the TFEQ-R17 (CTFEQ-R17) has been developed[8] to measure the cognitive and behavioural nature of food intake. The findings[8] supported a three-factor structure, with a good internal consistency[8]. This study also found that a higher CR score was associated with a higher weight and BMI, and high UE and EE scores were associated with a preference for high-fat savoury (HFSA) and sweet foods (HFSW)[8]. However, no research to date has reported on the utility or validation of the instrument in Canadian child and adolescent populations. Therefore, the development and validation of a Canadian child version of the questionnaire is needed for pediatric populations to elucidate relationships between eating behaviour traits and weight.

The primary objective of this study was to validate scores of a Child version of the 21-item Three-Factor Eating Questionnaire developed by Bryant and colleagues (CTFEQ-R21)[8], by examining reliability and validity evidence of CTFEQ-R21 responses in a sample of Canadian children and adolescents. The secondary aim was to examine the associations between the CTFEQ-R21 factors, BMI z-scores, and food/taste preferences.

Methods

Participants

Information letters and consent/assent form packages were sent to 11 schools in the Ottawa area and a convenience sample of 176 children was recruited from 7 schools. The final sample used for analysis was 158, as some students were absent during the time of data collection. The principal inclusion criteria were that the participants, both male and female, had to be between the ages of 8 and 15 and had to be fluent in English to participate. The participants who completed the questionnaires consisted of a sample of 158 children, 63 boys (mean age: 11.5 ± 1.6 years; mean BMI: 23.8 ± 4.5 kg/m^2; mean BMI Z-score: 0.22 ± 1.41) and 95 girls (mean age: mean age: 11.9 ± 1.9 years; mean BMI: 24.7 ± 6.5 kg/m^2; mean BMI Z-score: 0.13 ± 1.20).

Study Protocol

The study was conducted on one single occasion in the classroom at their school. Testing was carried out at approximately the same time of day each time (between 9 am, and 11 am) to reduce the effects of appetite on self-reported eating behaviour traits and food preferences. Participants were asked to self-complete two short questionnaires on eating behaviour traits and food preferences (20-25 minutes). All participants received verbal and written instructions on how to complete the questionnaires. Once the questionnaires were completed, the researcher measured the participant's height and weight in a separate, private area (3-5 minutes). The participant remained fully clothed, with socks on.

182 Measurements

183 *Questionnaires*

184 *The 21-item Child version of the Three-Factor Eating Questionnaire (CTFEQ-R21).* The TFEQ-R21
185 Child Version (CTFEQ-R21)[8] is a 21-item questionnaire based on the adult version of the
186 questionnaire[14]. Through structured interviews with children and adolescents a modified version of the
187 questionnaire for children and adolescents (CTFEQ-R21) was developed. The CTFEQ-R21 contains 21
188 questions, with a 4-point Likert scale for answering items 1 through 20, and an 8-point response scale
189 for item 21[8]. The CTFEQ-R21 was designed to measure three factors: (1) Cognitive Restraint
190 (unchanged; 6 items), (2) Uncontrolled Eating (i.e., eating in response to food palatability and
191 likelihood of overeating; 6 items), and (3) Emotional Eating (i.e., eating in response to negative moods;
192 6 items)[8]. Responses on each item of the questionnaire were given a score between 1 and 4, items 1-16
193 were reverse coded[39], and item 21 was coded as follows: 1-2 as "1", 3-4 as "2", 5-6 as "3", and 7-8 as
194 "4". After items were coded, domain scores were calculated, as a mean of all items within each
195 domain. Higher scores in each domain are indicative of greater CR, UE, or EE[8].

196

197 *Food Preference Questionnaire.* An adapted paper-based version of the Leeds Food Preference
198 Questionnaire (LFPQ), originally validated in an adult population[40], has been demonstrated to be
199 suitable for use in children and to predict actual food intake[41]. The questionnaire measures the liking,
200 wanting, and preference for certain foods that are categorized by low- and high-fat and by sweet and
201 savoury preferences[40]. The LFPQ has been shown to differentiate between weight statuses by food
202 preference categories in children[41]. The adapted food preference questionnaire[40] consists of a list of
203 32 common unbranded United Kingdom foods; this version of the questionnaire was modified to suit
204 common Canadian foods. The participant is asked to note which foods they would like to consume at
205 that moment. Responses were then coded as "1" for each item the participant indicated they would like
206 to consume. The responses were then summed into food and taste preference scores for eight
207 categories: high protein (8 food items), high-fat (8 food items), high carbohydrate (8 food items), and
208 low energy foods (8 food items), low-fat savoury foods (LFSA; 12 food items), low-fat sweet foods
209 (LFSW; 5 food items), high-fat savoury foods (HFSA; 8 food items), and high-fat sweet foods (HFSW;
210 7 food items)[8].

Anthropometric Measurements

Weight was assessed using a digital scale (A&D Medical, Milpitas, California, USA), recorded to the nearest 0.1 kg. Height was measured with a portable stadiometer (SECA, Hamburg, Germany) placed on a flat, level surface, recorded to the nearest 0.1 cm. Two height and weight measurements were taken, and a third measurement was taken in the instance that the first two measurements were more than 0.5 cm or kg apart. The average of the two closest measures was recorded. BMI was calculated as body weight in kilograms, divided by height in meters squared[42] and then converted to BMI z-scores[43] using the World Health Organization (WHO) BMI-for-age growth charts reference-standard[44].

Statistical Considerations

Sample Size Calculation

The literature provides little guidance in terms of the appropriate sample size for exploratory factor analysis, although some rules of thumb have been provided in the literature, such as including a minimum sample size of 100 participants[45] or 5 respondents per item[39], or 10-15 participants per item of the questionnaire[39]. Based on the recommendations for factor analysis sample size, and the possibility of attrition and missing data, the intent of the present study was to recruit a sample of 150-200 children and adolescents.

Data Analysis

All statistical analyses were completed using the SPSS Statistics Package[47]. Data were examined for missing data, multivariate and univariate outliers, and for violations to the assumptions for multivariate analysis through the procedures outlined by Tabachnick and Fidell[46]. Potential univariate outliers were detected from all variables in the questionnaire data (n=4) and from the regression scores calculated from the exploratory factor analysis (n=2). Based on the case by case analysis, two univariate outliers were removed from the analysis.

Data used in the Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA) met the assumptions for multivariate analysis, of linearity and homogeneity of variance. The assumptions of the absence of outliers and normality were violated, but disregarded, as the central limit theory posits that with a large sample, sampling distributions can be considered normal, and the ANOVA can produce valid results[46].

Primary Data Analysis

As suggested by the Standards for Educational and Psychological Testing validity theory and framework[48], validity evidence was examined using evidence based on internal structure, by determining the factor structure. An exploratory, maximum likelihood, analysis was performed to determine the factor structure of the CTFEQ-R21. Based on previous research, demonstrating correlations between the eating behaviour factors of the TFEQ-R21[8,10,14], oblique rotation (direct oblimin) was used, to account for the *a priori* hypothesized correlations between factors[39]. The initial number of factors to retain was determined using a structured sequence of criteria: the eigenvalue-one criteria (eigenvalue > 1)[39], the number of factors identified by the scree plot test[49], proportion of variance accounted for (>5%)[39], and the interpretability criterion. To be considered a meaningful factor that was retained, at least 3 variables (items) were required to load on the factor (minimum loading of 0.32)[46], the variables were required to share conceptual meaning and measure the same concept[39,46]. Subsequently, an item analysis was carried out to confirm the internal consistency, item-convergent validity, and item-discriminant validity of the CTFEQ-R21. Internal consistency was carried out by performing the Cronbach alpha test for each factor; an alpha >0.70 was considered adequate[39,46,48,50,51]. The obtained factor structure from the exploratory factor analysis was then examined to obtain factor-based scores (unit-weighting) by summing responses from items loading onto each factor and then taking the average of each factor to transform the domain scores into continuous variables. Factor-based scores were then used in subsequent analyses as dependent variables.

Secondary Data Analysis

A two-way factorial ANOVA was conducted to compare the main effects of age (8-11 years and 12-15 years) and sex (boys and girls), and the interaction effect between age and sex, on the questionnaire factor-based scores.

Since there are no clinical cut-offs of eating behaviour trait scores, a median split on CR, UE, and EE factor-based scores was used to dichotomize scores on each factor into low and high factor scores, to allow for group comparisons. A two-way factorial ANCOVA, controlling for age, was used to analyze the main effect of sex and eating behaviour trait median split factor-based groupings on anthropometric measures of weight, BMI, and BMI Z-score. A two-way factorial ANCOVA, controlling for BMI Z-score, was used to analyze the main effect of eating behaviour trait median split factor-based scores on food and taste preferences (high protein, high carbohydrate, high-fat and low energy food preference; HFSA, HFSW, LFSA, LFSW).

After conducting all ANOVA and ANCOVAs, Cohen's f^2 [52] based on the partial η^2 was used to determine the effect sizes in which $f^2 \geq 0.02$ was considered a small, $f^2 \geq 0.15$ was considered a medium, and $f^2 \geq 0.35$ was considered a large effect size[46].

Results

Primary Analysis Results

The data met the assumptions for exploratory factor analysis. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy index, with a value of 0.778 and Barlett's test of sphericity test was significant with a value of $\chi^2 = 938.55$ $p<0.001$, indicating that there was a sufficient proportion of variance within the sample and items were sufficiently correlated for factor analysis. The exploratory, maximum likelihood, analysis with oblique rotation produced six factors with Eigenvalues greater than 1, which

accounted for 48.4% of the total common variance. In an examination of the scree plot, 3-4 main factors were identified. The unrestricted exploratory factor analysis identified four common factors with at least three items loading on each, thereby suggesting a new four-factor structure (four-factor questionnaire). Two unique factors were also identified (Factors 5 and 6), accounting for 17.06 % of the total variance, but only one item from the questionnaire loaded onto each of the identified factors. Factors 5 and 6, as well as item 17, were removed in further analysis, and the questionnaire was referred to as the 20-item Child version of the Four-Factor Eating Questionnaire (CFFEQ-R20).

Table 1 presents the results from the maximum likelihood, exploratory factor analysis with oblique rotation (direct oblimin), with a four-factor restriction and item 17 removed from the CTFEQ-R21 questionnaire. The test produced four factors, accounting for 41.2% of the variance, with all items loading significantly on one factor only. As seen in Table 1, the factor of EE was retained as in the original TFEQ-R21[14] and CTFEQ-R21[8], with items 2, 4, 7, 10, 14, and 16 loading onto Factor 2. The original factor of CR[8,14] was also retained, with items 1, 5, 11, 18, and 21 loading onto Factor 3, with the exception of item 17. The original factor of UE[8,14] was also retained, but items from the original UE factor divided into two factors in the data; Factor 1 (items 3, 8, 9, 13, 19, and 20) and Factor 4 (items 6, 12, 15) in Table 2. Therefore, Factor 1 was titled UE 1, with items 3, 8, 9, 13, 19, and 20 loading onto the same factor and Factor 4 was titled UE 2, with items 6, 12, and 15 loading onto the same factor. The items in both UE 1 and UE 2 were related to uncontrolled eating items in UE 1 were conceptually related to cognition and internal hunger sensations (i.e., thinking about food or feeling hungry) and termed Internal Uncontrolled Eating, whereas the items in UE 2 were conceptually more related to senses and external food cues and stimuli (i.e., seeing or smelling food) and was termed External Uncontrolled Eating. Supported by the Externality theory, UE 1 was termed Internal Uncontrolled Eating, and UE 2 was termed External Uncontrolled Eating[53].

Insert Table 1 here

The internal reliability analysis revealed that the CFFEQ-R20 had a Cronbach α of 0.81, representing adequate/good internal consistency, with the factors of CR (α=0.71), EE (α=0.78), UE 1 (α=0.78), and UE 2 (α= 0.69) showing similarly acceptable scores. The item analysis revealed that all the factors had adequate to good inter-item correlations for CR (r=0.12-0.50), EE (r=0.24-0.62), UE 1 (r=0.27-0.48), and UE 2 (r=0.30-0.57), showing that the items within each scale correlated with one another. The corrected item-total correlation values were good for all factors: CR (r=0.30-0.50), EE (r=0.43-0.60), UE 1 (r=0.41-0.63), and UE 2 (r=0.40-0.61). Additionally, the strongest correlation of each item was found with the scale assigned, meeting the criteria for item-discriminant validity (UE 1: r=0.58-0.78; UE 2: r=0.72-0.85 CR: r=0.54-0.76; EE: r=0.62-0.76). Furthermore, the correlations between factors UE 1, EE and CR did not exceed 0.70 (r= -0.66-0.69), with the exception of factors UE 1 and UE 2 (r=0.58-0.92). The factor of UE 1 correlated significantly with UE 2 (r=0.52, $p<0.001$) and EE (r=0.27, $p<0.01$). The factor of UE 2 correlated significantly with EE (r=0.36, $p<0.001$). The factor of CR correlated significantly with EE (r=0.20, $p<0.05$).

The data can also be fit into a three-factor model to allow for comparison with the original CTFEQ-R21[8,14] currently used to assess eating behaviour traits in adults. The three-factor model is presented in the **Supplementary Material.**

Secondary Analysis Results

Relationship between CFFEQ-R20 factors and Participant Characteristics

Table 2 presents the mean CFFEQ-R20 factor-based scores by age groups (8-11 years and 12-15 years) and sex (boys and girls). The ANOVA revealed that younger children reported higher UE 1 scores [$F(1,143)= 3.99$, $p=0.048$, $f^2= 0.028$] and CR scores [$F(1,143)= 3.99$, $p= 0.001$, $f^2= 0.089$] (see Table 2). Mean factor scores of UE 2 and EE did not significantly differ between age groups. Men factor scores did not significantly differ between sex.

342

343 *Insert Table 2 here*

344

345 *Relationship between the CFFEQ-R20 and Anthropometric Measurements*

346 **Table 3** presents the mean anthropometric measurements by high and low CFFEQ-R20 factor-based
347 scores. The ANCOVA revealed that boys who reported a HUE1 had a significantly higher weight
348 [F(1,58)= 6.44, p=0.014, f^2= 0.117], BMI [F(1,58)= 5.77, p=0.020, f^2=0.106], and BMI z-score
349 [F(1,58)= 4.45, p=0.039, f^2=0.083], compared to boys that reported a LUE1. Age was a significant
350 covariate in the analysis of the difference between HUE1 and LUE1 scores and weight in boys
351 (p<0.001). No significant differences were found between sex on high and low factor-based scores, and
352 no significant differences were found within sex on high and low factor-based scores of UE 2, CR, and
353 EE.

354

355 *Insert Table 3 here*

356

357 *Relationship between CFFEQ-R20 Factors and Food and Taste Preferences*

358 **Table 4** presents the mean food preference scores derived from the Food Preference Questionnaire, by
359 high and low CFFEQ-R20 factor-based scores.

360 The ANCOVA controlling for BMI z-score showed that the HUE 1 and HUE 2 groups reported a
361 greater food preference for high protein compared to the LUE 1 [F(1,147)= 10.14, p=0.002, f^2= 0.071]
362 and LUE 2 [F(1,147)= 11.38, p=0.001, f^2= 0.079] group. The HUE 2 group reported a greater food
363 preference for high carbohydrate foods compared to the LUE 2 group [F(1,147)= 15.77, p<0.001,
364 f^2=0.110], whereas the LCR group reported a higher preference for high carbohydrate foods [F(1,147)=
365 7.98, p=0.005, f^2= 0.056] compared to the HCR group. Furthermore, the HUE 1, HUE 2, and LCR

groups reported a greater food preference for high-fat foods compared to the LUE 1 [F(1,147)= 9.50, p=0.002, f^2= 0.063], LUE 2 [F(1,147)= 13.92, p<0.001, f^2= 0.095] and HCR [F(1,147)= 6.97, p=0.009, f^2= 0.053] groups. BMI was a significant covariate in the analysis of low and high UE 2 [F(1,147)= 4.35, p=0.039, f^2= 0.030] and CR [F(1,147)= 7.60, p=0.041, f^2= 0.030].

The ANCOVA, controlling for BMI z-score, indicated that the HUE 1, HUE 2, and LCR groups reported a greater food preference for HFSA and HFSW foods, compared to the LUE 1 [HFSA: F(1,147)= 10.61, p=0.001, f^2= 0.074; HFSW: F(1,147)= 7.55, p=0.007, f^2= 0.048], LUE 2 [HFSA: F(1,147)= 9.68, p=0.002, f^2= 0.067; HFSW: F(1,147)= 14.58, p=0.000, f^2= 0.107], and HCR [HFSA: F(1,147)= 10.33, p=0.002, f^2= 0.072; HFSW: F(1,147)= 8.25, p=0.005, f^2= 0.046] groups. The HUE 2 group reported a greater food preference LFSW foods compared to the LUE 2 group [F(1,147)= 5.67, p=0.019, f^2= 0.039].

No significant relationships were found between high and low UE 1, UE 2, CR, and EE factor-based scores and low energy food preference. Additionally, no differences were found between boys and girls or young and older children, of low and high factor median split factor-based grouping on food and taste preferences.

Insert Table 4 here

Discussion

Despite the widespread utility of the adult version of the TFEQ, minimal studies have reported validity evidence of TFEQ scores in children[8,10]. The primary purpose of this article was to validate scores from a child version of the TFEQ[8] by examining the validity evidence (factor structure, convergent

and discriminant) reliability (internal consistency) of the CTFEQ-R21 in a sample of Canadian children and adolescents. The secondary aim was to examine the associations between the CTFEQ-R21 factors and BMI z-scores and food/taste preferences.

Validity of the responses to the Child version of the Three-Factor Eating Questionnaire

This study provided initial validation evidence, demonstrating that eating behaviour traits are best categorized into four factors representing: CR, UE 1, UE 2, and EE, partially supporting the original factor structure of the TFEQ-R21[14] and CTFEQ-R21[8] and the three-factor structure of the Spanish child version[10]. The four-factor model (CFFEQ-R20) was considered appropriate for our sample, as it accounted for more variance than the three-factor model, the Cronbach alpha values of the individual subscales of UE were adequate, and the model was supported by theory[53]. The different factor structure observed in this study highlights the importance of validation research to ensure we are obtaining meaningful results and cross-validation of findings to ensure they are stable across different samples.

A scale must be homogeneous for its scores and results to be interpretable and to provide relevant and useful information[48]. The original scale of UE was a heterogeneous construct, with internal and external hunger cues contributing to the overall score. This division of the original UE scale[14] in this sample is supported by Externality theory, which posits that external eating involves a decrease in internal signals to hunger and satiety and an increase in cues to external eating, which can contribute to overweight or obesity[53]. Similar to the division of UE into two factors found in our sample, Bond et al.[15] found the scale of Hunger could be usefully divided into two constructs: Internal Locus of Hunger and External Locus of Hunger. Interestingly, the items comprising the original UE factor of the TFEQ-R21[14] were composed of both Disinhibition and Hunger items of the original questionnaire[11] and Karlsson et al.[18] found that the most influential items were the items relating to appetite in participants with obesity. The division of the UE factor allows for the identification of heterogeneous

UE concepts, to determine if an increase in weight is influenced by impaired internal satiety signals[54], increased responsiveness to external food cues[55], or a combination of the two constructs.

Our findings showed that item 17 was identified as an item that did not load in the exploratory factor analysis, and items 6, 18, and 19 were items with low communalities and weak loading patterns, which is supported by the findings in adult[14,15,16,56] and child samples[10]. Items 17-20 are measured on three different 4-point Likert scales with reverse anchors, while items 1-16 are measured on the same 4-point Likert scale with different Likert response categories used for items measuring the same construct, which may contribute to the difficulty of the scale for children. It may be valuable to conduct structured interviews in which Canadian children are asked to verbalize the understanding and response to the stems[48], as the understanding of the items may vary culturally[14]. The weak loading items may be the result of response set bias in the form of social desirability, or response style bias[57,58]. Implementing a 5-point Likert scale with a neutral option should also be explored in this questionnaire to mitigate the non-response bias and social desirability response bias[59,60].

The factors of UE 1, UE 2, and CR were positively correlated with EE in our sample, which is in line with previous research[8,10,16,29] using the TFEQ and the DEBQ[10,35,38]. These results are also supported by the Externality theory[53], as an increase in EE, which is a form of disinhibition, may cause a feeling of loss of control which in turn can make an individual more susceptible to external food cues. The positive relationship between UE 1, UE 2, and EE demonstrates that emotionality and external food cues can operate together to elicit eating behaviour, despite being independent constructs[61]. The association between CR and EE was consistent with one study, in a sample of adolescents[16], but inconsistent with more recent findings in a sample of child and adolescents[8,10].

CFFEQ-R20 Factors and Participant Characteristics

441 The finding that younger children reported higher CR and UE 1 scores was supported by the findings
442 of Bryant et al.[8], whereas other research has indicated a null finding between age groups[35]. This
443 discrepancy observed in the relationships reported between CR and age may be the result of
444 adolescents underreporting restraint behaviours, particularly in girls[62]. The higher scores of UE 1 in
445 younger children demonstrate that they tend to eat more in relation to internal hunger and satiety
446 signals, than to external food cues. It has also been found that CR was related to BMI in early
447 adolescence, but later on did not predict any changes in BMI[63], which also may explain our findings
448 that CR was significantly higher in younger children (age 8-11 years). Although gender differences
449 between UE[8,16], External Eating[63], EE, and CR[16,32,36,64] have been observed previously, consistent
450 with the findings of Banos and colleagues[35], mean factor scores did not differ between sexes in our
451 sample. These results from the present study indicate that the CFFEQ-R20C may be influenced by
452 individual characteristics such as age, but not gender.

453

454 CFFEQ-R20 Factors and Anthropometrics

455 Our finding that boys reporting higher UE 1 scores had significantly higher weight, BMI and BMI z-
456 scores is concordant with previous research[8,29,55]; however, it has also been found that lower UE
457 scores were associated with a greater BMI[10]. As higher UE scores have been found to be associated
458 with overweight/obesity in adults[33], it is possible that the association between UE and BMI starts
459 developing in adolescence and increases with age, which is supported by the findings of Snoek and
460 colleagues[63]. The lack of relationship between UE 2 and weight outcomes may be the result of the
461 limited number of items within the factor to accurately measure this construct of eating behaviour.
462 Bruch[65] has also suggested that individuals with obesity may not be able to distinguish between
463 internal hunger sensations and other sensations which may stem from parents using food as a reward
464 instead of in response to internal hunger sensations. Furthermore, Banos and colleagues[35] found that
465 the relationship between External Eating and EE together, explained the higher BMI values. Therefore,
466 it may be useful to examine an aggregate score between UE and EE, and its relationship with BMI.

467

Contrary to our null findings, CR scores have been found to be linked to a higher BMI in children and adolescents[10,16,28,30,31,32,34], especially in girls[8,66]. These findings have been explained in terms of the Goal Conflict Theory[67], which states that restrained eaters have an internal conflict between eating food for enjoyment and restricting food intake to control weight. Furthermore, constantly being surrounded by an obesogenic environment makes it more difficult to exercise CR especially when stress and dysphoric moods act as disinhibitors[67]. The differences observed in the literature suggest that the relationship between CR is complex and it may interact with other eating behaviour traits to manifest weight outcomes[9,68]. Furthermore, Gallant et al.[68] found that when the CR factor was examined as a whole, there were no differences in BMI z-scores in children and adolescents, but when the CR factor was divided into the Flexible and Rigid Control scales, BMI z-scores were positively related to the Rigid Control scale of the CR factor, suggesting that the Flexible Control Scale may have a moderating effect on BMI.

CFFEQ-R20 Factors, and Food and Taste Preferences

Children who reported high UE 1 and high UE 2 scores reported greater preference for high protein and fat, and HFSA and HFSW foods; this taste preference pattern associated with high UE 1 and high UE 2 has also been observed in child and adolescent populations[8], showing higher preference for high carbohydrate and fat, and HFSA and HFSW foods. These results are also consistent with findings in adult populations, where it was found that high UE scores were related to more fatty and salty foods[16,69]. The main food/taste preference linked to overeating in both girls and boys has also been identified as sweet foods[70], which is also linked to high-fat foods, as sugar has been found to conceal the taste of fat[71]. This finding is consistent with the Externality Theory[53], in that an increase in sensitivity to external food cues can lead to overeating; in the current obesogenic environment those external food cues[72,73] are normally related to highly palatable foods, such as foods high in fat, salt, and sugar[23,74]. Furthermore, from the perspective of macronutrient composition, high-fat and carbohydrate foods have a higher energy density and have a low satiating ability, which can lead to increased food intake, passive overconsumption, and higher susceptibility to internal hunger cues[75]. In

fact, Chambers and Yeomans[76] found that girls often overate resulting from low satiating effects of carbohydrates. The consistency between findings in adult samples and children for UE suggests that these food preferences may develop in childhood and persist into adulthood. Research has shown that higher levels of the hunger hormone ghrelin have been associated with a higher preference for fat[77], which may explain the finding that high Internal Uncontrolled Eating (UE 1) scores were associated with high-fat, HFSA, and HFSW preferences. The preference for high-fat and sweet foods observed in those with high UE may be in fact related to EE, as sweet foods and high-fat foods are shown to relieve stress, by stimulating opioid release in the brain to protect the body from stress[78].

Our results showed that low CR scores were related to preference for high-fat and carbohydrate foods, and HFSA and HFSW foods. Consistent with our results, a higher CR score has also been shown to be negatively correlated with HFSW and HFSA foods in adults[79,80]. The variability of the relationship between CR and food preferences may be the result of some individuals having a better ability to maintain CR[26,54,81].

Limitations and Future Directions

While this study contributes to the current validity evidence for a tool to assess eating behaviour traits in Canadian children and adolescents and assess eating behaviour traits in relation to weight status, it is important to acknowledge the limitations of the study. Due to the small sample size, the use of a convenience sample of children mainly enrolled in public schools, and small number of participants with overweight/obesity (n=8) the results may not be generalizable to all Canadian children and we cannot rule out sampling bias[82] and the possibility that the children with healthier eating behaviours may have been more inclined to participate in the study. Although relationships between food/taste preferences, and anthropometric measures and CFFEQ-R20 were found, actual food intake was not recorded. Another limitation to note is that we did not collect data on ethnicity and socioeconomic status, which may act as extraneous variables. Future research should focus on examining the internal

structure of the new four-factor model of the questionnaire in a larger sample of Canadian children and adolescents taking into account extraneous variables[83,84]. Furthermore, future research should examine the relationship between off-spring and parental eating behaviours using the CFFEQ-R20 and the TFEQ-R21[14], to provide a more thorough understanding of the eating behaviour traits that are influenced by parental eating patterns.

Conclusion

In summary, this study demonstrated evidence of reliability and validity of scores that the CTFEQ-R21 is best represented by a 20-item four-factor model in our sample. The psychometric analysis revealed that revision of the instrument might increase the validity and reliability. It is also recommended that researchers conduct a psychometric analysis of the questionnaire in their sample before drawing conclusions based on the results. The CFFEQ-R20 was able to identify relevant eating behaviour traits associated with higher BMI z-scores in both sexes and age groups. In younger children, food and taste preferences were linked more strongly with the psychological factors of the CFFEQ-R20, whereas food and taste preferences in boys were linked more strongly with anthropometric measures. The process of accumulating validity evidence is ongoing and more evidence to support the four-factor model of the questionnaire is needed before it can be fully implemented as a stable measure of eating behaviour in children and adolescents. It is hoped that this research will stimulate research efforts in this area with a long-term goal of preventing and managing obesity across diverse pediatric populations.

546 **Table 1.** Rotated factor structure loading of the 20-item Child version of the Four-Factor Eating
547 Questionnaire (FFEQ-R20 C) of the exploratory factor analysis, with a four-factor restriction model.

548

Questionnaire Items	Factor 1 Uncontrolled Eating 1	Factor 2 Cognitive Restraint	Factor 3 Emotional Eating	Factor 4 Uncontrolled Eating 2	Communality
1. I eat small portions of food to control my weight	-.061	.622*	-.028	-.131	.430
2. I start to eat when I feel worried	.030	-.037	-.517*	-.003	.273
3. Sometimes when I start eating, it seems I can't stop	.590*	.179	.018	.020	.342
4. When I am sad, I usually eat too much	.031	.020	-.591*	.092	.328
5. I don't eat some kinds of food because they can make me fat	.052	.634*	.019	.103	.389
6. When I am eating next to someone who is eating, I also feel like eating	.017	.078	-.167	-.362*	.235
7. When I feel angry, I need to eat	.236	.062	-.403*	.002	.294
8. I often get so hungry that I feel like I could eat loads of food without getting full	.647*	-.034	-.020	-.145	.551
9. When I am hungry, I feel like I have to eat all of the food on my plate in one go, without stopping	.537*	-.014	-.060	-.058	.352
10. When I feel lonely, I make myself feel better by eating	-.148	.048	-.736*	-.117	.581
11. I eat less than I want at meal times to stop myself from putting on weight	.107	.692*	.007	-.081	.499

12. When I smell or see my favorite food, I find it hard to stop myself from eating it, even if I've just finished a meal	.080	-.025	.060	-.821*	.704
13. I am always hungry enough to eat at anytime	.530*	-.156	-.075	-.131	.439
14. If I feel nervous, I try to calm myself down by eating	-.114	.088	-.678*	-.067	.494
15. When I see something that looks delicious, I get so hungry that I have to eat it right away	.201	.065	-.059	-.578*	.543
16. When I feel really upset, I want to eat	.113	-.112	-.623*	-.011	.437
18. How often would you eat less than you wanted to in a meal?	-.012	.355*	-.034	-.105	.152
19. Do you eat lots of food even when you are not hungry?	.341*	.016	-.159	-.073	.219
20. How often do you feel hungry?	.737*	-.124	.073	.016	.537
21. What types of eater are you on a scale of 1 to 8? Where 1 means 'I eat whatever I want, whenever I want' and where 8 means 'I am careful about what I eat to control my weight'	-.136	.592*	-.011	.236	.449
Explained variance	21.47	11.27	5.53	2.97	-
Cumulative variance	21.47	32.74	38.27	41.24	-

549

550 FFEQ-R20 C, 20-item child version of the three-factor eating questionnaire.
551 *Items loading significantly onto subscales.
552 N=145

Table 2. 20-item Child Version of the Four-Factor Eating Questionnaire C (FFEQ-R20 C), mean factor-based scores between age and sex groups.

	8-11 years old			12-15 years old			All age groups (8-15 years old)	
	Boys (n=42)	Girls (n=44)	Total (n= 86)	Boys (n=16)	Girls (n=43)	Total (n=59)	Boys (n=58)	Girls (n=87)
CR	2.37 (0.50)	2.18 (0.64)	2.27*[B] (0.59)	1.98 (0.47)	1.85 (0.53)	1.89*[B] (0.51)	2.26 (0.52)	2.02 (0.62)
UE 1	2.25 (0.73)	2.07 (0.64)	2.16*[A] (0.69)	1.88 (0.47)	2.01 (0.47)	1.97*[A] (0.47)	2.15 (0.68)	2.04 (0.56)
UE 2	2.53 (0.83)	2.56 (0.76)	2.55 (0.79)	2.19 (0.82)	2.53 (0.69)	2.44 (0.73)	2.44 (0.83)	2.54 (0.72)
EE	1.72 (0.54)	1.57 (0.52)	1.64 (0.54)	1.54 (0.61)	1.47 (0.43)	1.49 (0.48)	1.67 (0.56)	1.52 (0.48)

CR, cognitive restraint; UE 1, uncontrolled eating 1; UE 2, uncontrolled eating 2; EE, emotional eating.
*P<0.05
[A]Younger children have significantly higher UE 1 score compared to older children [F(1,143)= 3.99, p=0.048].
[B]Younger children have significantly higher CR score compared to older children [F(1,143)= 3.99, p= 0.001].
Data are shown as mean (standard deviation).
N=145

Table 3. Anthropometric measurements and body weight categories by high and low Four-Factor Eating Questionnaire C (FFEQ-R20 C) factor-based scores.

	Low CR		High CR		Low UE 1		High UE 1		Low UE 2		High UE 2		Low EE		High EE	
	Boys (n=30)	Girls (n=59)	Boys (n=28)	Girls (n=28)	Boys (n=23)	Girls (n=24)	Boys (n=35)	Girls (n=63)	Boys (n=23)	Girls (n=24)	Boys (n=35)	Girls (n=63)	Boys (n=32)	Girls (n=54)	Boys (n=26)	Girls (n=33)
Weight (kg)	43.17 (14.41)	45.03 (10.66)	39.07 (10.06)	39.86 (10.91)	42.65*[A] (10.98)	45.93 (8.39)	40.24*[A] (13.57)	42.47 (11.62)	42.65 (10.98)	45.93 (8.39)	40.24 (13.57)	42.47 (11.62)	40.41 (11.58)	44.13 (9.54)	42.17 (13.85)	42.16 (12.96)
BMI (kg/m^2)	23.26 (5.20)	25.54 (7.20)	24.34 (3.55)	23.93 (4.83)	24.25*[B] (4.31)	25.34 (6.48)	21.48*[B] (4.62)	24.92 (6.64)	24.25 (4.31)	25.34 (6.48)	23.48 (4.62)	24.92 (6.64)	23.08 (5.03)	24.10 (6.67)	24.64 (3.60)	25.09 (6.47)
BMI z-score	0.071 (1.368)	0.134 (1.229)	0.389 (1.147)	0.212 (1.095)	0.358*[C] (1.125)	0.193 (.9872)	0.136*[C] (1.359)	0.147 (1.253)	0.358 (1.125)	0.193 (.9872)	0.135 (1.359)	0.147 (1.254)	0.003 (1.276)	0.225 (1.143)	0.504 (1.218)	0.047 (1.257)

BMI, body mass index; CR, cognitive restraint; UE 1, uncontrolled eating 1; UE 2, uncontrolled eating 2; EE, emotional eating.
*P<0.05
[A]Boys, in the High UE 1 group had a significantly higher weight compared to the Low UE 1 group [F(1,58)= 6.44, p=0.014].
[B] Boys in the High UE 1 group had a significantly higher BMI compared to the Low UE 1 group [F(1,58)= 5.77, p=0.020].
[C]Boys in the High UE 1 group had a significantly higher BMI Z-score compared to the Low UE 1 group [F(1,58)= 4.45, p=0.039].
Age was a significant covariate in the analyses (p<0.001).
Data are shown as mean (standard deviation).
N=145

Table 4. Mean food and taste preference scores (Leeds Food Preference Questionnaire) by high and low Four-Factor Eating Questionnaire C (FFEQ-R20 C) factor-based scores.

	Low CR (n=89)	High CR (n=56)	Low UE 1 (n=47)	High UE 1 (n=98)	Low UE 2 (n=47)	High UE 2 (n=98)	Low EE (n=88)	High EE (n=57)
High Protein Preference	3.32	2.68	2.48*[A]	3.58*[A]	2.26*[B]	2.48*[B]	2.81	3.47
	(2.17)	(2.00)	(1.93)	(2.16)	(1.91)	(2.12)	(2.13)	(2.06)
High Carbohydrate Preference	3.98*[D]	3.09*[D]	3.34	3.89	2.77*[C]	4.05*[C]	3.65	3.63
	(1.88)	(1.92)	(1.82)	(2.00)	(1.88)	(1.83)	(1.92)	(1.97)
High Fat Preference	4.09*[G]	3.20*[G]	3.19*[E]	34.21*[E]	2.89*[F]	4.15*[F]	3.55	4.05
	(2.05)	(2.01)	(2.02)	(2.02)	(1.90)	(2.04)	(2.08)	(2.05)
Low Energy Preference	4.69	4.61	4.84	4.51	4.57	4.70	4.65	4.68
	(1.89)	(1.84)	(1.88)	(1.85)	(1.67)	(1.86)	(1.76)	(2.02)
High Fat Savoury Preference	0.47*[J]	0.33*[J]	0.34*[H]	0.49*[H]	0.32*[I]	0.47*[I]	0.39	0.47
	(0.27)	(0.25)	(0.26)	(0.26)	(0.24)	(0.27)	(0.27)	(0.27)
High Fat Sweet Preference	0.53*[M]	0.43*[M]	0.43*[K]	0.54*[K]	0.38*[L]	0.54*[L]	0.48	0.52
	(0.24)	(0.24)	(0.25)	(0.02)	(0.23)	(0.24)	(0.23)	(0.27)
Low Fat Savoury Preference	0.44	0.40	0.40	0.43	0.36*[N]	0.45*[N]	0.41	0.44
	(0.22)	(0.22)	(0.21)	(0.24)	(0.21)	(0.22)	(0.21)	(0.22)
Low Fat Sweet Preference	0.64	0.66	0.66	0.64	0.62	0.66	0.67	0.62
	(0.25)	(0.26)	(0.25)	(0.28)	(0.23)	(0.28)	(0.25)	(0.28)

CR, cognitive restraint; UE 1, uncontrolled eating 1; UE 2, uncontrolled eating 2; EE, emotional eating.
*P<0.05

[A]The high UE 1 group reported a significantly higher preference for high protein foods, compared to the Low UE 1 group [F(1,147)= 10.14, p=0.002]
[B]The high UE 2 group reported significantly higher preference for high protein foods, compared to the Low UE 2 group [F(1,147)= 11.38, p=0.001]
[C]The high UE 2 group reported significantly higher preference for high carbohydrate foods, compared to the Low UE 2 group [F(1,147)= 15.77, p<0.001]
[D]The Low CR group reported significantly higher preference for high carbohydrate foods, compared to the High CR group [F(1,147)= 7.98, p=0.005]
[E]The High UE 1 group reported significantly higher preference for high fat foods, compared to the Low UE 1 group [F(1,147)= 9.50, p=0.002]
[F]The High UE 2 group reported significantly higher preference for high fat foods, compared to the Low UE 2 group [F(1,147)= 13.92, p<0.001]
[G]The Low CR group reported significantly higher preference for high fat foods, compared to the High CR group [F(1,147)= 9.50, p=0.002]
[H]The High UE 1 group reported significantly higher preference for HFSA foods, compared to the Low UE 1 group F(1,147)= 10.61, p=0.001]
[I]The high UE 2 group reported significantly higher preference for HFSA foods, compared to the Low UE 2 group [F(1,147)= 6.68, p=0.002]
[J]The Low CR group reported significantly higher preference for HFSA foods, compared to the High CR group [F(1,147)= 10.33, p=0.002]
[K]The High UE 1 group reported significantly higher preference for HFSW foods, compared to the Low UE 1 group [F(1,147)= 7.55, p=0.007]
[L]The High UE 2 group reported significantly higher preference for HFSW foods, compared to the Low UE 2 group [F(1,147)= 14.58, p=0.001]
[M]The Low CR group reported significantly higher preference for HFSW, compared to the High CR group [F(1,147)= 8.25, p=0.005]
[N]The High UE 2 group reported significantly higher preference for LFSA foods, compared to the Low UE 2 group
BMI was a significant covariate (p=0.039-0.041)
Age was a significant covariate in the analyses (p<0.001).
Data are shown as mean (standard deviation).
N= 145

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