# Eating Behaviour, Physical Activity, TV Exposure and Sleeping Habits in Five Year Olds: A Latent Class Analysis

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# Abstract

**Background** Diet, physical activity, sedentary behaviours, and sleep time are considered major contributory factors of the increased prevalence of childhood overweight and obesity. The aim of this study was to identify behavioural clusters of five year old children based on lifestyle behaviours, their association with sociodemographic and maternal characteristics and early feeding practices, and to determine if class membership was associated with cardio metabolic outcomes.

**Methods** Latent class analysis of eating behaviour, engagement in active play, TV watching, and sleep duration in 1,229 five year old children from the Cork BASELINE birth cohort study was used to identify behavioral clusters. Determinants of cluster membership were investigated using multinomial logistic regression. Associations between the identified classes and cardio body measures were examined using multivariate logistic and linear regression, with cluster membership used as the independent variable.

**Results** 51% of children belonged to a normative class, while 28% of children were in a class characterised by high scores on food avoidance scales in combination with low enjoyment of food, and 20% experienced high scores on the food approach scales. Children in both these classes had lower conditional probabilities of engaging in active play for at least one hour per day and sleeping for a minimum of 10 hours, and higher probability of watching TV for two hours or more, compared to the normative class. Children in the class with high scores on food approach scales, had higher fat mass index (FMI), lean mass index (LMI), and waist-to-height ratio (WtHR) compared to the normative class, and were at greater risk of overweight and obesity.

**Conclusion** Findings suggest that eating behaviour appeared to influence overweight and obesity risk to a greater degree than activity levels at five years old. Further research of how potentially obesogenic behaviours in early life track over time and influence adiposity and other cardio metabolic outcomes is crucial to inform the timing of interventions.


# 1. Introduction

Obesity is an important risk factor for multiple non-communicable diseases (NCD) and is associated with increased mortality[1-5]. Children and adolescents with obesity have been found to be approximately five times more likely to have obesity in adulthood compared to children without obesity[6]. Behaviours that directly or indirectly contribute to energy imbalance, including dietary patterns, physical activity (PA), sedentary behaviours, and sleep time are considered major contributory factors of the increased prevalence of childhood overweight and obesity[7]. Furthermore, these behaviours have been found to often coexist and interrelate, and to be established at an early age[7]. Exploratory data-driven methods have been increasingly used to examine patterns of lifestyle behaviours in children and adolescents[8]. Methods include cluster analysis (CA), a heuristic cluster technique which involves linking cases by looking at all possible pairs of cases and linking those in the pair with the smallest distance, then continuing in this manner until all cases lie in one large cluster, and latent class analysis (LCA), a model-

based clustering approach that derives clusters using a probabilistic model[9]. A key advantage of model-based over heuristic cluster techniques is that they provide fit statistics and information on the probability that an individual is within a particular class[10].

Reviews of studies using CA or LCA to identify patterns of lifestyle behaviours in children and adolescents have found that these behaviours often cluster in complex ways and that group membership differs by gender, age and socio economic status[8, 11]. Most previous studies have been conducted in older children, while evidence in young children (< 6 years) is more limited[12, 13]. Moreover, few studies have studied diet, physical activity, sedentary behaviour, and sleep simultaneously, with sleep in particular often not included[14, 15]. Previous research on eating behaviour clusters or profiles is also limited, with most studies having examined the quality of diet using food frequency questionnaires (FFQ) or dietary recall[8]. The Child Eating Behaviour Questionnaire (CEBQ) is a parent-report questionnaire designed to capture individual differences in aspects of eating style that may contribute to both underweight and overweight[16]. CEBQ has previously been used to identify eating behaviour reflecting fussy/picky eating in children using latent profile analysis (LPA)[17], however it has not previously been considered in conjunction with other lifestyle behaviours.

The aim of this study, using data from Irish Cork BASELINE (Babies after SCOPE: Evaluating the Longitudinal Impact using Neurological and Nutritional Endpoints) Birth Cohort Study[18], was to identify groups of children based on eating behaviour, activity-related behaviours, and sleep at 5 years of age. Further, we aimed to assess whether the groups identified were associated with sociodemographic and maternal characteristics and early feeding practices. We also sought to determine if class membership was associated with body measure outcomes at five years of age, including overweight and obesity, fat mass index (FMI), lean mass index (LMI), and waist-to-height ratio (WHtR).

# 2. Methods

## 2.1 Study population and design

Study subjects were participants of the Cork BASELINE (Babies after SCOPE: Evaluating the Longitudinal Impact using Neurological and Nutritional Endpoints) Birth Cohort Study [18], a mother–infant prospective birth cohort study based in Cork, Ireland. It was initiated in 2008 as a follow-up to the SCOPE (Screening for Pregnancy Endpoints) Ireland study, a major multi-centre prospective pregnancy study involving primiparous low-risk women. 1,537 SCOPE participants consented for their infants to participate in the BASELINE study and during a second stream of recruitment, a further 646 infants were recruited after delivery from the postnatal wards of Cork University Maternity Hospital, with primiparous low risk women having a singleton pregnancy being the main inclusion criterion. Paediatric follow-up with in-person assessments were conducted at birth, 2, 6, and 12 months and at 2 and 5 years. Data on the child’s early-life environment, diet, health and development were recorded at each assessment. In a subgroup of children (n=591), body composition and bone mineral density (total body and lumbar spine) were

measured at 5 years using DXA (GE Healthcare Lunar iDXATM). In total, 2,172 infants were recruited. 1,229 of the children had data at the five year assessment and was used for the purpose of this analysis; thus representing a 43% attrition rate.

## 2.2 Children's lifestyle factors included in LCA

Eating behaviour at 5 years of age was assessed using the CEBQ. The CEBQ consists of 35 items scored on a 5-point Likert scale from 1 'never' to 5 'always'. Items are assigned to eight subscales: Emotional Overeating (EOE), Food Responsiveness (FR), Enjoyment of Food (EF), Desire to Drink (DD), Emotional Undereating (EUE), Satiety Responsiveness (SR), Food Fussiness (FF) and Slowness in Eating (SE). Subscales represent two dimension; "food approach" (EOE, EF, FR, DD) and "food avoidance" (EUE, SR, FF, SE). All items are listed in Supplementary Table 1. The mean score was calculated for each subscale and expressed as z-scores. Physical activity and TV watching were assessed from the responses to questions regarding the time spent on average participating in active play and sitting still watching TV on weekdays and weekends. Dichotomous variables were created for active play <1 hour per day and ≥1 hour per day and TV watching <2 hours per day and ≥2 hours per day based on national and international guidelines and World Health Organization (WHO) recommendations on sedentary behaviour[19]. A dichotomous variable was created for sleep duration (<10 hours or ≥10 hours) as10-14 hours sleep has been recommended by the American Academy of Sleep Medicine as appropriate for children aged 5 years[20].

## 2.3 Sociodemographic and maternal characteristics and early feeding

Maternal educational attainment, socioeconomic status (SES), marital status, smoking status, and activity levels were assessed at the 5 year assessment. SES was determined using the New Zealand Socioeconomic Index (SEI)[21], with a variable created for SEI<24. A dichotomous variable was created for participation in physical activity other than walking and for TV watching with categories <2 and ≥2 hours per day. Maternal body mass index (BMI) was obtained according to standard operating procedures at the 5 year assessment and categorised as under/normal weight, overweight, or obese. Breastfeeding status was obtained at 2 months and categorised as any breastfeeding vs no breastfeeding. Timing of introduction of solids was assessed at 6 month and a dichotomous variable was created for introduction to solids <18 weeks.

## 2.4 Child anthropometric measurements

Weight, length, and waist circumference at 5 years were obtained according to standard operating procedures. Naked weight was measured using digital scales correct to the nearest 0.1 kg. Standing height was measured using a wall mounted stadiometer. Body composition (including fat mass and lean mass) and bone mineral density (total body and lumbar spine) was measured using DXA (GE Healthcare Lunar iDXATM). These measurements were used to calculate WHtR, BMI, FMI, and LMI (calculated as body weight, fat, and lean mass divided by square of height). Weight status was assessed according to the International Obesity Task Force BMI cut-offs, with the cut-offs for 5.5 years of age used[22].

### 2.5 Statistical analysis

To identify clusters of children, we conducted LCA using variables concerning eating behaviour, physical activity, sedentary behaviour, and sleep as outlined above. We used the maximum likelihood robust estimator to account for missing data by full information maximum likelihood (FIML). This process approximates missing data by estimating a likelihood function for each individual based on variables that are present, such that all the available data points are used[23]. The optimal number of latent classes was identified based on six model-fit indices: Akaike information criterion (AIC), sample-size adjusted Bayesian information criterion (BIC), adjusted Bootstrap likelihood ratio test (BLRT), Lo-Mendell Rubin test (LMRT), entropy, and interpretability of the trajectories. Lower AIC and BIC values indicate a better model fit, while the BLRT and LMRT provide a p-value indicating whether a model with one less trajectory group (k-1 model) should be rejected in favour of a model with k trajectories [24]. Entropy is a statistic that ranges from 0 to 1 with high values (>0.8) indicating that individuals are classified with confidence [25]. Distinct classes were coded as a categorical variable (with k number of categories) and were named based on their visual appearance.

Associations between sociodemographic and maternal characteristics (educational attainment, socioeconomic index, marital status, smoking status, physical activity other than walking, TV watching, and weight status), child sex, and early feeding (breastfeeding at 2 months and timing of introduction to solids) and latent class membership were examined using multinomial logistic regression, with class membership the outcome of interest and the most commonly occurring class chosen as the reference category. Associations between class membership and weight status, FMI, LMI, and WHtR were examined using logistic and linear regression, with class membership as the independent variable. These models were further adjusted for maternal characteristics, sex, and early feeding. Analysis was conducted using Mplus version 8[26] and Stata version 14[27].

# 3. Results

### 3.1 Latent class analysis results

LCA of the CEBQ subscales, daily activity level, TV-watching, and sleep duration indicated three distinct classes. The three-class model was selected based on the fit indices in Table 1.. AIC, BIC, and BLRT indicated a better fit for a four trajectory model, however LMRT indicated that a four trajectory model was not significantly superior to the three trajectory one. Additionally, entropy was slightly superior for the three-class model. Descriptive statistics of maternal (educational attainment, SEI, marital status, weight status, smoking status, physical activity, and TV watching) and child (sex, breastfeeding, introduction of solids, physical activity, TV watching, and CEBQ subscale scores) characteristics by latent class membership are outlined in table 2. Table 3 describes the conditional probabilities of active play ≥1hr/day, TV-watching ≥2hrs/day, and sleep duration ≥10hrs/night and Figure 1 shows the pattern of CEBQ subscale scores for each of the three identified classes. 51% of children were found to be in the normative class, with CEBQ subscale scores within 1SD. This class had higher conditional probabilities of

engaging in active play for at least one hour per day and sleeping for a minimum of 10 hours, and lower probability of watching TV for two hours or more, compared to the two other classes. Class 2 (28%) was found to be characterised by a pattern of high scores on food avoidance scales (food fussiness, slowness in eating, and satiety responsiveness) in combination with low enjoyment of food. Class 3 (20%) experienced high scores on the food approach scales (enjoyment of food, emotional overeating and food responsiveness).

### 3.2 Associations between sociodemographic and maternal characteristics and early feeding and latent class membership

For class 2, the class characterised by high food avoidance, low enjoyment of food, lower levels of activity play and higher levels of TV watching, compared to class 1 (normal-stable), SES and breastfeeding were found to be associated. SEI<24 increased the risk of membership of this class (Relative risk ratio (RRR) (95% Confidence Interval (CI)): 1.82 (1.09-3.07)), while any breastfeeding at two months was found to be inversely associated (RRR (95% CI): 0.64 (0.45-0.91)). Membership of class 3, the class characterised by high scores on the food approach scales and lower activity levels, was found to be associated with educational level, with attainment of a degree, compared to no third level education, inversely associated (RRR (95% CI): 0.44 (0.22-0.90)). No associations were found for mother’s weight or lifestyle behaviours, including smoking, participation in physical activity other than walking, and TV watching for 2 hours or more per day. Table 4 provides a full outline of the multinomial logistic regression analysis.

### 3.3 Class membership and weight status and cardio metabolic measures at 5 years

Associations between latent class membership and body outcome measures at 5 years of age are displayed in Table 5. Class 2, characterised by high food avoidance, low enjoyment of food, and lower activity levels, had significantly lower FMI and LMI compared to Class 1. These differences persisted after adjusting for demographic and maternal characteristics, child sex, and early feeding. Conversely, class 3, the class with high food approach subscale scores and lower activity levels, had significantly higher FMI, LMI, and WtHR. Additionally, class 3 had a significantly higher risk of overweight and obesity at 5 years. Children in this class were 2.88 (95% CI 1.86-4.47) times as likely to have overweight compared children in class 1, and 5.11 (95% CI 1.81-14.41) times as likely to have obesity. No significant differences in weight status were identified between class 1 and class 2.

## 4. Discussion

Using latent class analysis, we identified distinct groups of children based on eating behaviour, physical activity, TV use, and sleep at 5 years of age. Approximately half of children belonged to a normative class, while 28% of children were in a class characterised by high scores on the food avoidance scales (food fussiness, slowness in eating, and satiety responsiveness) in combination with low enjoyment of food, and 20% experienced high scores on the food approach scales (enjoyment of food, emotional overeating and food responsiveness). Children in both these classes had lower conditional probabilities

of engaging in active play for at least one hour per day and sleeping for a minimum of 10 hours, and higher probability of watching TV for two hours or more, compared to the normative class. There was also some evidence that these classes were associated with lower maternal education level and SEI. There was evidence that children in class 3, the class with high scores on food approach scales, had higher FMI, LMI, and WtHR compared to the normative class, and were at greater risk of overweight and obesity. Conversely, children in class 2 had lower FMI and LMI compared to class 1. These differences persisted after adjusting for potential confounders.

Several literature reviews have analysed the results of studies using CA or LCA to identify lifestyle behaviour patterns in children and adolescents[8, 28, 29]. Few studies included children younger than 6 years, and only one previous study considered diet, physical activity, sedentary behaviour, and sleep concurrently[12]. In addition to including variables on all these lifestyle behaviour in young children, this is also to our knowledge the first study to include eating behaviour, as opposed to dietary quality. There is a large body of evidence showing the link between eating behaviours and weight status in young children[30-32]. The CEBQ has been shown to have a robust factor structure, high internal validity and test–retest reliability[33]. LPA has previously been used to identify an eating behaviour profile reflecting fussy/picky eating in children and to describe characteristics of fussy eaters[17, 34], however CEBQ subscale scores have not been considered in conjunction with other lifestyle factors. A previous study using data from the same cohort as this study found an association between CEBQ scores and weight status at 2 years of age[35]

Previous findings suggest that obesogenic behaviour patterns are complex, with a mixed high physical activity and high sedentary behaviour cluster observed most frequently, but with healthy and unhealthy patterning of all behaviours also reported[8]. Our study found no evidence of a mixed pattern in terms of physical activity and sedentary behaviour; as both classes deviating from the normative group in terms of eating behaviour had lower physical activity and higher sedentary behaviour levels. Similarly to previous studies[8], SES appeared to influence group membership, with children from lower socioeconomic backgrounds more likely to belong to the high food avoidance class, and children with lower educated parents more likely to the high food approach class.

Previous evidence in relation to an association between lifestyle behaviours and obesity outcomes has been inconsistent; some studies have found a higher prevalence of overweight/obesity in unhealthy classes while other studies found no such association[8]. This study found a strong association between class membership and overweight and obesity, with children in the high food approach group at approximately three times as high risk of overweight and five times as high risk of obesity compared to the normative group. As children in both class 2 and 3 had lower conditional probabilities of engaging in active play for at least one hour per day and sleeping for a minimum of 10 hours, and higher probability of watching TV for two hours or more, compared to class 1, it appears that eating behaviour influences overweight and obesity risk to a greater degree than activity levels. Diet has previously been found to be more strongly associated with weight and weight loss than exercise and physical activity. While negative

energy balance and subsequent weight loss can be achieved by either reducing energy intake or increasing energy expenditure, exercise-induced weight loss is usually small, and smaller than expected from an exercise-induced increase in energy expenditure[36, 37]. Physical activity does however have multiple benefits for adults and children alike, regardless of weight status. Previous studies have found physical activity to be inversely associated with all-cause mortality at all levels of BMI and waist circumference[38], while others have found that sustained physical activity, rather than weight loss, was associated with improved survival in coronary heart disease[39]. For children physical activity has been found to have numerous benefits. Apart from positive changes in adiposity, it is also associated with skeletal and psychological health, cognitive function and cardiorespiratory fitness[40]. Physical inactivity may therefore be an important issue to address in all groups of children, regardless of adiposity status. In our study, the children in the food avoidance class had the lowest conditional probability of engaging in active play for 60 minutes per day and the highest of watching TV for more than two hours per day. While there were no associations between membership of this class and overweight or obesity risk, it is possible that the higher levels of physical inactivity could have other implications.

### *Strengths and limitations*

This study has several strengths. The relatively large sample was recruited from the only maternity hospital in Cork, Ireland, and therefore included mothers and children from a broad range of social circumstances, thus increasing the generalisability of the findings. Our study included several adiposity-specific outcomes, which were obtained by trained staff using standardised instruments using Standard Operating Procedures. Furthermore, our analytical approach is based on LCA, which involve fewer subjective decisions than clustering techniques such as CA do, and presents several advantages, specially dealing with missing values and mixed-type variables, as well as the possibility of full model selection. Another advantage of LCA is that it provides class membership probabilities for each child, which may be used to effectively assess the robustness of the classification.

However, limitations remain. Firstly, although the CEBQ is a validated tool, the study includes a reliance on parental report for all behavioural data, which is known to be vulnerable to both recall and social desirability biases. Further, measures of physical activity and sedentary behaviour were assessed using participation in active play and TV-watching as proxies, thus not providing us with a complete profile of activity-related behaviour. As the study sample consisted of predominantly Caucasian women and children (98%), ethnic differences could not be taken into account. Finally, longitudinal attrition has the potential to introduce bias. Lost to follow-up is an important issue to be considered in any cohort study due to its potential threat to study validity. Of the 2,172 participants at the start of the study, 1,229 were still enrolled and assessed at age five, resulting in an attrition rate of 43%. Certain methodological limitations must also be noted. The assignment of children to latent classes is based on their highest estimated group-membership probability to the identified pattern. Thus, these latent patterns should not be considered as the actual behavioural patterns but, rather, as approximations of more complex ones.

## 5. Conclusion

We identified three latent classes based on eating behaviour, activity and sleep in children aged 5 years using a large prospective birth cohort in Ireland. Children with high food approach scores combined with lower levels of activity and sleep duration were at increased risk of overweight and obesity. Further research of how early life eating behaviour and activity levels influence overweight and obesity risk is warranted. In particular, longitudinal evidence that examines younger children over time is important; understanding how the clustering of potentially obesogenic behaviours track over time and the timing of critical periods where activity levels may decline or eating behaviour change are crucial to inform the timing of interventions. Additionally, extended follow-up of cohorts is imperative in order to determine how long-term exposure of different clustering patterns is associated with overweight and obesity and other cardio metabolic measures.

## Abbreviations

NCD – non-communicable disease

PA – physical activity

CA – cluster analysis

LCA – latent class analysis

FFQ – food frequency questionnaire

CEBQ – Child Eating Behaviour Questionnaire

LPA – latent profile analysis

BASELINE – Babies after SCOPE: Evaluating the Longitudinal Impact using Neurological and Nutritional Endpoints

FMI – fat mass index

LMI – lean mass index

WHtR – waist-to-height ratio

SCOPE – Screening for Pregnancy Endpoints

EOE – emotional overeating

FR – food responsiveness

EF – enjoyment of food

DD – desire to drink

EUE – emotional undereating

SR – satiety responsiveness

FF – food fussiness

SE – slowness in eating

WHO – World Health Organization

SES – socioeconomic status

SEI – socioeconomic index

BMI – body mass index

FIML – full information maximum likelihood

AIC – Akaike information criterion

BIC – Bayesian information criterion

BLRT – Bootstrap likelihood ratio test

LMRT – Lo-Mendell Rubin test

RRR – relative risk ratio

CI – confidence interval

# Declarations

### Ethics approval and consent to participate

Research objectives and measurements were conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures were approved by the Clinical Research Ethics Committee of the Cork Teaching Hospitals. The SCOPE Ireland study is registered at the Australian New Zealand Clinical Trials Registry (ID: ACTRN12607000551493, registration date: 26/10/2007)). The Cork BASELINE birth cohort study is registered at the United States National Institutes of Health Clinical Trials Registry (ID: NCT01498965, registration date: 21/12/2011). Families provided written informed consent at 20 weeks' gestation or at birth.

### Consent for publication

Not applicable

**Availability of data and materials**

The datasets analysed during the current study are not publicly available but are available from the study principal investigator Prof Deirdre Murray (d.murray@ucc.ie) on reasonable request.

**Competing interests**

The authors declare that they have no competing interests.

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**Authors' contributions**

DM, FB, MM, and RB were involved in the study conception and design. MM requested the data sets, performed statistical analysis of the data, and drafted the manuscript. FB provided statistical support. DM and MK were the principal investigators of BASELINE. DM, EM FB, FM, MK, and RB critically reviewed the draft manuscript. All authors reviewed and approved the final version of this manuscript.

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# Tables

### Table 1. Fit indices

| No. of classes | Class proportions | AIC | Sample-size adjusted BIC | LMRT for *k-1* versus k classes | BLRT for *k-1* versus *k* classes | Entropy |
|---|---|---|---|---|---|---|
| | | ***Value*** | ***Value*** | ***P-value*** | ***P-value*** | |
| **2** | C1: 820 (66.7%)<br>C2: 409 (33.3%) | 30350 | 30410 | <0.001 | <0.001 | 0.78 |
| **3** | C1: 644 (52.4%)<br>C2: 336 (27.3%)<br>C3: 249 (20.3%) | 29580 | 29663 | <0.001 | <0.001 | 0.79 |
| **4** | C1: 467 (38.0%)<br>C2: 285 (23.2%)<br>C3: 309 (25.1%)<br>C4: 168 (13.7%) | 29303 | 29410 | 0.0752 | <0.001 | 0.77 |
| **5** | C1: 166 (13.5%)<br>C2: 416 (33.8%)<br>C3: 301 (24.4%)<br>C4: 88 (7.2%)<br>C5: 258 (21.0%) | 29093 | 29223 | 0.0168 | <0.001 | 0.79 |

**Table 2. Population characteristics by latent class membership**

| | Total (n = 1,229) | Class 1: (n=644) | Class 2: (n=336) | Class 3: (n=248) |
|---|---|---|---|---|
| | n(%)[b] | n(%) | n(%) | n(%) |
| *Maternal characteristics* | | | | |
| **Educational attainment** | | | | |
| No third level | 94 (7.7) | 32 (5.0) | 37 (11.2) | 25 (10.1) |
| Some third level | 371 (30.5) | 186 (29.1) | 111 (33.6) | 74 (30.0) |
| Degree or higher | 752 (61.8) | 422 (65.9) | 182 (55.2) | 148 (59.9) |
| **SEI < 24** | | | | |
| No | 1,094 (89.1) | 594 (92.4) | 279 (83.0) | 221 (88.8) |
| Yes | 134 (10.9) | 49 (7.6) | 57 (17.0) | 212 (11.2) |
| **Marital status** | | | | |
| Single | 71 (5.8) | 32 (5.0) | 26 (7.7) | 13 (5.2) |
| Married/de-facto relationship | 1,157 (94.2) | 611 (95.0) | 310 (92.3) | 236 (94.8) |
| **Weight status** | | | | |
| Underweight/normal weight | 507 (52.5) | 275 (54.0) | 131 (50.2) | 101 (51.5) |
| Overweight | 292 (30.2) | 145 (28.5) | 86 (33.0) | 61 (31.1) |
| Obese | 167 (17.3) | 89 (17.5) | 44 (16.9) | 34 (17.4) |
| **Smoking status** | | | | |
| No | 1,095 (89.2) | 589 (91.6) | 284 (84.5) | 222 (89.2) |
| Yes | 133 (10.8 | 54 (8.4) | 52 (15.5) | 27 (10.8) |
| **Physical activity other than walking** | 24.9 ±4.0 | 24.9±4.1 | 24.8±3.9 | 25.3±4.1 |
| No | 493 (40.2) | 254 (39.5) | 136 (40.5) | 103 (41.4) |
| Yes | 735 (59.9) | 389 (60.5) | 200 (59.5) | 146 (58.6) |
| **Watching TV >= 2 hours per day** | | | | |
| No | 859 (72.3) | 448 (72.3) | 228 (70.4) | 183 (75.0) |
| Yes | 329 (27.7) | 172 (27.7) | 96 (29.6) | 61 (25.0) |

| | | | | |
|---|---|---|---|---|
| *Child characteristics* <br> - | - | - | - | - |
| **Sex** | | | | |
| Male | 631 (51.3) | 318 (50.4) | 192 (30.4) | 121 (19.2) |
| Female | 598 (48.7) | 326 (54.5) | 144 (24.1) | 128 (21.4) |
| **Breastfeeding at two months** | | | | |
| No | 601 (50.1) | 340 (56.6) | 142 (23.6) | 119 (19.8) |
| Yes | 604 (49.9) | 294(48.7) | 183 (30.3) | 127 (21.0) |
| **Introduction to solids <18 weeks** | | | | |
| No | 854 (71.6) | 456 (73.2) | 221 (68.0) | 177 (72.2) |
| Yes | 339 (28.3) | 167 (26.8) | 104 (32.0) | 68 (27.8) |
| **Active play >=1 hour per day** | | | | |
| No | 160 (13.0) | 61 (9.5) | 59 (17.6) | 40 (16.1) |
| Yes | 1,068 (87.0) | 582 (90.5) | 277 (82.4) | 209 (83.9) |
| **Watching TV >= 2 hours per day** | | | | |
| No | 1,024 (83.4) | 568 (88.3) | 250 (74.4) | 206 (82.7) |
| Yes | 204 (16.6) | 75 (11.7) | 86 (25.5) | 43 (17.3) |
| **Sleeping >= 11 hours per night** | | | | |
| No | 633 (51.6) | 289 (45.0) | 194 (57.7) | 150 (60.2) |
| Yes | 595 (48.5) | 354 (55.0) | 142 (42.3) | 99 (39.8) |
| **EF subscale score[c] ±SD** | 3.78 ±0.75 | 4.01 ±0.53 | 2.9 ±0.51 | 4.3 ±0.51 |
| **EOE subscale score[d] ±SD** | 1.71 ±0.61 | 1.51 ±0.41 | 1.48 ±0.46 | 2.52 ±0.57 |
| **DD subscale score[e] ±SD** | 2.56 ±0.90 | 2.31 ±0.76 | 2.74 ±1.01 | 2.97 ±0.87 |
| **FF subscale score[f] ±SD** | 2.94 ±0.90 | 2.61 ±0.70 | 3.80 ±0.76 | 2.64 ±0.77 |
| **SE subscale score[g] ±SD** | 3.08 ±0.78 | 2.89 ±0.65 | 3.75 ±0.63 | 2.69 ±0.71 |
| **EUE subscale score[h] ±SD** | 2.44 ±0.85 | 2.25 ±0.78 | 2.66 ±0.93 | 2.62 ±0.82 |
| **FR subscale score[i] ±SD** | 2.38 ±0.76 | 2.12 ±0.49 | 2.06 ±0.54 | 3.47 ±0.55 |
| **SR subscale score[j] ±SD** | 2.97 ±0.61 | 2.80 ±0.46 | 3.58 ±0.47 | 2.60 ±0.53 |

[b]n (%); indicates column percentages.

[c]Enjoyment of food

[d]Emotional overeating

[e]Desire to drink

[f]Food fussiness

[g]Slowness in eating

[h]Emotional undereating

[i]Food responsiveness

[j]Satiety responsiveness

**Table 3. Conditional probabilities by latent class**

| | Total (n=1,229) | Class 1: (n=644) | Class 2: (n=336) | Class 3: (n=248) | P-value[a] |
|---|---|---|---|---|---|
| **Active play => 1hr/day** | | | | | <0.001 |
| No | 0.13 | 0.09 | 0.18 | 0.16 | |
| Yes | 0.87 | 0.91 | 0.83 | 0.84 | |
| **Watching TV => 2hrs/day** | | | | | <0.001 |
| No | 0.83 | 0.88 | 0.75 | 0.83 | |
| Yes | 0.17 | 0.12 | 0.25 | 0.17 | |
| **Sleeping => 10hrs/night** | | | | | <0.001 |
| No | 0.52 | 0.45 | 0.57 | 0.60 | |
| Yes | 0.49 | 0.55 | 0.43 | 0.40 | |

[a]Chi-square tests

**Table 4. Multinomial logistic regression for latent class membership**

| | Class 1: RRR (95% CI) p-value | Class 2: RRR (95% CI) p-value | Class 3: RRR (95% CI) p-value |
|---|---|---|---|
| *Maternal factors* | | | |
| **Educational attainment (vs no third level)** | | | |
| Some third level | Ref | 0.66 (0.35-1.24) 0.195 | 0.64 (0.32-1.30) 0.215 |
| Degree or higher | Ref | 0.54 (0.28-1.02) 0.057 | 0.44 (0.22-0.90) **0.024** |
| **SEI < 24 (vs ≥24)** | Ref | 1.82 (1.09-3.07) **0.023** | 1.10 (0.59-2.06) 0.76 |
| **Marital status (vs single)** | | | |
| Married/de-facto relationship | Ref | 0.64 (0.34-1.22) 0.177 | 0.90 (0.42-1.91) 0.776 |
| **Weight status (vs underweight /normal weight)** | | | |
| Overweight | Ref | 1.12 (0.78-1.62) 0.539 | 1.21 (0.82-1.80) 0.337 |
| Obese | Ref | 0.74 (0.46-1.17) 0.197 | 0.95 (0.58-1.56) 0.837 |
| **Current smoker (vs nonsmoker)** | Ref | 1.46 (0.91-2.35) 0.12 | 1.15 (0.66-2.00) 0.62 |
| **Physical activity participation (vs no participation)** | Ref | 0.95 (0.68-1.33) 0.785 | 1.04 (0.73-1.49) 0.81 |
| **Watching TV ≥ 2 hours per day (vs <2 hours per day)** | Ref | 0.96 (0.67-1.38) | 0.74 (0.49-1.11) |

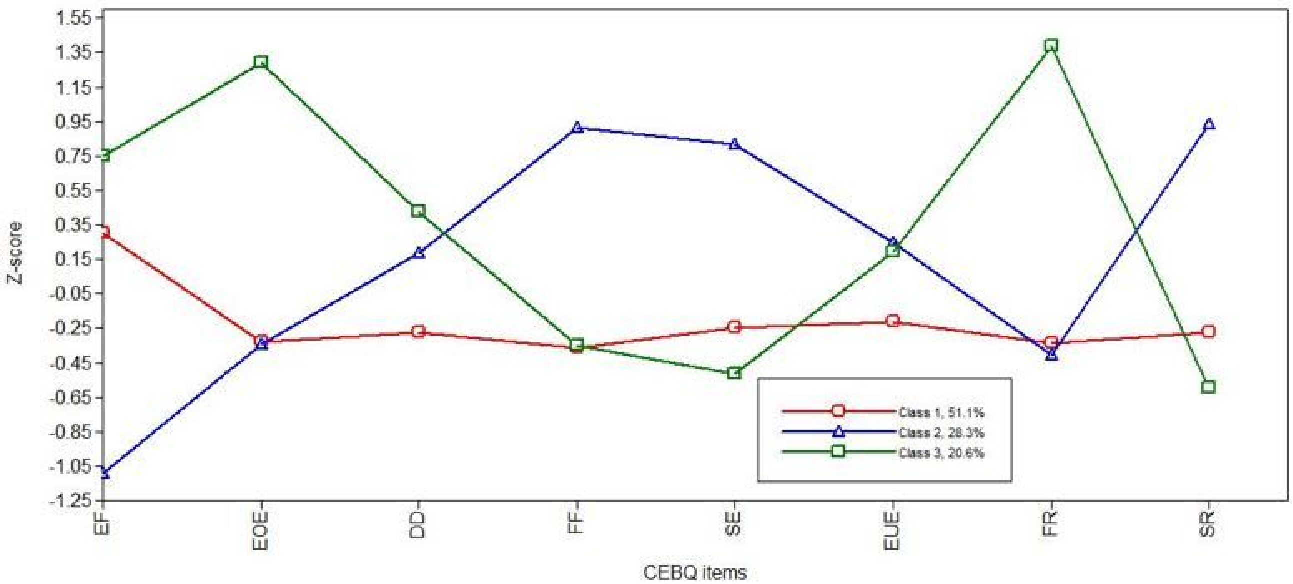
| | | | |
|---|---|---|---|
| | | 0.67 | 0.58 |
| *Child characteristics* | | | |
| **Child sex (vs male)** | | | |
| Female | Ref | 0.80 (0.58-1.11) | 1.06 (0.75-1.49) |
| | | 0.179 | 0.761 |
| **Breastfeeding at two months (vs not breast-feeding)** | Ref | 0.64 (0.45-0.91) | 1.01 (0.69-1.46) |
| | | **0.013** | 0.973 |
| **Introduction to solids <18 weeks (≥18 weeks)** | Ref | 0.98 (0.68-1.42) | 0.89 (0.59-1.34) |
| | | 0.923 | 0.58 |

**Table 5. Associations between latent classes and body measure outcomes at 5 years.**

| | Class 1 | Class 2 | Class 3 |
|---|---|---|---|
| | **Odds ratio (95% CI)**<br>**p-value** | **Odds ratio (95% CI)**<br>**p-value** | **Odds ratio (95% CI)**<br>**p-value** |
| **Overweight[a] (n=1,135)** | Ref. | 0.63 (0.37-1.07)<br>0.088 | 2.88 (1.86-4.47)<br>**<0.001** |
| **Obesity[a] (n=1,135)** | Ref. | 0.66 (0.16-2.77)<br>0.572 | 5.11 (1.81-14.41)<br>**0.002** |
| | | | |
| | **β coefficient (95% CI)**<br>**p-value** | **β coefficient (95% CI)**<br>**p-value** | **β coefficient (95% CI)**<br>**p-value** |
| **Fat mass index[a]**<br>**(n=591)** | Ref. | -.25 (-.47, -.02)<br>**0.033** | .42 (.18, .67)<br>**0.001** |
| **Lean mass index[a] (n=591)** | Ref.<br>. | -.48 (-.70, -.26)<br>**<0.001** | .30 (.06, .54)<br>**0.013** |
| **Waist-to-Height Ratio[a] (n=1,129)** | Ref. | -.002 (-.007, .003)<br>0.477 | .01 (.006, .02)<br>**<0.001** |

[a]Adjusted for maternal characteristics (educational attainment, socioeconomic index, marital status, smoking status, physical activity other than walking, TV watching, and weight status), child sex, and early feeding (breastfeeding at 2 months and timing of introduction to solids)

# Figures




EF = Enjoyment of food
EOE = Emotional overeating
DD = Desire to drink
FF = Food fussiness
SE = Slowness in eating
EUE = Emotional undereating
FR = Food responsiveness
SR = Satiety responsiveness

**Figure 1**

Figure 1 shows the pattern of CEBQ subscale scores for each of the three identified classes. 51% of children were found to be in the normative class, with CEBQ subscale scores within 1SD. This class had higher conditional probabilities of engaging in active play for at least one hour per day and sleeping for a minimum of 10 hours, and lower probability of watching TV for two hours or more, compared to the two other classes. Class 2 (28%) was found to be characterised by a pattern of high scores on food avoidance scales (food fussiness, slowness in eating, and satiety responsiveness) in combination with low enjoyment of food. Class 3 (20%) experienced high scores on the food approach scales (enjoyment of food, emotional overeating and food responsiveness).

# Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementaltable1CEBQ.docx