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Appetite and early behaviours predict growth during the first 4 months of life among infants in Klang Valley, Malaysia

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ABSTRACT

Introduction: Early infant behaviour and nutrition are linked to health and development. While appetite and temperament relate to growth, they are highly inter-correlated. Using a prospective longitudinal design, we hypothesise that early behavioural traits are longitudinally associated with infant growth. **Methods:** Breastfeeding mothers (n=64), recruited during pregnancy at antenatal clinics in Klang Valley, Malaysia, were followed up during home visits (HV) after birth at 2, 6-8, 12-14, and 16-18 weeks of infant age. Mothers completed validated questionnaires assessing infant appetite (Baby Eating Behaviour Questionnaire) and temperament (Revised Rothbart's Infant Behaviour Questionnaire), while infant weight and length were measured at each HV. At the final follow-up, 62 infants were included in the regression analyses. **Results:** Appetite and temperament traits were shown to be associated with infant growth outcomes at different time points (n=63 at HV3 and n=62 at HV4). Specifically, food responsiveness and effortful control were positively correlated with infant growth (e.g., weight standard deviation, SD gain: B=0.50, p=0.01). Conversely, slowness in eating was negatively associated with infant weight outcomes across time points (e.g., weight SD HV4: B=-0.45, p<0.01). Multivariate analyses consistently demonstrated appetite and temperament traits as predictors of infant growth measurements at different time points. **Conclusion:** Early determination of appetite and temperament traits was associated with early infant growth trajectories. Further research with a longer follow-up and larger sample size is needed to ascertain the influence of possible infant behavioural programming on later health outcomes.

Keywords: appetite, feeding behaviour, infant growth, prospective cohort, temperament

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INTRODUCTION

Optimal child development is influenced by early-life factors such as nutrition, safety, and learning opportunities. Increasing evidence also points to the importance of appetite and early behavioural patterns in shaping infant growth trajectories (Wood, 2018). Understanding the development of eating behaviours is essential for designing early interventions. Appetite is a multidimensional trait that encompasses both "food approach" behaviours (e.g., food responsiveness and enjoyment of food) and "food avoidant" behaviours (e.g., satiety responsiveness and slowness in eating), all of which can significantly affect growth outcomes (Wood, 2018).

While the roles of appetite and behaviours in body weight have been extensively studied in adults, emerging evidence suggests that these factors are also relevant in infancy and early childhood. Differences in appetite and behavioural traits among young children have been associated with varying risks of both overnutrition and undernutrition (Kininmonth *et al.*, 2021). Cohort studies have shown considerable variability in appetite traits during feeding, which can predict later weight gain in children (Llewellyn *et al.*, 2012). According to a systematic review, children with a stronger appetite, as indicated by higher scores of traits related to food approach, are predisposed to greater weight gain and an increased risk of being overweight (Kininmonth *et al.*, 2021). Additionally, maternal feeding responses to infant temperament, such as using food to soothe fussy or highly active infants, may also influence growth patterns (Harris *et al.*, 2022). These findings highlight the complex interplay between appetite, temperament, and feeding practices in shaping early weight outcomes. Understanding the variability of these traits in infancy is important, as early growth predicts both short- and long-term health. This knowledge can inform targeted interventions to reduce the risk of malnutrition. Underlying these appetite–growth associations are both behavioural mechanisms, such as maternal feeding responses, and biological pathways, including the influence of early microbiomes and hormones on metabolism.

Specifically, among breastfed infants, it has been hypothesised that certain breast milk components, such as milk hormones, may influence infant appetite, temperament, and feeding regulation, thereby affecting growth (Fewtrell, Shukri & Wells, 2020). Additionally, microbiomes in both breast milk and the infant gut, which are shaped by breastfeeding, may play a role in the production of growth-related hormones (Yu *et al.*, 2024). Previous studies also suggest that maternal relaxation therapy, aimed at reducing stress, can alter the composition and diversity of these microbiomes, potentially supporting optimal growth through enhanced hormone regulation (Robertson *et al.*, 2019).

A longitudinal infant study found that breast-fed and mixed-fed infants were reported to have more challenging infant temperaments (exhibiting greater distress, less smiling, and vocalisation) compared to formula-fed infants (de Lauzon-Guillain *et al.*, 2012). Breast milk is also digested more quickly than formula, leading breastfed infants to signal hunger more frequently through vocalisations (He *et al.*, 2020). Additionally, breastfeeding mothers may be more attuned to infant cues, as the let-down reflex is often triggered by infant crying or fussiness (Hahn-Holbrook, Little & Abbott, 2021). These behavioural responses may reflect early appetite regulation and feeding dynamics that influence growth trajectories. Temperament has also been described through personality dimensions that reflect individual

differences in reactivity and self-regulation (Bergmeier *et al.*, 2014). While partly heritable, these traits are also shaped by the environment, maturation, and life experiences. Therefore, prospective data collection is essential to understand how early behaviours influence later health outcomes, including infant growth.

Regardless of feeding method, infant appetite, reflected in feeding demand, style, or frequency, may influence later growth. For example, a vigorous feeding style at one month marked by rapid suckling has been linked to greater adiposity and a higher risk of later obesity (Stunkard *et al.*, 2004). Conversely, infant growth may also shape feeding behaviours, as greater weight gain could reflect increased appetite. While causality cannot be determined from observational studies, cohort data suggest that appetite more strongly predicts future growth than the reverse (van Jaarsveld *et al.*, 2014). However, a gap remains, as many prior studies rely on single time point assessments. Because infant behaviour fluctuates rapidly, repeated measurements are analytically crucial to capture trait stability, reduce measurement error, and establish clearer temporal directionality. These findings support further investigation into how early behavioural traits relate to infant growth trajectories. Therefore, this study aimed to examine the associations between infant appetite and temperament with weight, weight gain, and body mass index (BMI) during early life using a prospective longitudinal design. We hypothesise that early appetite and temperament predict infant growth outcomes.

METHODOLOGY

This was an observational study using longitudinal data across four months of infancy. Data were collected as part of a randomised controlled trial, known as the MOM Study, that followed up infants from 2 weeks to 16 weeks of age (Shukri *et al.,* 2017; Mohd Shukri *et al.,* 2019). This trial investigated mother-infant signalling during breastfeeding and received ethics approval from the Medical Research Ethics Committee, MOH Malaysia (ID: 13-841-16720).

Sample population

First-time mothers with a singleton pregnancy who were healthy (no chronic illness) (n=88) were recruited at antenatal clinics in Klang Valley, Malaysia. After birth, mother-infant dyads were screened for eligibility: exclusive breastfeeding mothers and healthy full-term infants who weighed >2.5 kg (n=64). Mothers who were on medication for any chronic illnesses and who smoked were excluded. Mother-infant dyads were followed up during home visits (HV) at four time points, which were 2 weeks (HV1), 6-8 weeks (HV2), 12-14 weeks (HV3), and 16-18 weeks (HV4) of infant age (Mohd Shukri *et al.*, 2019).

Study procedure

During home visits, mothers were asked to complete a questionnaire on sociodemographic factors, such as age, educational levels, and household incomes, and also validated questionnaires on infant behaviours (Baby-Eating-Behaviour-Questionnaire (BEBQ) and Revised Rothbart's Infant Behaviour Questionnaire (RIBQ). Mean scores and standard deviations for each trait from the BEBQ and RIBQ were calculated at HV1–3 and HV4, respectively. Infant weight and length were recorded during each home visit (HV1–4).

Baby Eating Behaviour Questionnaire (BEBQ)
The BEBQ, which is suitable for use in exclusive milk-feeding infants, was used to assess infant appetite from HV1 to HV3. This tool had been tested for reliability, with Cronbach's alpha values ranging from 0.73-0.81 (Llewellyn *et al.*, 2011). It comprised 18 items designed to assess general appetite (GE) and four other traits: 'enjoyment of food' (4 items), 'food responsiveness' (6 items), 'slowness in eating' (4 items), and 'satiety responsiveness' (3 items). Mothers were asked to rate or evaluate their infant's appetite and feeding behaviours during typical days on a scale from 1 (never) to 5 (always) (Llewellyn *et al.*, 2011). Scores for the items corresponding to each trait were summed and averaged to calculate a mean score, where a higher score indicated a higher inclination towards that specific appetite trait.

Revised Rothbart's Infant Behaviour Questionnaire (RIBQ)
Infant temperament was measured at 14-18 weeks of the infant's age using the validated RIBQ, which asked mothers to rate their infant's behaviour and temperament on a 7-point Likert scale, from 1 (never) to 7 (always) (Gartstein & Rothbart, 2003). Surgency/extraversion, negative affectivity, and effortful control were the three main dimensions used to evaluate infant temperament using this tool. This questionnaire had been tested for reliability and validity, with good Cronbach's alpha values (>0.7) (Gartstein & Rothbart, 2003). In this study, infants with negative affectivity scoring above 3.5 (on a 7-point scale) were classified as having a difficult temperament, while those with high effortful control scores were considered to have an easier or more adaptable temperament.

Measurements on infant
Infant weight and length were measured using a digital infant weighing machine (Seca 834, Germany) and an infant length measuring mat (Rollameter 60, UK), respectively. Using the LMS growth add-in for Microsoft Excel, data were converted to standard deviation (*SD*) scores (*Z*-scores) to calculate weight *SD* gain, as well as weight and BMI *SD* based on the WHO 2006 growth standard.

Statistical analyses
Data were analysed using IBM SPSS Statistics version 23.0 (IBM Corp., Armonk, New York, USA). Normality was tested prior to statistical analysis. Independent t-test was used to compare data between infant genders, specifically for appetite traits, whereas ANOVA was performed to compare sociodemographic groups. Paired t-test was used to compare mean scores of appetite traits between home visits. Because preliminary paired t-tests indicated that most infant appetite traits were stable across visits, aggregated mean scores were calculated across the time points to reduce intra-individual measurement errors. Univariate correlations were used to examine associations, while regression analysis or MANOVA was used to adjust for potential confounders. The backward elimination method was used for regression analysis; interaction terms were introduced where appropriate in the multivariate analyses. Potential confounders, such as infant and maternal characteristics and sociodemographics, were included in the model for regression analysis. The significance level was set at p-value <0.05. Overall study attrition was negligible, with only one dropout at HV3 (n=63) and two at HV4 (n=62).

While weight data were available for all remaining infants, length measurements at HV4 were only obtained for 50 infants because weight gain was the primary outcome of the original trial protocol, making length a secondary variable that was occasionally omitted. Consequently, missing data were handled using complete-case analysis without imputation.

RESULTS

All mother-infant dyads were followed up at all HVs, except for two dyads who dropped out from HV2 onwards due to maternal work commitments. Table 1 shows the sociodemographic characteristics of the study population.

Table 1. Maternal sociodemographic and infant gender

Characteristic	*n*	*%*
Maternal age (years)		
20-25	21	32.8
26-30	38	59.4
31-34	5	7.8
Ethnicity		
Malay	60	93.8
Chinese	2	3.1
Indian or other	2	3.1
Education levels		
School	10	15.7
Pre-university	8	12.5
Bachelor degree	39	60.9
Postgraduate degree	7	10.9
Household income		
<RM3000	19	30.0
RM3001-8000	35	55.0
>RM8000	14	15.0
Infant gender		
Boy	25	39.0
Girl	39	61.0

Infant appetite (BEBQ)

BEBQ data revealed no statistically significant differences between genders in appetite traits across all HVs, with the exception of 'slowness in eating' (SE) observed at HV3. At this time point, female infants had significantly higher SE scores compared to males, indicating a tendency towards slower feeding behaviour (p=0.03, Table 2). However, when average scores for each appetite trait were considered across all HVs, no significant gender differences were detected (all p>0.05). Furthermore, appetite traits did not vary significantly across categories

Table 2. Mean scores for appetite traits by genders

Variables	Male		Female		*p-value*	*CI lower*	*CI upper*
	n	*Mean±SD*	*n*	*Mean±SD*			
HV1							
Enjoyment of food (EF)	25	4.39±0.40	39	4.27±0.40	0.24	-0.33	0.08
Food responsiveness (FR)	25	2.98±0.80	39	3.26±0.65	0.13	-0.08	0.64
Slowness in eating (SE)	25	2.94±0.76	39	3.03±0.71	0.62	-0.28	0.47
Satiety responsiveness (SR)	25	2.49±0.62	39	2.52±0.49	0.84	-0.25	0.31
General appetite (GA)	25	4.12±0.88	39	4.21±0.80	0.69	-0.34	0.51
HV2							
Enjoyment of food (EF)	25	4.42±0.38	38	4.22±0.40	0.06	-0.40	0.00
Food responsiveness (FR)	25	3.15±0.86	38	3.31±0.69	0.43	-0.24	0.55
Slowness in eating (SE)	25	2.78±0.70	38	2.96±0.66	0.31	-0.17	0.53
Satiety responsiveness (SR)	25	2.59±0.52	38	2.55±0.47	0.79	-0.29	0.22
General appetite (GA)	25	4.20±0.91	38	4.18±0.73	0.94	-0.43	0.40
HV3							
Enjoyment of food (EF)	25	4.32±0.62	38	4.30±0.32	0.88	-0.26	0.22
Food responsiveness (FR)	25	2.89±0.75	38	3.23±0.68	0.07	-0.02	0.71
Slowness in eating (SE)	25	2.54±0.78	38	2.91±0.56	0.03	0.04	0.71
Satiety responsiveness (SR)	25	2.56±0.57	38	2.69±0.45	0.31	-0.13	0.39
General appetite (GA)	25	4.00±0.91	38	3.97±0.88	0.91	-0.49	0.44

HV: Home visit; SD: Standard deviation

of maternal age, educational attainment, or household income (all $p>0.05$). Distributions of the appetite traits 'enjoyment of food', 'food responsiveness', and 'general appetite' were positively skewed at all HVs, with mean scores approaching the upper range of the scale (approximately 5). In contrast, average scores for 'slowness in eating' and 'satiety responsiveness' tended to cluster around the midpoint (approximately 2.5). These findings suggest that most infants were perceived by their caregivers as having a strong interest in feeding and demonstrated good responsiveness to breast milk or feeding cues.

All appetite traits showed significant positive associations between visits. In addition, no significant differences were found in any of the appetite traits between home visits ($p>0.05$), except for SE between HV1 and HV3 ($p=0.02$). This demonstrates the stability of all appetite traits across time points except SE.

Infant temperament (RIBQ)

The average (±*SD*) scores for the temperament dimensions were 4.71±0.75 for surgency, 3.78±0.96 for negative affectivity, and 5.53±0.64 for effortful control. No significant differences were observed in these temperament dimensions based on gender or socio-demographic variables, with all comparisons yielding non-significant *p*-values.

Table 3. Standard deviation (*SD)* values for infant weight and body mass index (BMI) at baseline (HV1) and end-point (HV4)

Growth data	*n*	*Mean±SD*	*Minimum*	*Maximum*
Weight *SD* HV1	64	-0.74±0.78	-2.43	1.32
Weight *SD* HV4	62	-0.54±0.88	-2.37	1.81
Length *SD* HV1	64	-0.17±0.91	-1.95	1.71
Length *SD* HV4	50	0.40±0.86	-1.70	2.49
BMI *SD* HV1	64	-0.93±0.86	-2.59	0.94
BMI *SD* HV4	50	-1.08±0.92	-2.72	1.89

HV: Home visit

Infant growth measurements

At baseline (HV1, *n*=64), mean weight SD was -0.74±0.78, mean length SD was -0.17±0.91, and mean BMI SD was -0.93±0.86. At the final follow-up (HV4), mean weight SD for the 62 remaining infants was -0.54±0.88. For the 50 infants with complete measurements at HV4, mean length SD increased to 0.40±0.86, while mean BMI SD was -1.08±0.92.

Associations of infant temperament and appetite with growth outcomes

Appetite and temperament traits were included in the multivariate regression analyses as predictor variables, while socio-economic status, randomised groups, and the baby's gender were regarded as potential confounding variables. Table 4 shows the final regression models (models 1 - 5) with adjusted *R*-square values.

Summary of models 1–3 for weight *SD* at HV3–HV4 and weight *SD* gain from HV1 to HV4: Models 1 and 2 identified SE as the most robust predictor of infant weight among the behavioural variables assessed. Specifically, each 1-point addition in SE score was associated with a reduction of 0.47 and 0.45 *SD* in weight at HV3 and HV4, respectively ($p<0.01$). Conversely, higher food responsiveness scores were positively associated with infant weight outcomes. A 1-point addition in this trait estimated a rise of 0.38 *SD* in weight at HV3 and 0.50 *SD* in overall weight *SD* gain from HV1 to HV4 (both $p<0.05$). The models explained 38.0%, 40.0%, and 21.0% of the variance in weight *SD* at HV3, HV4, and *SD* increment, respectively.

Summary of Models 4 and 5 for BMI SD at HV3 and HV4: Among the infant behavioural traits included in the models, SE emerged as the most influential determinant of BMI *SD*. Each 1-point addition in SE score was associated with a reduction of 0.36 SD in BMI at both HV3 and HV4 (all $p<0.05$). In contrast, food responsiveness was positively associated with BMI at HV3, where a 1-point addition in score corresponded to an estimated elevation of 0.47 *SD* ($p<0.01$). However, this association was not statistically significant at HV4 ($p=0.06$). Models 4 and 5 explained 37.0% and 35.0% of the variance in BMI *SD* at HV3 and HV4, respectively.

DISCUSSION

The study findings supported the hypothesis that infant temperament and appetite traits were longitudinally associated with infant growth outcomes. Using prospectively collected data, consistent associations were observed across all

Table 4. Regression models for associations between infant behaviours and growth outcomes

Model/ Outcome	*Statistic*				*Adjusted R-Square*
	B	*p-value*	*CI: upper*	*CI: lower*	
Model 1 Weight *SD* HV3 (*n*=63)					
(Constant)	-0.21	0.72	-1.38	0.95	0.38
Randomised group	0.83	<0.01	0.48	1.18	
Baby's gender	-0.37	0.05	-0.74	-0.01	
Slowness in Eating	-0.47	0.01	-0.73	-0.21	
Mean FR (all HV)	0.26	0.07	-0.03	0.54	
Model 2 Weight *SD* HV4 (*n*=62)					
(Constant)	-0.73	0.21	-1.88	0.43	0.40
Randomised group	0.82	<0.01	0.47	1.17	
Baby's gender	-0.37	0.05	-0.73	0.00	
Slowness in Eating	-0.45	0.01	-0.71	-0.18	
Mean FR (all HV)	0.38	0.01	0.10	0.67	
Model 3 Weight *SD* gain HV1-4 (*n*=62)					
(Constant)	-1.32	0.07	-2.75	0.12	0.21
Randomised group	0.72	0.01	0.27	1.18	
Slowness in Eating	-0.23	0.18	-0.57	0.11	
Mean FR (all HV)	0.50	0.01	0.13	0.86	
Model 4 BMI *SD* HV3 (*n*=62)					
(Constant)	-2.83	0.01	-4.99	-0.66	0.37
Randomised group	0.99	<0.01	0.59	1.39	
Slowness in Eating	-0.36	0.02	-0.66	-0.06	
Mean FR (all HV)	0.47	0.01	0.14	0.79	
Effortful control	0.17	0.29	-0.15	0.49	
Model 5 BMI *SD* HV4 (*n*=50)					
(Constant)	-1.36	0.07	-2.85	0.13	
Randomised group	0.87	<0.01	0.44	1.30	
Baby's gender	-0.58	0.01	-1.03	-0.12	
Slowness in Eating	-0.36	0.03	-0.67	-0.04	
Mean FR (all HV)	0.35	0.06	-0.01	0.71	

HV: Home visit; SD: Standard deviation; BMI: Body mass index; FR: Food responsiveness
Backward multiple regression analysis models with infant temperament and appetite traits as dependent variables, and SES groups, randomised groups and gender as potential confounding variables.
Baby's gender: 1=Male, 0=Female. All these variables were included in all models. Only significant predictors are shown (p<0.05).

growth models in this study (weight *SD* and BMI *SD* at later time points of HV3-4 and weight *SD* gain at HV1-4), even after adjusting for confounders. This is important considering that infant appetite and behaviour data depended on parental reports. This strengthens the validity of the findings, as prospective designs reduce the risk of recall bias and reverse causality often seen in retrospective studies (van Jaarsveld *et al.*, 2014), thereby providing greater confidence in observing the temporal sequence between early behaviours and growth during early infancy.

Appetite findings in this study indicated that infants were generally perceived as enjoying feeding, being responsive to cues, and having a large appetite. Although breastfed infants are generally assumed to have a higher satiety responsiveness, which is suggested as a possible mechanism for the protective effects of breastfeeding against obesity (Carnell & Wardle, 2008), this was not shown in the present study population. This aligns with studies reporting that breastfed infants may show higher food responsiveness and lower satiety sensitivity than formula-fed infants (Llewellyn *et al.*, 2011; Yu *et al.*, 2020). A possible explanation is the faster digestion of breast milk, which may lead to more frequent hunger cues compared to formula feeding (He *et al.*, 2020).

As infant appetite appeared stable over the study period, mean scores of appetite traits were used to examine associations with growth. Overall, infant growth in the present study was positively correlated with food responsiveness and negatively correlated with the slowness in eating trait during infancy, consistent with previous studies (Quah *et al.*, 2015; van Jaarsveld *et al.*, 2014). Chen *et al.* (2020) also reported that exclusively breastfed infants show greater responsiveness, as breastfeeding is more aligned with infant cues than formula feeding. These findings also suggest that infants in the present study who were more responsive to breastfeeding tended to have greater weight gain from 2-8 weeks and thus were also heavier at later ages. In contrast, infants who fed slowly at 6-8 weeks of age had lower weight and BMI at later ages. These associations have been shown to persist up to 9-15 months in other cohorts (Quah *et al.*, 2015; van Jaarsveld *et al.*, 2014). Appetite traits are also considered partially heritable, and higher food responsiveness or large appetite in infancy may promote rapid weight gain, potentially increasing the risk of overweight in obesogenic environments (Llewellyn *et al.*, 2012; van Jaarsveld *et al.*, 2014).

Using the RIBQ tool, infants in this study demonstrated high scores in effortful control and neutral scores in negative affectivity, suggesting that mothers perceived them as having good emotional self-regulation in early infancy. Consistently, Neppl *et al.* (2020) found that positive parenting in early years is linked to better effortful control, which may influence growth. Although early temperament is considered relatively stable from birth to 18 months (Else-Quest *et al.*, 2006), it may affect infant growth, particularly during periods of rapid development. For example, a high activity level (high surgency trait) and distressing emotions (negative affectivity traits) could affect the use of energy and thus energy balance. Dupont *et al.* (2018) reported that infants with high surgency traits showed slower head circumference growth in the first year. Persistent distress behaviours like crying and vocalisation also increase energy expenditure, which may affect growth, especially during the first 6 months of life when energy demands for growth are highest (Pontzer *et al.*, 2021).

Conversely, infants with lower distress and a calmer personality (higher effortful control) could save more energy for growth. This concept is supported

by our findings, as effortful control was positively correlated with infant weight *SD*, BMI *SD*, and weight gain. However, surgency and negative affectivity were not associated with growth in this sample, differing from previous studies reporting positive correlations with growth at 3 months or later (Burton *et al.*, 2011; Niegel *et al.*, 2007; Slining *et al.*, 2009). Infant temperament may also influence parental feeding styles, particularly among first-time mothers learning to interpret infant cues. For instance, higher vocalisation or irritability may lead to more frequent feeding, even when not hunger-related, potentially explaining the association between challenging temperament and greater weight gain found in earlier studies. Such cues may reflect genuine hunger in early infancy, given the high energy cost of vocalisation. However, this behaviour may become less reliable as infants grow, especially after six months, when energy demands for growth significantly decline (Pontzer *et al.*, 2021).

Previous studies linking difficult temperament and infant growth relied solely on maternal reports, without incorporating objective measures of physical activity or energy expenditure (Niegel *et al.*, 2007; Slining *et al.*, 2009). As a result, the underlying mechanisms of the association between temperament and growth remain unclear. Nevertheless, maternal reports can still be considered valid when the objective is to assess maternal perception of infant appetite and how mothers interpret and respond to infant cues. Furthermore, Putnam *et al.* (2024) reported that patterns of negative affectivity are stable from infancy to childhood, and regulatory capacity persists into toddlerhood. These findings suggest that certain temperament traits are stable across early development, offering valuable insight into how early behavioural patterns relate to growth trajectories during infancy.

As this study was based on observational data, several limitations should be acknowledged. Firstly, the modest sample size (n=64), combined with multiple predictors and outcome variables, may have limited the statistical power to detect smaller effects. While the overall study dropout was negligible, missing secondary measurements (e.g., length at HV4) reduced the analytical sample for BMI calculations, which could limit the statistical power of these specific models. Secondly, infant appetite and temperament were assessed exclusively via parent-report instruments (BEBQ and RIBQ). Although these were validated tools, they relied on maternal perception and may introduce respondent bias compared to objective physiological or behavioural measurements. Thirdly, the follow-up period was relatively short, being limited to 4 months. Because early behaviours and growth trajectories evolve rapidly and are shaped by ongoing environmental factors, parenting styles, and maturation (Bergmeier *et al.*, 2014), our findings cannot firmly predict long-term childhood outcomes such as obesity. Longer follow-up is needed to fully understand the long-term impact of early feeding behaviours and nutritional programming on growth and health outcomes. Lastly, as with any observational study, causal relationships cannot be established; however, the findings highlighted significant longitudinal associations and suggested possible pathways for further investigation. Despite these limitations, the study offers valuable insights and contributes to the growing evidence base for future research in this area.

CONCLUSION

The findings of this study supported the hypothesis that measures of infant appetite and early behavioural traits can predict growth outcomes. If these traits remain persistent during childhood, early determination of appetite and temperament traits may help identify infants at risk of rapid weight changes during early development. However, the generalisability of the results is limited, as the sample consisted predominantly of highly educated Malay mothers living in urban areas due to unintentional selection bias from recruiting exclusively breastfeeding mothers. Nevertheless, the current study highlights the potential of appetite traits to be identified as early markers for the risk of rapid weight gain among children, particularly in obesogenic environments. Future research should explore whether these traits can be used to develop targeted interventions aimed at preventing malnutrition.

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Authors' contributions

Shukri NHM, served as the principal investigator; she conceptualised and designed the study, carried out data collection, performed data analysis and interpretation, and prepared the initial draft of the manuscript; Wells JC, reviewed and revised the manuscript; Fewtrell M, contributed to study conceptualisation and data interpretation, assisted in drafting the manuscript, and reviewed its final version.

Conflict of interest

All authors declare that they have no conflict of interest.

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