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DOI:
10.1093/ajcn/nqy241

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Sources of Support and Disclaimer: This project was funded by the National Institute for Health Research Health Technology Assessment Programme (project number 06/85/11). KLH is funded by the National Institute for Health Research, Collaboration for Leadership in Applied Health Research and Care West Midlands (NIHR CLAHRC WM). The views and opinions expressed therein are those of the authors and do not necessarily reflect those of the HTA, NIHR, NHS or the Department of Health. The funders have played no role in the design of the study or collection, analysis, and interpretation of data, nor in the writing of the manuscript and in the decision to submit the manuscript for publication.

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Short running head: Parent feeding, child eating, and weight status

Abbreviations:

BMI	Body Mass Index
CEBQ	Child Eating Behaviours Questionnaire
CFPQ	Comprehensive Feeding Practices Questionnaire
IMD	Index of Multiple Deprivation
WAVES	West Midlands ActiVe lifestyle and healthy Eating in School children study
UK	United Kingdom

Abstract:

Background: Some research suggests that parent/carer feeding practices may influence children's weight patterns, but longitudinal evidence is limited and inconsistent.

Objective: To investigate the relationship between various parent/carer feeding practices when a child is 7-8 years and proxy measurements of child adiposity at 8-9 years (weight status, waist-to-height ratio, and body fat percentage).

Design: Secondary analysis of data from the West Midlands ActiVe lifestyle and healthy Eating in School children (WAVES) study comprising a diverse sample of parents/carers and their children from 54 primary schools in the West Midlands, England (n= 774 parent-child dyads (53% of the WAVES study sample)). Information on feeding practices was collected using subscales from Comprehensive Feeding Practices Questionnaire, completed by the child's main parent/carer (self-defined). Child height, weight, body fat percentage, and waist circumference were measured and converted into three proxy measurements of adiposity (weight status, waist-to-height ratio, and body fat percentage). Associations between these measurements and parent/carer feeding practices were examined using mixed-effects logistic regression models.

Results: Of the questionnaire respondents, 80% were mothers, 16% were fathers and 4% other carers**.** Median standardised subscale scores ranged from 1.7 (Interquartile Range=1.0; (emotion regulation)) to 4.0 (Interquartile Range =1.5; (monitoring and modelling)) and significantly different subscale scores were present between child weight statuses for emotion regulation, pressure-to-eat, and restriction for weight control. Logistic regression modelling showed that when baseline adiposity measures were included as covariates, all associations between parental feeding practices at age 7-8 years and measures of adiposity at age 8-9 years were attenuated.

Conclusions: Observed relationships between various parental feeding practices and later are mitigated by inclusion of the baseline adiposity measure. This finding lends support to the theory of reverse causation, whereby the child's size may influence parental choice of specific feeding practices, rather than the child's subsequent weight status being a consequence of these feeding practices.

Introduction:

Excess weight in children is an important public health concern, with adverse physical and psychosocial consequences in childhood, and increased risk of morbidity and mortality in later life (1, 2). Two recent reviews have highlighted that common environmental factors, such as parent feeding practices, have a substantial effect on Body Mass Index (BMI) from childhood through to adolescence (3) and that parental food habits and feeding practices are the most dominant family system determinants of children's eating habits and food choices (4). There is also evidence of 'intergenerational ripples', whereby parents develop their feeding practices based on their own childhood feeding experience (5).Therefore, understanding the effect of parental feeding practices on children's adiposity has been identified as a research priority, as it could inform the development of interventions with potential impact beyond the current generation (6).

Parent feeding practices relate to the specific methods and behaviours that parents employ to influence children's behaviour, health, or weight (7, 8) and are distinct from the more generalistic parent feeding style which typifies the levels of demandingness and responsiveness a parent expresses in feeding and eating interactions (9, 10). Examples of parental feeding practices include pressuring children to eat certain foods, using food as a reward, or not allowing the child to eat certain foods. Evidence from a variety of studies suggests that certain parent feeding practices are associated with child weight status. For example, restrictive feeding practices are associated with higher weight status (11-16), whilst pressure to eat is related to lower weight status (11, 15-18). However, these findings are inconsistent and sometimes conflicting (18-22), particularly in relation to other parent feeding practices (for example, using food as a reward (15, 16, 19, 20)). A number of methodological limitations in previous studies constrain potential interpretation. For example, most were cross-sectional in nature, and the measures of adiposity used have been limited, with few previous studies using multiple measures such as waist-to-height ratio or body fat percentage. Additionally, previous studies rarely consider how child characteristics influence parental feeding practices. Shloim *et al.* (2015) noted in their systematic review of studies (n = 31) that, where child characteristics were measured, the parental feeding practices employed were responsive to the child. For example, more restriction was seen in children with greater adiposity or greater perceived food approach tendencies and more pressure to eat in thinner children or those perceived to be undereating (10). However, the direction of the proposed effect is still ambiguous. Therefore, it is important to consider the possibility of reverse causation, whereby parental use of specific feeding practices may be driven by a child's weight status, rather than subsequent child weight status being a consequence of them. Additionally, much of the research focus in this area has been on young children and so little is known about whether a relationship between these factors exists in older children when they begin to exert some level of autonomy over their food decisions.

This study investigates the relationship between parent feeding practices when children are aged 7-8 years, and their adiposity measures at 8-9 years, using a socially and ethnically diverse sample of UK families. Adiposity is assessed through the primary outcome of weight status based on BMI z-score and the secondary outcomes of waist-to-height ratio, and body fat percentage.

Methods:

We conducted a secondary analysis of data collected between 2011 and 2014 at baseline (T0: children aged 5-6 years), first (T1: children aged 7-8 years) and second (T2: children aged 8-9 years) follow-up for the **W**est Midlands **A**cti**V**e lifestyle and healthy **E**ating in **S**chool children (WAVES) study; a cluster-randomised controlled trial evaluating the clinical and cost-effectiveness of an obesity prevention programme in an ethnically diverse population of children from the West Midlands, UK. National Health Service Research Ethics approval for the WAVES study was obtained from the Black Country Research Ethics Committee (NHS REC no.10/H1202/69) and the trial was registered in May 2010 (ISRCTN97000586).

The WAVES study cohort was recruited from 54 state-funded primary schools in the West Midlands, UK. Written informed consent was obtained from parents and verbal assent was obtained from each child prior to measurements commencing. Further information can be found in the WAVES study protocol (23).

Trained researchers, blind to the WAVES study trial arm allocation, measured the height, weight and waist circumference of each child in school at each time point, using validated instruments (Leicester Height Measure MK II (Harlow Healthcare, UK) and Tanita BC-420MA Class 111 Body Composition Analyser (Tanita, Japan)) and standard proctocols (23). Child weight status was dichotomised into individuals with overweight (including individuals with obesity) or individuals without overweight using the age and sex specific 85th centile cut-off from the UK 1990 growth reference charts (24). Waist-to-height ratio was calculated by dividing the child’s waist circumference (cm) by their height (m) and dichotomised into high or low risk using a threshold of 0.5 (25, 26). Body fat percentage was calculated using bioelectrical impedance (27) and was dichotomised using the age and sex specific threshold for a high body fat percentage for each child provided by Tanita® (28).

Data on parent feeding practices were collected through a self-administered questionnaire booklet sent home for completion by the child's main parent or carer (self-defined) at T1. Subscales of the Comprehensive Feeding Practices Questionnaire (CFPQ) were used to assess a wide range of parent feeding practices (29). The CFPQ has been shown to be valid in children up to twelve years old (22, 29, 30) and in varied cultural contexts (30-32). To keep respondent burden to a minimum, only the following subscales were included in the WAVES study parent questionnaire: child control; emotion regulation; environment; food as a reward; modelling; monitoring; pressure to eat; and restriction for weight control. Minor wording changes from the original questionnaire were applied to make the tool appropriate for a UK population e.g. replacing 'Soda' with 'Fizzy pop'.

Likert scales ranging from one (never) to five (always) scored each item. For ease of interpretation, item scores were summed, and then divided by the number of items in the subscale. Subscale scores were not calculated if there were missing data from more than one (3-5 item scales) or two (6-8 item scales) item(s). Where subscale scores were calculated with missing data, the subscale was standardised using the completed number of items as the denominator. Questionnaire subscale response rates ranged from 89% (modelling) to 92% (emotion regulation). All questionnaire subscales had moderate to good internal consistency with Cronbach Alphas (α) ranging from 0.6 (environment) to 0.9 (monitoring).

Parent reported home postcodes, mapped to the English Indices of Multiple Deprivation 2007 (IMD), were used as a measure of socioeconomic status (using the quintile cut offs for England) (33). Child eating behaviour subscales of ‘food responsiveness’, ‘enjoyment of food’ and ‘emotional over eating’ were collected from the Child Eating Behaviour Questionnaire (CEBQ) embedded within the WAVES parent questionnaire booklet. Scoring of these subscales was conducted in the same manner as the CFPQ. As these three CEBQ subscales all represent eating behaviours that potentially lead to greater food intake, they were combined to create one “food approaching eating behaviour” score. Other relevant information (parent age and ethnicity (using the UK census ethnic group categories (34))) were also collected through the WAVES study parent questionnaire booklet. Where parent ethnicity was missing, child ethnicity from school records was used as a proxy.

Parents and children participating in the WAVES study were included in the present study if a questionnaire booklet was returned at T1 and any child anthropometric adiposity measurement (weight status, waist-to-height ratio or body fat percentage) was available at T2. Statistical analysis was performed using STATA 13 (StataCorp LP, US) and, due to multiple tests being performed, a conservative *a priori* significance level of 1% (two-sided) was utilised. Descriptive statistics to summarise participant characteristics are presented by child weight status. The internal validity of all questionnaire subscales was assessed using Cronbach Alpha.

To account for the clustered nature of the sample, mixed-effects logistic regression models were used to evaluate the relationship between CFPQ subscales and each anthropometric outcome measure. Three models were developed. Model 1 was adjusted only for the WAVES study trial arm allocation (fixed effect) and school attended (random effect) to account for the data being collected after delivery of the WAVES study intervention and the clustered nature of the sample. Model 2 was additionally adjusted for the sex of the child, child food approaching feeding behaviour score, IMD score (deprivation index), and parent level factors (age and ethnicity). Model 3 was further adjusted for T0 values for the outcome measure (BMI z-score, waist-to-height ratio or body fat percentage) to investigate whether any associations exist independently of baseline values.

To consider the impact of missing data on the relationships investigated, all further adjusted models (Model 3) were repeated on a dataset where missing covariate information was imputed. Generation of imputed datasets was conducted in REALCOM-Impute (35) to account for the clustered nature of the sample, imported into STATA using the realcomImputeLoad command, and analysed in STATA 13. Generation of imputed datasets included the following incomplete variables: T2 outcome of interest, T0 outcome measure, child food approaching eating behaviour composite score, parent age, parent ethnicity (White, South Asian, Black African-Caribbean and Mixed/Other ethnicities), deprivation score of household (IMD 2010). Additionally, the following complete variables were included to improve the accuracy of the imputation: sex of the child, WAVES study trial arm, school level free school meal entitlement proportion, and school level ethnic mix (White, South Asian, Black African-Caribbean and Mixed/Other ethnicities). The results of ten imputed datasets were pooled to produce imputation estimates.

Results:

There were between 716-774 parent-child dyads included in these analyses (49-53% of the WAVES study participants, **Figure 1**). Parents of White children were the most likely to respond to the questionnaire (64%) and parents of Black children were least likely to respond (44%). Additionally, there was a graded response rate across the deprivation quintiles, with the highest responses coming from the least deprived quintile (75%) and the lowest from the most deprived quintile (53%). There was no difference in the response rates according to the age or sex of the child (**Supplemental Table 1**).

Child and parent characteristics at T2 (aged 8-9 years) are described by child weight status in **Table 1**. Overall, 80% of responders were mothers, 16% fathers, and 4% other relatives (e.g. grandmother, stepfather, or aunt). The mean parent age was 36.7 years (standard deviation (SD) 6.7 years). Additionally, almost a third of children were identified with overweight (30.6%). A slightly higher proportion of boys than girls had overweight and children of a mixed, Black or South Asian ethnicity were more likely to have overweight than White children, which is in line with England averages (36). However, there was only a significant difference in children of a Black ethnicity.

High median scores were seen in the parent feeding practices of monitoring and modelling (median scores 4.0 (Interquartile range (IQR) 1.5)), indicating that parents employed these practices most frequently (**Figure 2**). Significant differences between weight status groups were evident for the parent feeding practices of emotion regulation, pressure to eat, and restriction for weight control, with parents of children with overweight using more restriction and emotion regulation and less pressure to eat.

Association with proxy measures of child adiposity

Similar patterns emerged across all proxy measurements for adiposity (**Figure 3**). In Models 1 (minimal adjustment) and 2 (which accounted for most covariates), a significantly increased risk of overweight, central adiposity, or high body fat percentage were found if parents employed restriction and a significantly decreased risk if parents employed pressure to eat. However, after the inclusion of a baseline measure for the adiposity outcome being considered (Model 3), the effect sizes were reduced and these associations were no longer significant. Interestingly, a significantly lower risk of adiposity, measured by all three outcomes (risk of overweight, high waist to height ratio, or high body fat percentage), was seen with greater use of food as a reward in Model 2, however in all cases, this association was attenuated in the subsequent model that adjusted for baseline values. Multiple imputation in Model 3 generated results which were similar to the main analyses, whereby no parent feeding practice was significantly associated with any measure of overweight at the 1% level.

Discussion

The aim of this study was to investigate the relationship between parental feeding practices and three proxy measures of child adiposity a year later, in an ethnically diverse sample of UK children. Although there were associations between certain parental feeding practices and measures of child adiposity, inclusion of a baseline adiposity measure attenuated the observed relationships. This finding has two potential explanations. First, it may lend support to the theory of reverse causation, whereby it is the child's level of adiposity that may lead to parental utilisation of specific feeding practices, rather than being a consequence of them. However, it may also be suggestive of a reduced impact of parental feeding practices on adiposity in older children.

Before adjusting for baseline values we found significant associations between 'restriction for weight control' and 'pressure-to-eat' with child levels of adiposity, which was consistent with previous research findings (13, 16). However, once we included baseline adiposity in the models, the effect sizes approached null and the associations were no longer statistically significant. This suggests that the use of these feeding practices may be in response to initial child weight status (37, 38). Thus, parents of higher weight children may be more likely to implement restrictive feeding practices whilst parents of lower weight children may pressure their child to eat. This complements a finding by Gregory et al. (2010; n = 156) which suggested that mothers' feeding practices may influence children's eating behaviours, but not their weight status after one year in children aged 2-4 years (39). Both the present study and the study by Gregory et al. (2010) had relatively short follow-up periods which limit the ability to capture the impact on weight status of altered eating behaviours as a result of a parent feeding practice. However, Webber et al. (2010; n= 113) also found no significant longitudinal associations between maternal feeding practices and change in child adiposity three years later, in children aged 7-9 years (40).

Our findings contradict a body of evidence that suggested restriction is associated with increased child weight, both cross-sectionally (11, 14, 41, 42) and longitudinally (40, 43). Mechanisms to explain why restriction may be a counterproductive feeding practice relate to food becoming more desirable and so consumed in excess when outside of the parent's control (44). Given the larger sample size and longitudinal nature of our study, our findings challenge these previous theories; however, it is important to note that the confidence intervals were wide in Model 3, and in some cases, only just crossed the point of no significance. Additionally, it has been hypothesised that the influence of parental feeding practices may be stronger at younger ages (45-47), and therefore the pre-adolescent age range included in the present study may indicate the point at which children begin to strive for greater autonomy around their feeding and, as such, parental feeding practices begin to have a lesser impact on subsequent child weight. Hence, the null findings in both the present study and that of Webber et al. (2010) may be due to the age group studied (40). Such information is important for future childhood obesity prevention strategies and so further investigations of longitudinal relationships at various ages are needed.

Several strengths and limitations are noteworthy within this study. First, whilst the diverse nature of the West Midlands population, the purposeful oversampling of schools with higher proportions of South Asian and Black children in the WAVES study, and the availability of questionnaire responses from the main carer (including mothers, fathers, and other guardians/carers), may have maximised the external validity of the study findings, it also adds an element of heterogeneity to the sample which may reduce the power to detect true effect estimates in certain sub-groups (48). However, the models were developed to control for various demographic factors to counteract this variability. Second, whilst all outcome data were objectively measured by trained researchers, parent data were all self-reported, and child eating behaviour was based on parent perception and therefore may be subject to some social desirability bias. However, validation studies on both the CEBQ and CFPQ have reported that the responses correlate well with observed practices and behaviours and so these questionnaires allow a relatively quick and cost-effective method of collecting this data on a large scale (29, 49). Third, some variables were missing a substantial amount of data. To assess the impact of this missing covariate data, multiple imputation sensitivity analyses were conducted and the results were found to be very similar to the results of the main analyses, increasing the confidence in our conclusions. Additionally, despite the researchers employing numerous techniques to encourage questionnaire completion the parental response rate was relatively low which may bias the results presented.

This study has allowed further exploration of a wide range of parent feeding practices and their relationships with a number of proxy measurements for child adiposity. It has extended the current evidence by allowing adjustment for the child's previous level of adiposity and current eating behaviour. The pathway to which parent feeding practices are often hypothesised to impact child adiposity is through changes in dietary behaviour, for example the use of emotion regulation inadvertently encouraging intake of energy dense, nutrient poor foods in times of distress, leading to excess energy intake and overweight over time. Therefore, it would be useful for future research to quantify the impact these feeding practices may have on dietary intake. Additionally, qualitative studies, investigating why parents adopt such feeding practices, would contribute to understanding the complex relationship between feeding practices and weight status. Finally, the findings of this study challenge the notion that parent feeding practices are associated with adiposity, particularly in older children. However, further evidence is needed to evaluate whether this is a result of reverse causation or an artefact of the changing feeding relationship between parents and their growing children.

Acknowledgements

A special thanks to Dr Karla Hemming for her advice on the preparation of this manuscript and all of the WAVES study team for the collection and cleaning of this data.

KLH is a Research Fellow funded by the NIHR CLAHRC West Midlands initiative. This article presents independent research and the views expressed are those of the authors and not necessarily those of the NHS, the NIHR, or the Department of Health.

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Conflict of Interest

The authors declare no conflict of interest.

Author contributions

PA, MJP and ERL, alongside the WAVES study trial investigators, designed the original WAVES study research; KLH developed the research plan for this paper, conducted the data collection and wrote the paper, with significant input from PA, MJP, and ERL. All authors read and approved the final manuscript.

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Tables

Table 1: Participant characteristics, by weight status at T2 (aged 8-9 years)

	Not overweight/ Obese[1] (n=626)	Overweight/ Obese[1] (n=207)	p-value
Child Age (years) N=833, mean (SD)[2]	7.7 (0.3)	7.7 (0.3)	0.389
Sex of the child (N=833, n (%))[3]			
Males	310 (73.5)	112 (26.5)	(reference)
Females	316 (76.9)	95 (23.1)	0.237
Child Ethnicity (N=833, n (%))[3]			
White	320 (77.3)	94 (22.7)	(reference)
South Asian	190 (74.8)	64 (25.2)	0.492
Black	30 (60.0)	20 (40.0)	0.020
Other/Mixed	86 (74.8)	29 (25.2)	0.604
Average physical activity energy expenditure (kJ/kg/day; mean (SD); N=802) [2]	92.7 (25.5)	87.5 (22.4)	0.024
IMD quintiles (N=824, n (%))[3]			
Quintile 1 (more deprived)	298 (72.9)	111 (27.1)	(reference)
Quintile 2	120 (77.4)	35 (22.6)	0.272
Quintile 3	72 (78.3)	20 (21.7)	0.230
Quintile 4	66 (75.9)	21 (24.1)	0.550
Quintile 5 (less deprived)	62 (76.5)	19 (23.5)	0.748
Main carer relationship to child (N=828, n (%))[3]			
Mother	509 (76.7)	155 (23.3)	(reference)
Father	91 (69.5)	40 (30.5)	0.088
Other	22 (66.7)	11 (33.3)	0.200
Main carer age ((years) N=781, mean (SD))[2]	36.7 (6.6)	37.0 (6.9)	0.512

[1] Based on the UK 1990 growth reference data (UK90);

[2] p-values generated using mixed effect linear regression models, fitting weight status as a continuous variable, , controlling for WAVES study trial arm allocation as a fixed effect, and school attended as a random effect

[3] p-values generated using multinomial logistic regression models, fitting weight status as a continuous variable, controlling for WAVES study trial arm allocation as a fixed effect, and using robust standard errors to account for clustering

Figures

Figure 1: Flow diagram of participants from the over-arching WAVES study into the present study

Figure 2: Median scores for each parent feeding practice by child weight status at T2 (aged 8-9 years) and p-for-trends generated using mixed-effects linear regressions. Children without overweight/obesity, n=626, children identified with overweight and obesity, n= 207.

Figure 3: Mixed effects logistic regression generated odds ratios (and 99% confidence intervals) to show the association between parent feeding styles and three proxy measures for child adiposity. Maximum number included in models, n=716, minimum number included in models, n=549.