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An exploration of the longitudinal relation between parental feeding practices and child anthropometric adiposity measures from the West Midlands Active Lifestyle and Healthy Eating in Schoolchildren (WAVES) Study

WAVES Study Investigators; Pallan, Miranda

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An exploration of the longitudinal relationship between parental feeding practices and child anthropometric adiposity measures from the WAVES study

Dr. Kiya L. Hurley, Dr. Miranda J. Pallan, Dr. Emma R. Lancashire, and Prof. Peymane Adab, And on behalf of the WAVES study investigators.

<u>Affiliation:</u> Institute of Applied Health Research, University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK. (Authors affiliated: KLH, MJP, ERL, and PA)

Author Last Names: Hurley, Pallan, Lancashire, Adab

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<u>Corresponding author</u>: Dr. Miranda J. Pallan, Institute of Applied Health Research, University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK., Tel: +44121 414 7990, Email: <u>m.j.pallan@bham.ac.uk</u> Short running head: Parent feeding, child eating, and weight status

Abbreviations:

ВМІ	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			

1 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).

8 **Design:** Secondary analysis of data from the West Midlands ActiVe lifestyle and 9 healthy Eating in School children (WAVES) study comprising a diverse sample of 10 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 11 12 on feeding practices was collected using subscales from Comprehensive Feeding 13 Practices Questionnaire, completed by the child's main parent/carer (self-defined). 14 Child height, weight, body fat percentage, and waist circumference were measured and converted into three proxy measurements of adiposity (weight status, waist-to-15 16 height ratio, and body fat percentage). Associations between these measurements and parent/carer feeding practices were examined using mixed-effects logistic 17 18 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. 33 Introduction:

34 Excess weight in children is an important public health concern, with adverse physical and psychosocial consequences in childhood, and increased risk of 35 morbidity and mortality in later life (1, 2). Two recent reviews have highlighted that 36 37 common environmental factors, such as parent feeding practices, have a substantial 38 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 39 40 determinants of children's eating habits and food choices (4). There is also evidence of 'intergenerational ripples', whereby parents develop their feeding practices based 41 on their own childhood feeding experience (5). Therefore, understanding the effect of 42 parental feeding practices on children's adiposity has been identified as a research 43 44 priority, as it could inform the development of interventions with potential impact beyond the current generation (6). 45

Parent feeding practices relate to the specific methods and behaviours that parents 46 employ to influence children's behaviour, health, or weight (7, 8) and are distinct 47 from the more generalistic parent feeding style which typifies the levels of 48 49 demandingness and responsiveness a parent expresses in feeding and eating 50 interactions (9, 10). Examples of parental feeding practices include pressuring 51 children to eat certain foods, using food as a reward, or not allowing the child to eat 52 certain foods. Evidence from a variety of studies suggests that certain parent feeding 53 practices are associated with child weight status. For example, restrictive feeding 54 practices are associated with higher weight status (11-16), whilst pressure to eat is 55 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 56

57 practices (for example, using food as a reward (15, 16, 19, 20)). A number of methodological limitations in previous studies constrain potential interpretation. For 58 example, most were cross-sectional in nature, and the measures of adiposity used 59 have been limited, with few previous studies using multiple measures such as waist-60 to-height ratio or body fat percentage. Additionally, previous studies rarely consider 61 how child characteristics influence parental feeding practices. Shloim et al. (2015) 62 63 noted in their systematic review of studies (n = 31) that, where child characteristics were measured, the parental feeding practices employed were responsive to the 64 65 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 66 children or those perceived to be undereating (10). However, the direction of the 67 proposed effect is still ambiguous. Therefore, it is important to consider the 68 69 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 70 71 being a consequence of them. Additionally, much of the research focus in this area 72 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 73 autonomy over their food decisions. 74

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.

80

81 Methods:

82 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 83 (T2: children aged 8-9 years) follow-up for the West Midlands ActiVe lifestyle and 84 85 healthy Eating in School children (WAVES) study; a cluster-randomised controlled 86 trial evaluating the clinical and cost-effectiveness of an obesity prevention programme in an ethnically diverse population of children from the West Midlands, 87 UK. National Health Service Research Ethics approval for the WAVES study was 88 obtained from the Black Country Research Ethics Committee (NHS REC 89 no.10/H1202/69) and the trial was registered in May 2010 (ISRCTN97000586). 90 91 The WAVES study cohort was recruited from 54 state-funded primary schools in the 92 West Midlands, UK. Written informed consent was obtained from parents and verbal 93 assent was obtained from each child prior to measurements commencing. Further 94 information can be found in the WAVES study protocol (23). 95 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, 96 using validated instruments (Leicester Height Measure MK II (Harlow Healthcare, 97 98 UK) and Tanita BC-420MA Class 111 Body Composition Analyser (Tanita, Japan)) and standard proctocols (23). Child weight status was dichotomised into individuals 99 100 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 101 charts (24). Waist-to-height ratio was calculated by dividing the child's waist 102 103 circumference (cm) by their height (m) and dichotomised into high or low risk using a 104 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 107 108 questionnaire booklet sent home for completion by the child's main parent or carer (self-defined) at T1. Subscales of the Comprehensive Feeding Practices 109 110 Questionnaire (CFPQ) were used to assess a wide range of parent feeding practices 111 (29). The CFPQ has been shown to be valid in children up to twelve years old (22, 112 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 113 114 questionnaire: child control; emotion regulation; environment; food as a reward; modelling; monitoring; pressure to eat; and restriction for weight control. Minor 115 116 wording changes from the original questionnaire were applied to make the tool 117 appropriate for a UK population e.g. replacing 'Soda' with 'Fizzy pop'.

118 Likert scales ranging from one (never) to five (always) scored each item. For ease of 119 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 120 121 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 122 completed number of items as the denominator. Questionnaire subscale response 123 124 rates ranged from 89% (modelling) to 92% (emotion regulation). All questionnaire subscales had moderate to good internal consistency with Cronbach Alphas (α) 125 126 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

129 quintile cut offs for England) (33). Child eating behaviour subscales of 'food 130 responsiveness', 'enjoyment of food' and 'emotional over eating' were collected from the Child Eating Behaviour Questionnaire (CEBQ) embedded within the WAVES 131 132 parent questionnaire booklet. Scoring of these subscales was conducted in the same 133 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 134 135 one "food approaching eating behaviour" score. Other relevant information (parent age and ethnicity (using the UK census ethnic group categories (34))) were also 136 137 collected through the WAVES study parent questionnaire booklet. Where parent ethnicity was missing, child ethnicity from school records was used as a proxy. 138 139 Parents and children participating in the WAVES study were included in the present 140 study if a questionnaire booklet was returned at T1 and any child anthropometric 141 adiposity measurement (weight status, waist-to-height ratio or body fat percentage) was available at T2. Statistical analysis was performed using STATA 13 (StataCorp 142

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 158 159 adjusted models (Model 3) were repeated on a dataset where missing covariate 160 information was imputed. Generation of imputed datasets was conducted in REALCOM-Impute (35) to account for the clustered nature of the sample, imported 161 into STATA using the realcomImputeLoad command, and analysed in STATA 13. 162 163 Generation of imputed datasets included the following incomplete variables: T2 outcome of interest, T0 outcome measure, child food approaching eating behaviour 164 165 composite score, parent age, parent ethnicity (White, South Asian, Black African-166 Caribbean and Mixed/Other ethnicities), deprivation score of household (IMD 2010). Additionally, the following complete variables were included to improve the accuracy 167 168 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 169 170 African-Caribbean and Mixed/Other ethnicities). The results of ten imputed datasets 171 were pooled to produce imputation estimates.

172 **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 guintiles, with the highest responses coming from the least deprived quintile (75%) and the lowest from the most deprived quintile (53%). There was nodifference in the response rates according to the age or sex of the child

180 (Supplemental Table 1).

181 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% 182 183 other relatives (e.g. grandmother, stepfather, or aunt). The mean parent age was 184 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 185 than girls had overweight and children of a mixed, Black or South Asian ethnicity 186 187 were more likely to have overweight than White children, which is in line with 188 England averages (36). However, there was only a significant difference in children 189 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.

197 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

202 risk if parents employed pressure to eat. However, after the inclusion of a baseline 203 measure for the adiposity outcome being considered (Model 3), the effect sizes were reduced and these associations were no longer significant. Interestingly, a 204 205 significantly lower risk of adiposity, measured by all three outcomes (risk of 206 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 207 208 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, 209 210 whereby no parent feeding practice was significantly associated with any measure of 211 overweight at the 1% level.

212 Discussion

213 The aim of this study was to investigate the relationship between parental feeding 214 practices and three proxy measures of child adiposity a year later, in an ethnically 215 diverse sample of UK children. Although there were associations between certain parental feeding practices and measures of child adiposity, inclusion of a baseline 216 adiposity measure attenuated the observed relationships. This finding has two 217 218 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 219 220 specific feeding practices, rather than being a consequence of them. However, it 221 may also be suggestive of a reduced impact of parental feeding practices on 222 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

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226 included baseline adiposity in the models, the effect sizes approached null and the 227 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). 228 229 Thus, parents of higher weight children may be more likely to implement restrictive 230 feeding practices whilst parents of lower weight children may pressure their child to 231 eat. This complements a finding by Gregory et al. (2010; n = 156) which suggested 232 that mothers' feeding practices may influence children's eating behaviours, but not 233 their weight status after one year in children aged 2-4 years (39). Both the present 234 study and the study by Gregory et al. (2010) had relatively short follow-up periods 235 which limit the ability to capture the impact on weight status of altered eating 236 behaviours as a result of a parent feeding practice. However, Webber et al. (2010; 237 n= 113) also found no significant longitudinal associations between maternal feeding 238 practices and change in child adiposity three years later, in children aged 7-9 years (40). 239

240 Our findings contradict a body of evidence that suggested restriction is associated 241 with increased child weight, both cross-sectionally (11, 14, 41, 42) and longitudinally 242 (40, 43). Mechanisms to explain why restriction may be a counterproductive feeding 243 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 244 nature of our study, our findings challenge these previous theories; however, it is 245 246 important to note that the confidence intervals were wide in Model 3, and in some 247 cases, only just crossed the point of no significance. Additionally, it has been 248 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 249 present study may indicate the point at which children begin to strive for greater 250

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.

256 Several strengths and limitations are noteworthy within this study. First, whilst the 257 diverse nature of the West Midlands population, the purposeful oversampling of schools with higher proportions of South Asian and Black children in the WAVES 258 259 study, and the availability of questionnaire responses from the main carer (including 260 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 261 262 which may reduce the power to detect true effect estimates in certain sub-groups 263 (48). However, the models were developed to control for various demographic factors to counteract this variability. Second, whilst all outcome data were objectively 264 265 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 266 267 social desirability bias. However, validation studies on both the CEBQ and CFPQ 268 have reported that the responses correlate well with observed practices and behaviours and so these questionnaires allow a relatively quick and cost-effective 269 method of collecting this data on a large scale (29, 49). Third, some variables were 270 271 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 272 273 found to be very similar to the results of the main analyses, increasing the 274 confidence in our conclusions. Additionally, despite the researchers employing

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numerous techniques to encourage questionnaire completion the parental responserate was relatively low which may bias the results presented.

This study has allowed further exploration of a wide range of parent feeding 277 practices and their relationships with a number of proxy measurements for child 278 adiposity. It has extended the current evidence by allowing adjustment for the child's 279 previous level of adiposity and current eating behaviour. The pathway to which 280 281 parent feeding practices are often hypothesised to impact child adiposity is through changes in dietary behaviour, for example the use of emotion regulation 282 inadvertently encouraging intake of energy dense, nutrient poor foods in times of 283 284 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 285 may have on dietary intake. Additionally, gualitative studies, investigating why 286 287 parents adopt such feeding practices, would contribute to understanding the complex relationship between feeding practices and weight status. Finally, the findings of this 288 289 study challenge the notion that parent feeding practices are associated with adiposity, particularly in older children. However, further evidence is needed to 290 291 evaluate whether this is a result of reverse causation or an artefact of the changing 292 feeding relationship between parents and their growing children.

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301 WAVES study trial investigators and collaborators

302 University of Birmingham: Peymane Adab (Professor of Public Health and Chief Investigator), Tim Barrett (Professor of Paediatrics), KK Cheng (Professor of 303 Epidemiology) Amanda Daley (Reader in Behavioural Medicine), Jonathan J Deeks 304 (Professor of Biostatistics), Joan L Duda (Professor of Sport and Exercise 305 Psychology), Emma Frew (Reader in Health Economics), Karla Hemming (Reader in 306 307 Medical Statistics), Miranda Pallan (Senior clinical lecturer), Jayne Parry (Professor 308 of Policy and Public Health). University of Warwick: Paramjit Gill (Professor of General Practice), University of Cambridge, Cambridge MRC Epidemiology Unit / 309 310 Norwegian School of Sports Sciences: Ulf Ekelund (Professor of Physical Activity 311 Epidemiology and Public Health / Senior Investigator Scientist). University of Leeds: Janet E Cade (Professor of Nutritional Epidemiology and Public Health). University 312 313 of Edinburgh, Usher Institute of Population Health Sciences and Informatics: Raj 314 Bhopal (Bruce and John Usher Chair in Public Health). Birmingham Community Healthcare NHS Trust: Eleanor McGee (Public Health Nutrition Lead). Birmingham 315 316 Services for Education: Sandra Passmore (Health Education Advisor).

317 **Conflict of Interest**

318 The authors declare no conflict of interest.

319 Author contributions

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

References

- 1. Reilly JJ, Methven E, McDowell ZC, Hacking B, Alexander D, Stewart L, Kelnar CJH. Health consequences of obesity. Arch Dis Child 2003;88(9):748-52. doi: 10.1136/adc.88.9.748.
- 2. Friedlander SL, Larkin EK, Rosen CL, Palermo TM, Redline S. Decreased quality of life associated with obesity in school-aged children. Arch Pediatr Adolesc Med 2003;157(12):1206-11. doi: 10.1001/archpedi.157.12.1206.
- Silventoinen K, Rokholm B, Kaprio J, Sorensen TI. The genetic and environmental influences on childhood obesity: a systematic review of twin and adoption studies. Int J Obes (Lond) 2010;34(1):29-40. doi: 10.1038/ijo.2009.177.
- 4. Scaglioni S, De Cosmi V, Ciappolino V, Parazzini F, Brambilla P, Agostoni C. Factors Influencing Children's Eating Behaviours. Nutrients 2018;10(6):706.
- 5. Brewis A, Gartin M. Biocultural construction of obesogenic ecologies of childhood: Parent-feeding versus child-eating strategies. Am J Hum Biol 2006;18(2):203-13. doi: 10.1002/ajhb.20491.
- 6. Bergmeier H, Skouteris H, Horwood S, Hooley M, Richardson B. Associations between child temperament, maternal feeding practices and child body mass index during the preschool years: a systematic review of the literature. Obes Rev 2014;15(1):9-18. doi: 10.1111/obr.12066.
- 7. Fisher JO, Birch LL. Restricting access to foods and children's eating. Appetite 1999;32(3):405-19. doi: http://dx.doi.org/10.1006/appe.1999.0231.
- Hoerr SL, Hughes SO, Fisher JO, Nicklas TA, Liu Y, Shewchuk RM. Associations among parental feeding styles and children's food intake in families with limited incomes. Int J Behav Nutr Phys Act 2009;6:55. doi: 10.1186/1479-5868-6-55.
- L. VR, Mobley AR. Parenting styles, feeding styles, and their influence on child obesogenic behaviors and body weight. A review. Appetite 2013;71:232-41.
- Shloim N, Edelson LR, Martin N, Hetherington MM. Parenting styles, feeding styles, feeding practices, and weight status in 4-12 year-old children: A systematic review of the literature. Front Psychol 2015;6:1-20. doi: 10.3389/fpsyg.2015.01849.

- 11. Jansen PW, Roza SJ, Jaddoe VWV, Mackenbach JD, Raat H, Hofman A, Verhulst FC, Tiemeier H. Children's eating behavior, feeding practices of parents and weight problems in early childhood: results from the populationbased Generation R Study. Int J Behav Nutr Phys Act 2012;9(130):1-11.
- 12. Birch LL, Fisher JO. Mothers' child-feeding practices influence daughters' eating and weight. Am J Clin Nutr 2000;71(5):1054-61.
- 13. Musher-Eizenman DR, de Lauzon-Guillain B, Holub SC, Leporc E, Charles MA. Child and parent characteristics related to parental feeding practices. A cross-cultural examination in the US and France. Appetite 2009;52(1):89-95. doi: 10.1016/j.appet.2008.08.007.
- Joyce JL, Zimmer-Gembeck MJ. Parent feeding restriction and child weight. The mediating role of child disinhibited eating and the moderating role of the parenting context. Appetite 2009;52(3):726-34. doi: 10.1016/j.appet.2009.03.015.
- 15. Webber L, Hill C, Cooke L, Carnell S, Wardle J. Associations between child weight and maternal feeding styles are mediated by maternal perceptions and concerns. Eur J Clin Nutr 2010;64(3):259-65. doi: 10.1038/ejcn.2009.146.
- 16. Rodgers RF, Paxton S, Massey R, Campbell KJ, Wertheim EH, Skouteris H, Gibbons K. Maternal feeding practices predict weight gain and obesogenic eating behaviors in young children: a prospective study. Int J Behav Nutr Phys Act 2013;10(24):1-10.
- 17. Spruijt-Metz D, Lindquist CH, Birch LL, Fisher JO, Goran MI. Relation between mothers' child-feeding practices and children's adiposity. Am J Clin Nutr 2002;75:581–6.
- 18. Carnell S, Wardle J. Associations between multiple measures of parental feeding and children's adiposity in United Kingdom preschoolers. Obesity 2007;15(1):137-44. doi: 10.1038/oby.2007.513.
- 19. Montgomery C, Jackson DM, Kelly LA, Reilly JJ. Parental feeding style, energy intake and weight status in young Scottish children. Br J Nutr 2007;96(6):1149-53. doi: 10.1017/bjn20061968.
- 20. Haycraft EL, Blissett JM. Maternal and paternal controlling feeding practices: reliability and relationships with BMI. Obesity 2008;16(7):1552-8. doi: 10.1038/oby.2008.238.
- 21. Brown KA, Ogden J, Vogele C, Gibson EL. The role of parental control practices in explaining children's diet and BMI. Appetite 2008;50(2-3):252-9. doi: 10.1016/j.appet.2007.07.010.
- 22. Baughcum AE, Powers SW, Johnson SB, Chamberlin LA, Deeks CM, Jain A, Whitaker RC. Maternal feeding practices and beliefs and their relationships to overweight in early childhood. J Dev Behav Pediatr 2001;22(6):391-408.
- 23. Adab P, Pallan MJ, Lancashire ER, Hemming K, Frew E, Griffin T, Barrett T, Bhopal R, Cade JE, Daley A, et al. A cluster-randomised controlled trial to assess the effectiveness and cost-effectiveness of a childhood obesity prevention programme delivered through schools, targeting 6-7 year old children: the WAVES study protocol. BMC Public Health 2015;15(1):488-98. doi: 10.1186/s12889-015-1800-8.

- 24. Cole TJ, Freeman JV, Preece MA. Body mass index reference curves for the UK, 1990. Arch Dis Child 1995;73:25-9.
- Martin-Calvo N, Moreno-Galarraga L, Martinez-Gonzalez MA. Association between Body Mass Index, Waist-to-Height Ratio and Adiposity in Children: A Systematic Review and Meta-Analysis. Nutrients 2016;8(8). doi: 10.3390/nu8080512.
- 26. Ashwell M. Obesity risk: importance of the waist to height ratio. Nurs Stand 2009;23(41):49-54.
- 27. Talma H, Chinapaw MJ, Bakker B, HiraSing RA, Terwee CB, Altenburg TM. Bioelectrical impedance analysis to estimate body composition in children and adolescents: a systematic review and evidence appraisal of validity, responsiveness, reliability and measurement error. Obes Rev 2013;14(11):895-905. doi: 10.1111/obr.12061.
- 28. Tanita. Internet: https://tanita.eu/help-guides/understanding-measurements (accessed 12/10/17).
- 29. Musher-Eizenman D, Holub S. Comprehensive Feeding Practices Questionnaire: Validation of a New Measure of Parental Feeding Practices. J Pediatr Psychol 2007;32(8):960-72. doi: 10.1093/jpepsy/jsm037.
- 30. Melbye EL, Ogaard T, Overby NC. Validation of the Comprehensive Feeding Practices Questionnaire with parents of 10-to-12-year-olds. BMC Med Res Methodol 2011;11(113):1-12. doi: 10.1186/1471-2288-11-113.
- 31. Blissett J, Bennett C. Cultural differences in parental feeding practices and children's eating behaviours and their relationships with child BMI: a comparison of Black Afro-Caribbean, White British and White German samples. Eur J Clin Nutr 2013;67(2):180-4. doi: 10.1038/ejcn.2012.198.
- 32. Powell FC, Farrow CV, Meyer C. Food avoidance in children. The influence of maternal feeding practices and behaviours. Appetite 2011;57(3):683-92. doi: 10.1016/j.appet.2011.08.011.
- Payne RA, Abel GA. UK indices of multiple deprivation a way to make comparisons across constituent countries easier. Health Stat Q 2012;53:22-37.
- 34. Office for National Statistics. Harmonised concepts and questions for social data sources. Primary principles: Ethnic group. 2015.
- 35. Carpenter JR, Goldstein H, Kenward MG. REALCOM-IMPUTE software for multilevel multiple imputation with mixed response types. J Stat Softw 2011;45(5):1-14.
- 36. Niblett P, Team LS. National Child Measurement Programme: England, 2014/15 school year. [Online]: Health and Social Care Information Centre, 2015.
- Faith MS, Berkowitz RI, Stallings VA, Kerns J, Storey M, Stunkard AJ. Parental feeding attitudes and styles and child body mass index: prospective analysis of a gene-environment interaction. Pediatrics 2004;114:429 - 36. doi: 10.1542/peds.2003-1075-L.

- Rifas-Shiman SL, Sherry B, Scanlon K, Birch LL, Gillman MW, Taveras EM. Does maternal feeding restriction lead to childhood obesity in a prospective cohort study? Arch Dis Child 2011;96(3):265-9. doi: http://dx.doi.org/10.1136/adc.2009.175240.
- Gregory JE, Paxton SJ, Brozovic AM. Maternal feeding practices, child eating behaviour and body mass index in preschool-aged children: a prospective analysis. Int J Behav Nutr Phys Act 2010;7:55-65. doi: 10.1186/1479-5868-7-55.
- 40. Webber L, Cooke L, Hill C, Wardle J. Child adiposity and maternal feeding practices: a longitudinal analysis. Am J Clin Nutr 2010;92(6):1423-8. doi: http://dx.doi.org/10.3945/ajcn.2010.30112.
- 41. Dev DA, McBride BA, Fiese BH, Jones BL, Cho H. Risk Factors for Overweight/Obesity in Preschool Children: An Ecological Approach. Child Obes 2013;9(5):399-408. doi: 10.1089/chi.2012.0150.
- 42. de Lauzon-Guillain B, Musher-Eizenman D, Leporc E, Holub S, Charles MA. Parental feeding practices in the United States and in France: relationships with child's characteristics and parent's eating behavior. J Am Diet Assoc 2009;109(6):1064-9. doi: 10.1016/j.jada.2009.03.008.
- 43. Anzman SL, Birch LL. Low inhibitory control and restrictive feeding practices predict weight outcomes. J Pediatr 2009;155(5):651-6. doi: 10.1016/j.jpeds.2009.04.052.
- 44. Clark HR, Goyder E, Bissell P, Blank L, Peters J. How do parents' childfeeding behaviours influence child weight? Implications for childhood obesity policy. J Public Health 2007;29(2):132-41. doi: 10.1093/pubmed/fdm012.
- 45. Campbell K, Andrianopoulos N, Hesketh K, Ball K, Crawford D, Brennan L, Corsini N, Timperio A. Parental use of restrictive feeding practices and child BMI z-score. A 3-year prospective cohort study. Appetite 2010;55(1):84-8. doi: 10.1016/j.appet.2010.04.006.
- 46. Tschann JM, Martinez SM, Penilla C, Gregorich SE, Pasch LA, de Groat CL, Flores E, Deardorff J, Greenspan LC, Butte NF. Parental feeding practices and child weight status in Mexican American families: a longitudinal analysis. Int J Behav Nutr Phys Act 2015;12:66. doi: 10.1186/s12966-015-0224-2.
- Derks IPM, Tiemeier H, Sijbrands EJG, Nicholson JM, Voortman T, Verhulst FC, Jaddoe VWV, Jansen PW. Testing the direction of effects between child body composition and restrictive feeding practices: results from a populationbased cohort. Am J Clin Nutr 2017;106(3):783-90. doi: 10.3945/ajcn.117.156448.
- 48. Hansen WB, Collins LM. Seven ways to increase power without increasing N. NIDA Research Monograph 1994;142:184–95.
- 49. Wardle J, Guthrie CA, Sanderson S, Rapoport L. Development of the children's eating behaviour questionnaire. J Child Psychol Psychiatry 2001;42(7):963-70.

Tables

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

	Not overweight/	Overweight/ Obese ¹	
	Obese ¹		
	(n=626)	(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	92.7 (25.5)	87.5 (22.4)	0.024
expenditure (kJ/kg/day; mean (SD); N=802) ²			
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.