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ORIGINAL ARTICLE

An examination of children's eating behaviours as mediators of the relationship between parents' feeding practices and early childhood body mass index *z*-scores

N. Boswell[1], R. Byrne[2] and P. S. W. Davies[1]

[1]The University of Queensland, Brisbane, QLD, Australia; [2]Queensland University of Technology, Brisbane, QLD, Australia.

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Correspondence:
Nikki Boswell, The University of Queensland, Child Health Research Centre, Level 6, Centre for Children's Health Research (CCHR), 62 Graham Street, South Brisbane, QLD 4101, Australia.
E-mail: nikki.boswell@uqconnect.edu.au

Summary

Objective

Parent's use of restrictive feeding practices is associated with child weight. Similarly, the literature shows that children's eating behaviours are also associated with child weight. Given this interrelationship between children's eating behaviours, restrictive feeding practices and child weight, examination of possible mediator relationships is warranted. This study aimed to examine the relationships between overt restriction and covert restriction with child body mass index *z*-scores (BMIz) and determine if children's eating behaviours (satiety responsiveness and food responsiveness) act as mediators.

Method

Parents of Australian children (n = 977) 2.0–5.0 years of age (49.4% male) provided data in an online survey on child eating behaviours, parent's restrictive feeding practices and child anthropometrics (modified *z*-scores were created to screen for biologically implausible values). Correlation analysis was used to determine variables to include in mediation models. Hayes' PROCESS macros in SPSS was used to examine mediation, controlling for covariates of child BMIz.

Results

Overt restriction was the only parent feeding practice related to child BMIz (B = 0.132, P = 0.04). Mediation analysis showed that the indirect effect of overt restriction on child BMIz (controlling for child age, gender, parent BMI and income) became non-significant when controlling for food responsiveness, thus suggesting full mediation, explaining 5.75% of the relation.

Conclusion

Overt restriction and covert restriction have distinctly different relationships with children's eating behaviours. Food responsiveness appears an important intermediary in the relationship between overt restriction and child BMIz.

Keywords: Childhood obesity, feeding practices, eating behaviors, mediation.

Introduction

The high prevalence and significant impact of obesity on physical, socio-emotional and economic health renders it an issue of major public health priority (1,2). The early childhood period is a crucial time to interject in the development of obesity as it is during this period that children develop socio-cultural and psychological associations with food and eating that can increase the risk of obesity (3). Parents are considered key gatekeepers in the development of these associations, with parental feeding practices gaining much attention in the literature for their contributing role in shaping children's eating behaviours and obesity risk (4–6).

Whilst there is evidence to specifically support a relationship between parent's use of restrictive feeding practices and increases in child weight, the evidence overall is not consistent (4). A 2015 systematic review of cross-sectional and longitudinal studies involving children 4–12 years, for instance, reported restrictive feeding practices to be associated with increased child weight in 14 out of 21 studies, with findings predominantly from cross-sectional data (4). Ogden *et al*. suggest that such inconsistencies may be due to different studies assessing some aspects of restrictive feeding that are beneficial to a child's eating and some that are detrimental (7). This perspective seems relevant to the interpretation of this systematic review (4) because included studies used a range of measures to capture parent's use of restriction, which, unlike the more recently validated Feeding Practice and Structure Questionnaire (FPSQ), did not make distinctions between overt restriction and covert restriction (8,9).

Overt restriction, as defined as 'controlling a child's food intake in a way that can be detected by the child', is theorized to have a detrimental impact on children's eating by undermining a child's ability to self-regulate food intake through increased preoccupation with food (7,10,11), whilst covert restriction, as defined as 'controlling a child's food intake in a way that cannot be detected by the child', is theorized to have a beneficial impact on child eating by providing structure and limits to appropriately guide a child (7,10,11). Whilst there is limited data examining the impact of these differing restrictive feeding practices on child weight, the evidence for impact on children's eating behaviours appears largely consistent with the theorized impact in cross-sectional, longitudinal and experimental studies (6,8,12,13). For instance, overt restriction has been seen to relate positively with the Children's Eating Behaviour Questionnaire (CEBQ) sub-scales food fussiness, food responsiveness, emotional eating (overeating and under-eating) and desire to drink (8). Because the CEBQ sub-scales food responsiveness, emotional over eating and desire to drink are consistently associated with increased child weight, it is possible that overt restriction increases the risk of obesity (14,15). Although less evidence is available to reflect the relationship between covert restriction and children's eating behaviours (8), results of a recent cross-lag analysis of longitudinal data from the NOURISH RCT showed that lower use of covert restriction at 2 years of age increased food responsiveness at 3.7 years of age, as would also theoretically confer an increased obesity risk (6,14). These results were adjusted for child body mass index *z*-scores (BMIz) (at 14 months); however, they did not control for baseline eating behaviours, which could alter interpretation.

Given this, further research is needed to examine the impact of both overt restriction and covert restriction on child weight, as well as the interrelationship of these variables with children's eating behaviours. In one of the few studies that has examined such an interrelationship between restrictive feeding practices, child eating behaviours and child weight, Joyce and colleagues show that child disinhibited eating (a composite of food responsiveness and emotional eating sub-scales from the CEBQ) partially mediated the association between parent restriction and child BMI (4–8 years; *n* = 230) (16). A distinction was not made, however, between the type of restriction implemented in this study, which may have contributed to the small effect size and marginal significance reported (16).

The present study hypothesised that overt restriction and covert restriction would have distinct relationships with child BMIz and that children's eating behaviours would mediate the relationship between parent's use of overt restriction and/or covert restriction and child BMIz. The findings from this study will provide important insight into the unique role of overt restriction and covert restriction in childhood obesity and behavioural intermediaries in these relationships and could provide opportunity for obesity prevention interventions.

Methods

Recruitment and measures

Methods of recruitment and data collected have been detailed previously (17). Briefly, between July and November 2016, Australian parents of children aged 2.0–5.0 years self-enrolled to complete an online survey. Recruitment was via advertising on the social media website Facebook®. No incentives were offered for participation. Participants were asked to use household measures (e.g. bathroom scales/household tape measure) to report their weight and height and that of their child, which were subsequently used to calculate BMI scores and categories (*z*-scores for children [BMIz]; according to the 2000 CDC growth charts for children; BMI categories as per Cole 2000 and 2007) (18–20). As child height and weight were by parental report, data were screened for biologically implausible values as per Boswell *et al*. (17). Demographic variables recorded included child's age to the nearest half year, gender, gender of the parent completing the questionnaire, family income reported as low, middle or high (less than $40,000, $40,000–$100,000 or more than $100,000 per year, respectively), duration the response child was breastfed and the region and Australian state of residency.

Children's eating behaviour

Of the five CEBQ sub-scales reported in this study (food responsiveness, satiety responsiveness, slowness in eating, food fussiness and enjoyment of food; as consistent with the scales measured by Webber *et al*. and Fildes *et al*.) previous analysis of these data has shown only food responsiveness (i.e. 'Even if my child is full up she/he finds room to eat his/her favourite food') and satiety responsiveness (i.e. 'My child gets full before his/her meal is finished') to be significantly associated with child BMIz in multiple regression (B = 0.188, P = 0.02 and B = −0.260, P = 0.01, respectively) (17,21,22). These CEBQ sub-scales were consequently analysed in this study. These CEBQ sub-scales showed acceptable internal reliability; food responsiveness (five items; Cronbach α 0.921); satiety responsiveness (five items; Cronbach α 0.800) and have previously been validated in an early childhood population (1–5 years) in Australia (17,23). Items were scored on a 5-point scale, with higher scores indicating higher values of each trait.

Parents' feeding practices

Sub-scales from the FPSQ-28 were used to measure parent's use of overt restriction (i.e. 'I intentionally keep some foods out of my child's reach') and covert restriction (i.e. 'How often do you avoid going with your child to cafes or restaurants which sell unhealthy foods?') (8,9). These sub-scales, as validated in a sample of Australian children 2–5 years, were scored as per the relevant literature (9). Both included FPSQ-28 sub-scales produced a Cronbach α above 0.6 in the current study (covert restriction [four items; Cronbach α 0.808], overt restriction [four items; Cronbach α 0.604]).

Statistical method

The distribution of dependant variables was examined for multicollinearity and normality (skewness and kurtosis between 1 and −1). In order to determine the relation between FPSQ-28 sub-scales (overt restriction and covert restriction) with CEBQ sub-scales (food responsiveness and satiety responsiveness) and child BMIz, correlation analysis was conducted. Where independent variables (overt restriction and covert restriction) showed relation with child BMIz, additional relation with CEBQ sub-scales were examined to determine variables for further investigation as potential mediators.

Exploration of mediators

To assess whether CEBQ sub-scales (food responsiveness and/or satiety responsiveness) mediated the relationship between restrictive feeding (overt and/or covert restriction) and child BMIz (controlling for previously identified covariates (17) and income), a bootstrapping procedure using the PROCESS macro for SPSS (24) was conducted using 5,000 resamples.

Bootstrapping procedure, as a nonparametric resampling procedure, is recommended as it assists in clarifying mediator relations and is recommended due to its robust nature and ability to determine mediator effect size (24,25). Specifically, PROCESS, a SPSS add-on, was used to perform bootstrapping with bias-corrected confidence estimates, as recommended (24–26). The 95% confidence interval of the direct effects in this study were obtained with 5,000 bootstrap resamples (25). In using this bootstrapping method, if zero does not fall between the resulting confidence intervals, a significant mediation effect can be concluded (25). PROCESS coefficients are reported as unstandardized; hence, the confidence limits should not be interpreted as properly standardized (25–27). All hypotheses assumed a 0.05 significance level and a two-sided alternative hypothesis. All analyses were carried out using SPSS v25 (SPSS Inc., Chicago, IL, USA). The SPSS add-on, PROCESS, was also used (24). Covariates of child BMIz identified in previous analysis of these data (parent BMI, child age and being a boy), as well as income, were controlled for.

Results

A sample of 977 Australian children, aged between 2.0 and 5.0 years, were retained for analysis in this study after the removal of biologically implausible values (n = 209) (17). As reported previously for this sample, excluded cases did not differ significantly based on parent BMI category, parent gender, single parent status, income group or state or region of residency in one-way ANOVA analysis, however, were significantly younger (mean age 3.1 years, compared with 3.4 years, P = 0.000) and were significantly more likely to be boys (58.0% in excluded case compared with 49.4% in retained sample, P = 0.026) (17). Demographic variables of participants are in Table 1.

In correlation analysis, overt restriction was the only independent variable related to child BMIz. Overt restriction was also correlated with CEBQ sub-scale food responsiveness. For this reason, these variables were carried forward for additional analysis in the mediation model (Table 2).

Mediator analysis

In order to determine if the relation between overt restriction and child BMIz, controlling for covariates, was mediated by food responsiveness, mediation analysis with bootstrapping was performed. First, it was found that overt restriction was positively associated with child BMIz

Table 1 Demographic data

	n = 977 (%)
Gender	
Boy	483 (49.4)
Age (years)	
2	108 (11)
2.5	161 (16.5)
3	153 (15.6)
3.5	164 (16.8)
4	173 (17.7)
4.5	128 (13.1)
5	90 (9.2)
Child BMI category[a]	
Underweight	219 (22.4)
Normal	586 (59.9)
Overweight	109 (11.1)
Obese	63 (6.5)
Child BMI z-score[b]	Mean −0.181 (SD 1.79)
Parent Gender	
Men	52 (5.3)
Marital Status	
Single	114 (11.7)
Parent BMI category[c]	
Underweight (<18.50 kg m^{-2})	13 (1.3)
Normal weight (18.50–24.99 kg m^{-2})	398 (40.7)
Overweight (≥25.00 kg m^{-2})	254 (26.0)
Obese (≥30.00 kg m^{-2})	312 (32)
Breastfeeding history	
Less than 6 months	358 (36.6)
6 months or more	619 (63.4)
Income	
Low: less than AU$40,000	129 (13.2)
Middle: AU$40,000–100,000	407 (41.6)
High: more than AU$100,000	441 (45.2)
Australian state	
VIC	173 (17.7)
NSW	246 (25.2)
QLD	292 (30.0)
ACT	28 (2.9)
WA	122 (12.5)
TAS	29 (3.0)
NT	5 (0.5)
SA	82 (8.4)
Region type	
Capital city	255 (26.1)
Metro (population over 100,000)	301 (30.8)
Large rural (population 25,000–99,999)	188 (19.3)
Small rural (population 10,000–24,999)	128 (13.1)
Large remote (population 5,000 – 9,999)	41 (4.2)
Small remote (population less than 5,000)	64 (6.5)

Mean (SD) reported for continuous; n (%) reported for dichotomous variables. BMI, body mass index.
[a]Cut offs per Cole (2000 and 2007).
[b]2000 CDC growth charts.
[c]Cut offs per WHO classifications for adults (2000).

in the c-path (B = 0.132, t(1, 975) = 1.98, P = 0.048). Next, it was found that overt restriction was positively associated with food responsiveness in the a-path (B = 0.230, t(5, 971) = 8.481, P = 0.000). Finally, results indicated that the mediator, food responsiveness, was positively associated with child BMIz, in the b-path (B = 0.249, t(6, 970) = 3.237, P = 0.001). As both the a-path and the b-path were significant, mediation analyses were tested using the bootstrapping method with bias-corrected confidence estimates (25,26). Results of the mediation analysis confirmed the mediating role of food responsiveness in the relation between overt restriction and child BMIz (effect = 0.0575; confidence interval = 0.0249 to 0.0990), controlling for covariates (parent BMI, child age, child gender [boy] and income). In addition, results indicated that the direct effect of overt restriction on child BMIz became non-significant (B = 0.057, t(6, 970) = 0.848, P = 0.396) when controlling for food responsiveness, thus suggesting full mediation, explaining 5.75% of the relation (Figure 1; Table 3).

Discussion

This study provides support for the differing roles of overt restriction and covert restriction in childhood obesity and uniquely indicates the presence of a mediator relation between parent's use of overt restriction, child food responsiveness and child BMIz, controlling for parent BMI, child age, child gender and income. The results of this study add to the recommendation that parents should avoid the use of overt restrictive feeding practices in young children, whilst the use of covert restriction may be more appropriate (10,11).

This recommendation makes sense from the perspective of a 'forbidden fruit effect' by suggesting that when children are aware of food restriction (e.g. overt restriction), they show increased preference for, and diminished self-regulatory behaviours towards food, which, may contribute to heightened food responsiveness (16,28,29). From this perspective, it is likely that the impact of overt restriction on children's food responsiveness reflects activation of the hedonic appetite system and triggering of neurological 'liking' and 'wanting' the reference food (30,31). The use of overt restriction, thereby, may alter the reinforcing value of foods (liking) and weaken inhibitory neural control (wanting) (30,31). This effect of overt restriction has been shown in experimental feeding studies wherein children's (3–5 years) eating behaviours towards a snack food was examined before, during and after 5 weeks of overt restriction (12). The results of this experiment demonstrated that during restriction to the target food, children significantly increased behavioural response to that food, relative to the control food (12).

Table 2 Correlations matrix: CEBQ sub-scales, child BMIz and FPSQ sub-scales (n = 977)

	Child BMIz	Food responsiveness	Satiety responsiveness	Covert restriction	Overt restriction
Child BMIz	1	0.096**	−0.105**	0.025	0.063*
Food responsiveness		1	−0.401**	0.008	0.260**
Satiety responsiveness			1	−0.066*	0.042
Covert restriction				1	0.089**
Overt restriction					1

BMIz, body mass index *z*-scores; CEBQ, Children's Eating Behaviour Questionnaire; FPSQ, Feeding Practice and Structure Questionnaire.
**Correlation is significant at 0.01 level (two-tailed).
*Correlation is significant at 0.05 level (two-tailed).

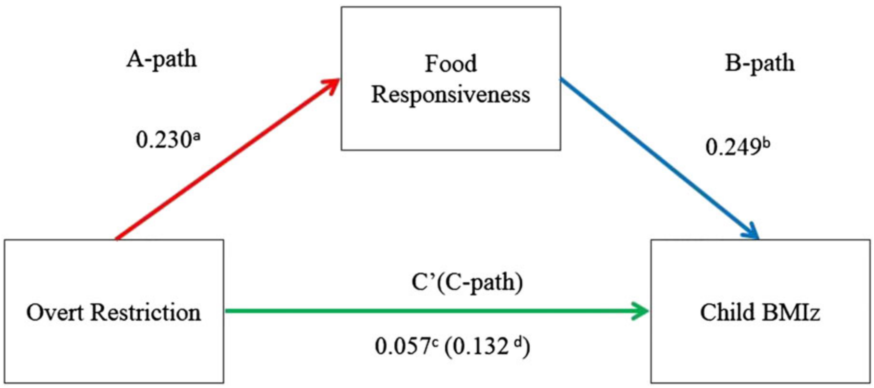

Figure 1 Mediation analysis: overt restriction, food responsiveness, child BMIz. BMIz, body mass index *z*-scores.

Table 3 Mediation analysis output (n = 977)

		Food responsiveness (M)				Child BMI *z*-score (Y)		
		Coeff.	SE	*P*		Coeff.	SE	*P*
Overt restriction (X)					*C*	0.132	0.067	0.04
	a	0.230	0.027	0.00	*c′*	0.057	0.068	0.39
M		—	—	—	*b*	0.249	0.077	0.00
Constant		1.762	0.19	0.00		−0.547	0.478	0.25
Covariates								
Parent BMI		−0.007	0.003	0.04		0.018	0.008	0.02
Boy		0.060	0.046	0.19		−0.583	0.112	0.00
Child age		0.071	0.025	0.00		−0.191	0.061	0.00
Income		−0.053	0.034	0.11		−0.017	0.081	0.83
		R^2 = 0.083				R^2 = 0.052′		
		F(5, 971) = 17.72, P = 0.000				F(6, 970) = 8.88, P = 0.000		
		Effect		Bootstrap SE		BootLLCI	BootULCI	
Indirect effect of X on Y		0.0575		0.018		0.0249	0.0990	

BMI, body mass index; Coeff., coefficient; BootLLCI, bootstrap lower level confidence interval; BootULCI, bootstrap upper level confidence interval; SE, standard error.

This difference in response to the restricted food was not, however, observed before or after the restricted access period (12).

In this regard, the results of this study suggest that the use of overt restriction is likely to be particularly problematic for children with tendencies towards food responsiveness, which is said to be 59% heritable (32,33). In support of this perspective, a study aiming to assess whether a child's (n = 178, aged 9–10 years) fat mass and obesity-associated (FTO) gene moderated the relation between parents restrictive feeding practices and child weight showed parent restriction was positively associated with child BMIz only among children with high risk FTO alleles (34). Although a distinction was not made between the type of restrictive feeding practices used by parents, the results may be relevant to the interpretation of this study due to the known association between FTO and obesogenic eating behaviours in children (35–37).

On this note, parents have also been reported to implement restrictive feeding practices in response to (maternal) perceptions of child appetite or concerns about child weight, which suggests that a bidirectional relationship may exist (4,15,38). Specifically, in investigating parent's (n = 70 mother and father pairs) differential use of restrictive feeding practices between siblings (6–12 years) Payne *et al*. concluded that parents were more likely to use differential restrictive feeding practices when they had differential concerns for the weight status of their children (but not actual weight) (39). In this study, Payne *et al*. did not, however, make a distinction between the type of restriction implemented by parents that, as indicated, could alter the results seen. With this in mind, covert restriction and overt restriction were positively correlated in the present study, which may suggest that parents implement these restrictive feeding practices simultaneously.

Whilst the mediator effect size between overt restriction, food responsiveness and child BMIz detected appears to be small (~6%), similar studies, particularly those that derive an effect size, are scarce, which limits comparison with previous research. A recent Australian study examining mediator relation between children's psychological problems, eating behaviours and child BMI using the SPSS add-on PROCESS showed effect sizes in the realms of 5% (40). That study conducted a secondary cross-sectional analysis of data from 194 children, 3.5–5 years of age (97% healthy weight), to show that food responsiveness (measured using the CEBQ) fully mediated the relation between child conduct problems (measured using the Strengths and Difficulties Questionnaire) and child BMIz, accounting for 5.33% of the variance in BMIz (40). Similarly, Darling *et al*. examined mediation between restrictive/controlling feeding practices, food insecurity and child BMI percentile (n = 790, 7–17 years), reporting an effect size of 6.8% after controlling for familial income and child age (41). The similar works of Joyce *et al*., who reported that children's disinhibited eating partially mediated the association between parent restriction and children's BMI (n = 247, 4–8 years), have already been discussed (16).

Neither Darling *et al*. nor Joyce *et al*. made distinctions between the type of restriction implemented by parents, as highlighted across the literature and in the results of the present study to be of importance in obesity development (16,41,42). Nor did they control for covariates of child weight. They did, however, make distinctions in terms of the context of parenting style, including additional factors such as general supportiveness, coerciveness and chaotic parenting, which are important to consider (16). These findings highlight the complexity of understanding the context (e.g. genetic, socio-economic, socio-emotional, other parenting or home environment factors) through which restriction and child weight interact and highlights the need to consider these factors in addition to children's eating behaviours in future research. It appears warranted to direct attention towards better understanding of parent's motivations in implementing overt restriction (as distinguishing from covert restriction) and how these motivations differ in given contexts (genetic and environmental), particularly because the relation between restriction and food responsiveness is likely bidirectional (6,43).

Whilst greater understanding of the context in which restrictive feeding influences child weight is needed, the intermediary role of food responsiveness in obesity development holds promise in obesity prevention initiatives. That is, targeting behavioural intermediaries, such as food responsiveness, is likely to provide a shorter term measure of intervention effectiveness and overcome the time and resource burdens that accompany achievement of weight-based outcomes (6). Although it is acknowledged that food responsiveness has genetic components (as discussed), follow-up of a recent intervention that used anticipatory guidance to increase parent's use of responsive feeding practices showed that intervention children, compared with the control group, had lower food responsiveness (2.3 vs. 2.4, scored out of 5 on the CEBQ sub-scale, P = 0.04) (32,44). Whilst this change was not seen to translate into lower BMI during this intervention timeframe, it does support the potential to alter eating behaviours via intervention, as obesity intermediaries (44). On this note and irrespective of context, the wealth of literature supports that targeting parent's use of overt restriction is likely to diminish the influence of external food cues on the commencement of eating thus promoting healthier body weight.

Although this study is limited by its cross-sectional nature, it makes a unique contribution in statistically endorsing a mediator relation between overt restriction, food responsiveness and weight outcomes in early childhood in Australia. Whilst the direction of this relation cannot be confirmed, the lack of association between covert restriction supports a distinctive effect of overt restriction on children's eating behaviours. Given this, measurements of both overt restriction and covert restriction were a distinguishing feature of this study that provides insight to the influence of these feeding practices on children's eating behaviours and weight status. The large, geographically diverse sample used was also a noteworthy strength (17), as was the use of well-established and previously validated tools to measure children's eating behaviours and parents' feeding practices. Whilst less than desirable internal reliability scores for overt restriction is a limitation of this study, the Cronbach's alpha score achieved is comparable with those reported in a validation study of the FPSQ-28 in a sample of Australian children aged 2, 3.7 and 5 years, which ranged between 0.61 and 0.68 across these age categories (9). These levels of internal reliability may be attributed to the few survey items included within this sub-scale, which can reduce Cronbach's alpha scores.

Given that anthropometric data used in this study were by parent report, steps were taken to ensure that included cases were biological plausible, as previously described (17). This was a methodological strength of the analysis, because approximately 41% of large epidemiological studies do not address biological implausibility (45). Additionally, a recent systematic review supports the use of self-reported BMI data specifically to screen children for overweight and obesity as a viable method, with good overall performance with moderate sensitivity and high specificity (46). With this in mind, once cases of biologically implausible data were removed, rates of overweight and obesity in this sample were comparable with national samples of 15.2% overweight and 5.5% obese (4–5 years of age), although rates of underweight appear to be over-represented compared with national data (22.4% vs. 7.55%, respectively) (47). Similar to what has been reported in other studies, anthropometric data deemed biologically implausible were higher in boys, although, contrary to other studies, implausible data were higher in younger children (48,49). No differences in demographic characteristics were seen between children classified as underweight compared with other BMI categories. The use of bootstrapping to examine mediator relation is an additional strength of this study, given its robust nature and ability to determine effect size (24,25).

Despite these strengths, additional research, particularly longitudinal investigations with objectively measured BMI and observations of feeding and eating behaviours, are needed to better understand the relation between restrictive feeding practices, children's eating behaviours and child weight, particularly within different family contexts, genetic predispositions and in consideration of the motivations of parents in implementing overt feeding practices.

The results of this study indicate distinctly different roles of overt restriction and covert restriction in child weight, with overt restriction associated with increased child BMIz. Food responsiveness additionally appears as an important behavioural intermediary in the relationship between overt restriction and child BMIz. Given this, it may be beneficial for future obesity prevention interventions to target parent's use of overt restriction as a means of reducing obesity risk. Further to this, food responsiveness, as an obesity intermediary, may be valuable as an interim measure of intervention effect.

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Authors' contributions

N. Boswell was the lead researcher for this project, supervised by P. S. W. Davies and R. Byrne. N. Boswell wrote the first draft of the manuscript and conducted all data analyses. P. S. W. Davies and R. Byrne provided guidance on statistical methodology, proof reading and editing.

Ethics approval

Ethical approval for this research project has been granted through the Behavioral and Social Sciences Ethical Review Committee, The University of Queensland (approval number 2016000860).

Conflict of Interest Statement

The authors declare that they have no competing interests.

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