Maternal and Paternal Distress in Early Childhood and Child Adiposity Trajectories: Evidence from the Millennium Cohort Study

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Objective: The current study investigated associations between mothers' and fathers' distress reported in early childhood (at ages 9 months and 3 years) and childhood adiposity trajectories from ages 5 to 14 years.

Methods: Linear mixed-effects models were undertaken in the Millennium Cohort Study. Self-reported maternal and paternal distress was measured at ages 9 months and 3 years. BMI and fat mass index (FMI) were modeled from ages 5 to 14 years, adjusting for socioeconomic and child characteristics and stratifying by child sex.

Results: Maternal distress reported at 9 months was associated with steeper increases in BMI and FMI trajectories for girls (BMI: $\beta = 0.06$; 95% CI: 0.01 to 0.11; FMI: $\beta = 0.04$; 95% CI: 0.00 to 0.08). Paternal distress reported at 9 months was associated with steeper increases in BMI and FMI for both girls (BMI: $\beta = 0.06$; 95% CI: 0.00 to 0.12, FMI: $\beta = 0.05$; 95% CI: −0.02 to 0.10) and boys (BMI: $\beta = 0.09$; 95% CI: 0.03 to 0.15, FMI: $\beta = 0.06$; 95% CI: 0.01 to 0.10). Maternal "moderate" distress at 3 years was associated with steeper BMI and FMI trajectories for girls only (BMI: $\beta = 0.08$; 95% CI: 0.03 to 0.12, FMI; $\beta = 0.06$; 95% CI: 0.02 to 0.10).

Conclusions: Maternal and paternal distress experienced in early childhood, particularly during infancy, was associated with steeper adiposity trajectories for children from ages 5 to 14 years.

Study Importance

What is already known?

► Nearly one-third of children in the UK are living with at least one parent reporting significant emotional distress.

► Cross-sectional studies have shown associations between maternal distress in early childhood and an increased risk of children developing obesity in later childhood. However, to the authors' knowledge, no studies have investigated potential associations between fathers' distress and children's long-term obesity risk.

What does this study add?

► Distress reported by mothers and fathers in early childhood, particularly during infancy, was associated with steeper increases in BMI and fat mass index (FMI) trajectories from ages 5 to 14 years in children.

► Fathers' distress reported during infancy, but not during toddlerhood, resulted in steeper BMI and FMI trajectories for both girls and boys. However, mothers' distress, both at 9 months and 3 years, was associated with steeper BMI and FMI trajectories only in girls.

How might these results change the direction of research or focus of clinical practice?

► Obesity prevention efforts placed in the early years may benefit from considering both mothers' and fathers' distress and well-being during the transition into parenthood.

Introduction

The development of overweight and obesity in childhood is a significant public health concern. By the age of 10 years, more than one-third of children in the UK will have developed a BMI in the overweight or obesity range (1). The early onset of adiposity carries both immediate and longitudinal health implications, including increased risk of type 2 diabetes (2) and cardiovascular complications (3). Moreover, epidemiological evidence suggests that adiposity tracks strongly from early childhood into later adolescence and adulthood (4). In one longitudinal study of 50,000 children, nearly 80% of 3-year-olds with BMI in the obesity range continued to have overweight or obesity in late adolescence (5). Nonetheless, the drivers of early adiposity are multifactorial, with

genetic, behavioral, and social influences shown to play substantial and interconnected roles in childhood obesity development (6). However, psychosocial risk factors that might contribute to the early development and sustainment of adiposity have gathered less empirical attention. A better understanding of such exposures has significant potential to highlight novel and practical targets for intervention.

According to a recent Public Health England survey, nearly one-third of children in the UK are living with at least one parent or caregiver with significant emotional distress (7). Such distress has been proposed as a potential contributor to the increasing prevalence of overweight and obesity in childhood. In a 2014 review of nine studies, postnatal depression showed significant positive associations with childhood BMI from infancy to age 12 (8). Similar associations have also been identified when investigating lower levels of emotional distress in relation to childhood adiposity. The potential influence of parental distress on children's adiposity outcomes might highlight how a lack of societal support and a presence of socioeconomic stress on parents carry long-term health implications for children.

In one review of 17 studies focused on distress, the majority of which were cross-sectional, children were at a significantly greater risk for developing obesity across childhood if mothers reported psychological distress in early childhood (9). Moreover, stronger effects were reported when maternal distress was reported during toddlerhood as compared with infancy. This demonstrated relationship between maternal distress and childhood adiposity is likely the result of numerous behavioral, psychological, and physiological mechanisms. For instance, parental distress has been associated with numerous potentially obesity-promoting behaviors across childhood. These include behaviors of emotional eating (10), higher intake of sugar-sweetened beverages (11), reduced familial physical activity (12), shorter duration of breastfeeding (13), and a reduced consumption of fruits, vegetables, and high-calcium foods (14). Therefore, distress experienced by parents might contribute to a more obesogenic shared-home environment and increase children's susceptibility to the wider societal obesogenic environment. It has also been shown that children exposed to concurrent maternal stress across infancy show higher cortisol levels in childhood, which may trigger biological adiposity-promoting pathways, such as alterations in the hypothalamic-pituitary-adrenal axis (15,16).

Although the breadth of findings highlights a relationship between maternal distress and childhood adiposity, several limitations must be addressed. Crucially, no studies, to our knowledge, have explored the influence of distress experienced by fathers on childhood adiposity despite one in eight children having a father who reports significant emotional distress in the UK (7). Paternal distress reported during the early parenting period has demonstrated far-reaching consequences for parenting behaviors (17), children's mental-health outcomes (18), and problem behaviors (19), which, in turn, may influence healthy weight development. Second, a recent longitudinal analysis found that the association between maternal distress reported at age 5 years and childhood BMI was attenuated by adjusting for relevant sociodemographic factors, calling for a greater consideration of potential confounders in these relationships (20). Finally, sex-specific effects may exist, as a recent sex-disaggregated study found associations between maternal distress and adiposity in girls, but not in boys (21).

The current study aimed to explore the association between maternal and paternal distress experienced in early childhood and children's BMI and fat mass index (FMI) trajectories from age 5 to 14 years. To the

author's knowledge, the present analysis is the first to consider the potential influence of distress experienced by fathers during infancy (age 9 months) and toddlerhood (age 3 years) on children's longitudinal weight development. Analyses were also stratified by child sex to investigate potential sex differences highlighted by previous investigations (21).

Methods

Participants
The current study was undertaken on the Millennium Cohort Study (MCS), a UK representative sample of nearly 19,000 families and children born between 2000 and 2002. MCS ensures adequate representation of "hard-to-reach" populations by oversampling children living in disadvantaged areas and those from minority ethnic backgrounds (22). The first wave of data collection occurred at age 9 months, with follow-ups at ages 3, 5, 7, 11, and 14 years. Informed consent was obtained for all participants at each respective wave. Response rates at the most recent sweep (age 14 years) were high at 76.3% of the original sample (23). The current analyses were limited to singleton cohort members with two-parent households at age 9 months to account for potential confounding from twin pairs and single-parent households. MCS data are available from the UK Data Service (www.ukdataservice.ac.uk).

Measures
Parental distress. At age 9 months, distress was measured in mothers and fathers using the Rutter Malaise 9-Item Scale (24). This shortened version of the original 24-item Malaise Inventory has been demonstrated to correlate well with clinically reported depression and anxiety and it carries a good internal consistency ($\alpha = 0.89$) (25). A score ≥ 4 (with a maximum of 9) was considered indicative of the presence of distress (26). Using this score, four categories were derived: 1) no parental distress (both parents < 4); 2) maternal-only distress (only mothers ≥ 4); 3) paternal-only distress (only fathers ≥ 4); and 4) both maternal and paternal distress present (both mother and father ≥ 4).

At age 3 years, distress was measured using the Kessler 6-Item Scale (27). Similar to the Rutter scale, this shortened version has demonstrated concurrence with clinical diagnosis of mental illness (27). In alignment with established cutoff score guidance, a score ≥ 13 was considered indicative of serious distress, whereas a score between 5 and 12 was indicative of moderate distress. From these scores, five categories were derived: 1) no parental distress (both parents < 5); 2) maternal-only moderate distress (only mothers 5-12); 3) paternal-only moderate distress (only fathers 5-12); 4) both maternal and paternal moderate distress (mothers and fathers 5-12); and 5) either maternal or paternal severe distress (either parent ≥ 13, combined because of the limited sample size of parents with severe distress). In contrast to the Rutter scale, the Kessler scale allowed for the segregation of "moderate" and "severe" distress, which was utilized in the current analysis.

Adiposity. Adiposity measures were obtained during home visits from trained interviewers, collecting height (to the nearest 0.1 cm) and weight (to the nearest 0.1 kg) at ages 3, 5, 7, and 14 years (age 5 to 14 years). Measurements were taken from each cohort member once, with data excluded if a valid measure was not obtained. BMI was calculated using height and weight (kilograms per meters squared) as a measure of excess weight at age 5 to 14 years. Body fat percentage (BFP) was

measured using bioelectrical impedance from age 7 to 14 years. FMI was then calculated using BFP and height (FMI = BFP divided by height [meters squared]) as a measure of excess fat. BMI trajectories were modeled at ages 5, 7, 11, and 14 years, whereas FMI trajectories were modeled at ages 7, 11, and 14 years.

Covariates. The covariates included in the current analyses varied between analysis of parental distress at 9 months and parental distress at 3 years. Covariate data were obtained from self-reported surveys and interviews at age 9 months and 3 years. For 9-month and 3-year distress models, covariates included birth weight (kilograms), cohort member ethnicity (White/Indian/Pakistani or Bangladeshi/Black/mixed/other), breastfeeding (never breastfed/ever breastfed), maternal BMI prior to childbirth (kilograms per meters squared), maternal and paternal highest educational achievement (degree level/secondary level [advanced level/ordinary level/General Certificate of Secondary Education]/ no qualifications/other [including overseas]), maternal and paternal employment status (employed/not employed), presence of maternal and paternal limiting illness in line with the *International Classification of Diseases, Tenth Revision* codes (yes/no) (28), equivalized household income quintile (lowest/second/third/fourth/highest quintile), having ever lost a parent (i.e., death or separation) at age 14 years (yes/no), parity (no siblings at birth/one or more siblings at birth), and gestational age (pre-term/term/post-term). The 3-year distress models also included the following covariate: whether the cohort member had a new sibling at age 3 years (no new sibling/new sibling).

Statistical analyses. In order to assess the influence of parental distress on BMI and FMI trajectories across the 9-year follow-up period, we employed linear mixed-effects models (LMMs) with maximum likelihood estimation. LMMs were chosen to maximize the availability of longitudinal data, as they can account for correlation between repeated measures (29,30). By applying maximum likelihood estimation, we were able to include all cohort members who had at least one observed adiposity measure as opposed to requiring complete adiposity data at each wave of follow-up. Therefore, our analyses included all cohort members with complete data on parental distress (9 months and 3 years, respectively), each covariate, and at least one adiposity measure (FMI and BMI, respectively). This included 6,408 children (51% of the eligible sample) and 6,421 children (51% of the eligible sample) for the BMI and FMI analyses in the 9-month distress models, respectively. For the 3-year distress models, this included 5,724 children (45% of the eligible sample) and 5,700 children (45% of the eligible sample) for the BMI and FMI analyses, respectively. The intercept in our LMMs was centered on age 5 years for the analyses with BMI and age 7 years for the analyses with FMI. Akaike information criterion and Bayesian information criterion were used to determine that quadratic LMMs (including an age^2 term) were the best fitting (31). Both crude and adjusted models (for all covariates) were stratified by child sex (male, female), the period of distress (9 months, 3 years), and measure of adiposity (BMI, FMI). This resulted in a total of eight crude and adjusted models. All models included age, age^2, parental distress, and parental distress-by-age interaction. MCS survey weights were applied to account for nonresponse and sampling bias (32). All analyses were conducted in Stata version 16 (StataCorp LLC, College Station, Texas) (33).

Sensitivity analysis. A supplementary analysis was undertaken to explore whether a continuous composite measure of maternal and paternal distress was associated with BMI and FMI trajectories. LMMs

were identical to the main analysis, as aforementioned in the present study. This composite measure was generated by summing the distress scores on the Rutter scale at 9 months and the Kessler scale at 3 years, for mothers and fathers separately.

Results

Descriptive characteristics

Table 1 presents descriptive characteristics pertaining to the 9-month and 3-year parental distress models, respectively, and shows how the analytic samples compared with the complete eligible sample. Maternal distress was more commonly reported (9.69%) than paternal distress (6.44%) when children were 9 months old. However, at age 3 years, levels of moderate distress were similar between mothers (10.09%) and fathers (9.79%). BMI consistently increased from age 5 years (boys: mean [M] = 16.35, standard deviation [SD] = 1.81; girls: M = 16.23, SD = 1.68) to 14 years (boys: M = 20.71, SD = 3.71; girls: M = 21.76, SD = 4.07) for both boys and girls. Whereas FMI showed a similar pattern of linear increase between age 7 years (M = 3.73 BFP/m^2, SD = 1.48) and 14 years (M = 6.04 BFP/m^2, SD = 2.82) for girls, FMI increased between age 7 years (M = 3.30 BFP/m^2, SD = 1.29) and 11 years (M = 3.84 BFP/m^2, SD = 2.15) and then slightly decreased at age 14 years (M = 3.57 BFP/m^2, SD = 2.39) for boys. The majority of the sample was of White ethnicity (90%), never lost a parent over the follow-up period (76%), and had no new siblings at age 3 years (69%).

Parental distress at 9 months and BMI and FMI trajectories from age 5 to 14 years

The LMM output for BMI and FMI trajectories in relation to parental distress, adjusted for covariates, is presented in Table 2. From the age of 5 years, we observed a divergence in BMI trajectories for girls who had either a mother or father with reported distress at age 9 months (maternal-only distress: β = 0.06; 95% CI: 0.01 to 0.11; paternal-only distress: β = 0.06; 95% CI: 0.00 to 0.12). We observed a similar pattern of findings for girls' FMI trajectories from age 7 years (maternal-only distress: FMI: β = 0.04; 95% CI: 0.00 to 0.08; paternal-only distress: β = 0.05; 95% CI: −0.02 to 0.10). However, there was no association between any parental distress group and BMI or FMI measures at baseline (ages 5 and 7 years respectively). For boys, we observed steeper BMI trajectories for those with fathers reporting distress at age 9 months (β = 0.09; 95% CI: 0.03 to 0.15). Similar patterns were observed in relation to FMI trajectories from age 7 years (β = 0.06; 95% CI: 0.01 to 0.10). These findings are represented through growth curve trajectories in Figures 1 and 2.

Parental distress at 3 years and BMI and FMI trajectories from age 5 to 14 years

The LMM output for BMI and FMI trajectories in relation to parental distress, adjusted for covariates, is presented in Table 3. From the age of 5 years, we observed steeper BMI trajectories for girls who had a mother reporting moderate distress at age 3 years (β = 0.08; 95% CI: 0.03 to 0.12). Similar patterns were observed for FMI trajectories (β = 0.06; 95% CI: 0.02 to 0.10). There was no association between any parental distress group and BMI or FMI measures at baseline for girls (ages 5 and 7 years, respectively). For boys, there was no association between parental distress and BMI or FMI trajectories. However, boys with either a mother or father reporting severe distress showed lower BMI values at

TABLE 1 Descriptive characteristics of Millennium Cohort Study (MCS) respondents

	Total sample[a] (N = 12,590)	Complete distress at age 9 months		Complete distress at age 3 years	
		BMI sample[b] (N = 6,408)	FMI sample[c] (N = 6,421)	BMI sample[d] (N = 5,724)	FMI sample[e] (N = 5,700)
Family structure					
Lost parent	2,315 (18.39%)	1,519 (23.70%)***	1,529 (23.81%)***	1,386 (24.21%)***	1,365 (23.95%)***
Never lost parent	6,280 (49.88%)	4,889 (76.30%)	4,892 (76.19%)	4,338 (75.79%)	4,335 (76.05%)
Missing	3,995 (31.73%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Presence of new sibling at 3 years					
No new sibling	8,381 (66.57%)	—	—	3,983 (69.88%)***	3,983 (69.88%)***
New sibling	3,590 (28.51%)	—	—	1,652 (28.98%)	1,652 (28.98%)
Missing	619 (4.92%)	—	—	0 (0%)	0 (0%)
Ethnicity					
White	10,512 (87.69%)	5,813 (90.71%)	5,826 (90.73%)	5,317 (92.89%)	5,059 (93.31%)
Other	467 (3.36%)	196 (3.06%)	196 (3.05%)	50 (2.62%)	141 (2.60%)
Indian	368 (2.06%)	133 (2.07%)	133 (2.07%)	99 (1.73%)	89 (1.64%)
Pakistani/Bangladeshi	911 (4.6%)	201 (3.13%)	201 (3.13%)	99 (1.73%)	85 (1.57%)
Black	273 (1.78%)	65 (1.01%)	65 (1.01%)	59 (1.03%)	48 (0.84%)
Missing	59 (0.47%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Gestational age of CM					
Pre-term	764 (6.07%)	406 (6.36%)	408 (6.38%)	344 (6.35%)***	342 (6.33%)***
Term	10,832 (86.04%)	5,735 (89.90%)	5,746 (89.89%)	4,862 (89.74%)	4,849 (89.75%)
Post-term	424 (3.37%)	238 (3.73%)	238 (3.72%)	212 (3.91%)	212 (3.92%)
Missing	570 (4.53%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Parity of CM					
Firstborn child	4,848 (38.51%)	2,663 (41.56%)***	2,670 (41.58%)***	2,309 (42.46%)***	2,306 (42.53%)***
Other children in household	7,286 (57.87%)	3,745 (58.44%)	3,751 (58.42%)	3,129 (57.54%)	3,116 (57.47%)
Missing	456 (3.62%)	0 (0%)	0 (0%)	456 (3.62%)	
Birth weight of CM	3.39 (0.67)	3.41 (0.57)***	3.41 (0.57)***	3.42 (0.58)***	3.42 (0.58)***
Missing	481 (3.82%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Breastfeeding duration					
Never breastfed	3,347 (26.58%)	1,423 (22.21%)***	1,428 (22.24%)***	1,267 (22.15%)***	1,261 (77.86%)***
Breastfed	8,770 (69.66%)	4,985 (77.79%)	4,993 (77.76%)	4,453 (77.85%)	4,435 (22.14%)
Missing	463 (3.76%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Family income					
Lowest quintile	1,685 (13.37%)	505 (7.88%)***	510 (7.94%)***	456 (7.97%)***	454 (7.97%)***
Second quintile	2,696 (21.41%)	1,142 (17.82%)	1,143 (17.80%)	922 (16.12%)	912 (16.01%)
Third quintile	2,750 (21.84%)	1,431 (22.33%)	1,433 (22.32%)	1,322 (23.11%)	1,316 (23.10%)

TABLE 1 (Continued)

	Total sample[a] (N = 12,590)	Complete distress at age 9 months		Complete distress at age 3 years	
		BMI sample[b] (N = 6,408)	FMI sample[c] (N = 6,421)	BMI sample[d] (N = 5,724)	FMI sample[e] (N= 5,700)
Fourth quintile	2,774 (22.03%)	1,665 (25.98%)	1,665 (25.93%)	1,491 (26.07%)	1,489 (26.14%)
Highest quintile	2,459 (21.03%)	1,665 (25.98%)	1,670 (26.01%)	1,529 (26.73%)	1,525 (26.77%)
Missing	37 (0.29%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Maternal highest education					
Degree level (first, diploma)	3,583 (28.45%)	2,365 (36.91%)***	2,369 (36.89%)***	2,135 (37.30%)***	2,133 (37.42%)***
Secondary (A/0 level/GSCE)	6432 (51.09%)	3,348 (52.25%)	3,353 (52.22%)	3,067 (53.58%)	3,051 (53.53%)
Other (inc. overseas)	329 (2.61%)	130 (2.03%)	130 (2.02%)	94 (1.64%)	92 (1.61%)
None	1,789 (14.04%)	565 (8.82%)	569 (8.86%)	428 (7.48%)	424 (7.44%)
Missing	478 (3.80%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Paternal highest education					
Degree level (first, diploma)	3,094 (24.58%)	2,209 (34.47%)***	2,210 (34.42%)***	1,984 (34.66 %)***	1,979 (34.72%)***
Secondary (A/0 level/GSCE)	5,034 (39.98%)	3,200 (49.94%)	3,207 (49.95%)	2,926 (51.12%)	2,912 (51.09%)
Other (inc. overseas)	268 (2.13%)	119 (1.86%)	119 (1.85%)	93 (1.62%)	92 (1.61%)
None	1,798 (14.28%)	885 (13.73%)	885 (13.78%)	721 (12.60%)	717 (12.58%)
Missing	2,396 (19.03%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Maternal employment					
Employed/self-employed	6,491 (54.36%)	4,161 (60.66%)***	4,141 (60.78%)***	3,733 (65.22%)***	3,720 (65.26%)***
Not employed	5,623 (45.64%)	2,699 (39.34%)	2,672 (39.22%)	147 (2.57%)	145 (2.54%)
Looking after family	–	–	–	1,844 (32.22%)	1,835 (32.19%)
Missing	476 (3.78%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Paternal employment					
Employed/self-employed	9,200 (73.07%)	5,928 (92.51%)***	5,937 (92.46%)***	5,102 (93.72%)***	5,336 (93.61%)***
Not employed	5,623 (7.96%)	480 (7.49%)	484 (7.54%)	278 (4.85%)	274 (4.81%)
Looking after family	–	–	–	90 (1.57%)	90 (1.58%)
Missing	2,388 (18.97%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Mother longstanding illness					
Yes	2,540 (20.17%)	1,348 (21.04%)	1,351 (21.04%)	1,216 (21.24%)	1,208 (21.19%)
No	9,580 (76.09%)	5,060 (78.96%)	5,070 (78.96%)	4,508 (78.76%)	4,492 (78.81%)
Missing	470 (3.73%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Father longstanding illness					
Yes	2,025 (16.08%)	1,304 (20.35%)	1,306 (20.34%)	1,214 (21.21%)	1,209 (21.21%)
No	8,179 (64.96%)	5,104 (79.65%)	5,115 (79.66%)	4,510 (78.79 %)	4,491 (78.79%)
Missing	2,386 (18.95%)				

TABLE 1 (Continued)

	Total sample[a] (N = 12,590)	Complete distress at age 9 months		Complete distress at age 3 years	
		BMI sample[b] (N = 6,408)	FMI sample[c] (N = 6,421)	BMI sample[d] (N = 5,724)	FMI sample[e] (N = 5,700)
Maternal BMI before pregnancy, mean (SD)	21.89 (7.89)	23.86 (4.39)	23.86 (4.39)	23.93 (4.36)	23.89 (4.37 sum)
Missing	1,395 (11.08%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Parental distress at 9 months					
No parental distress	7,878 (82.1%)	5,252 (81.96%)**	5,260 (81.92%)**	—	—
Maternal-only distress	1,010 (9.69%)	639 (9.97%)	640 (9.97%)	—	—
Paternal-only distress	643 (6.44%)	412 (6.43%)	415 (6.46%)	—	—
Both distress	184 (1.77%)	105 (1.64%)	106 (1.65%)	—	—
Missing	2,875 (22.84%)	0 (0%)	0 (0%)	—	—
Parental distress at 3 years					
No parental distress	5,700 (45.27%)	—	—	3,662 (63.98%)***	3,662 (63.98%)***
Maternal-only distress	1,270 (10.09%)	—	—	763 (13.33%)	763 (13.33%)
Paternal-only distress	1,232 (9.79%)	—	—	803 (14.03%)	803 (14.03%)
Both distress	500 (3.97%)	—	—	298 (5.21%)	298 (5.21%)
Either severe	368 (2.92%)	—	—	198 (3.46%)	198 (3.46%)
Missing	3,520 (27.96%)	—	—	0 (0%)	0 (0%)
BMI (boys), mean (SD)					
5 years	16.36 (1.82)	16.365 (1.87)	—	16.36 (1.80)*	—
7 years	16.54 (2.19)	16.47 (2.10)***	—	16.45 (2.05)	—
11 years	18.88 (3.43)	18.81 (3.35)***	—	18.75 (3.33)**	—
14 years	20.81 (3.83)	20.73 (3.78)***	—	20.65 (3.65)**	—
BMI (girls), mean (SD)					
5 years	16.27 (1.76)	16.23 (1.72)**	—	16.20 (1.70)**	—
7 years	16.61 (2.32)	16.59 (2.25)**	—	16.56 (2.24)**	—
11 years	19.31 (3.60)	19.26 (3.54)**	—	19.25 (3.55)**	—
14 years	21.78 (4.06)	21.72 (3.98)***	—	21.72 (4.06)**	—
FMI (boys), mean (SD)					
7 years	3.39 (1.42)	—	3.32 (1.32)***	—	3.30 (1.31)***
11 years	3.94 (2.27)	—	3.86 (2.20)***	—	3.80 (2.11)***
14 years	3.66 (2.54)	—	3.61 (2.46)***	—	3.50 (2.31)***
FMI (girls), mean (SD)					
7 years	3.77 (1.52)	—	3.73 (1.48)***	—	3.71 (1.47)***

TABLE 1 (Continued)

	Complete distress at age 9 months			Complete distress at age 3 years	
	Total sample[a] (N = 12,590)	BMI sample[b] (N = 6,408)	FMI sample[c] (N = 6,421)	BMI sample[d] (N = 5,724)	FMI sample[e] (N = 5,700)
11 years	4.94 (2.43)	—	4.89 (2.39)***	—	4.87 (2.40)***
14 years	6.07 (2.81)	—	6.02 (0.75)***	—	6.02 (2.82)***

[a]Sample of MCS singleton cohort members with two-parent households at Wave 1 (9 months).
[b]Sample of MCS singleton cohort members with two-parent households at Wave 1, with complete data for parental distress at 9 months, all covariates, and at least one BMI measure.
[c]Sample of MCS singleton cohort members with two-parent households at Wave 1, with complete data for parental distress at 9 months, all covariates, and at least one FMI measure.
[d]Sample of MCS singleton cohort members with two-parent households at Wave 1, with complete data for parental distress at 3 years, all covariates, and at least one BMI measure.
[e]Sample of MCS singleton cohort members with two-parent households at Wave 1, with complete data for parental distress at 3 years, all covariates, and at least one FMI measure.
Comparison of total sample to respective BMI/FMI sample:
*$P \leq 0.05$.
**$P \leq 0.01$.
***$P \leq 0.001$.
CM, cohort member; FMI, fat mass index; GSCE, General Certificate of Secondary Education.

age 5 years (β = −0.49; 95% CI: −0.82 to −0.14) and FMI values at age 7 years (β = −0.39; 95% CI: −0.66 to −0.12). These findings are represented through growth curve trajectories in Figures 3 and 4.

Sensitivity analyses

The supplementary LMMs for the composite measure of maternal and paternal distress, adjusted for covariates, are presented in Supporting Information Tables S1 and S2. For maternal distress, there was an association between higher total distress and BMI trajectories for girls (β = −0.01; 95% CI: −0.00 to 0.01) and FMI trajectories for girls (β = 0.01; 95% CI: 0.00 to 0.01) and boys (β = −0.00; 95% CI: −0.00 to 0.01). For paternal distress, there was an association only between higher total distress and FMI trajectories in boys (β = 0.00; 95% CI: −0.00 to 0.01).

Discussion

To our knowledge, the present study is the first study to investigate the association between both maternal and paternal distress and children's longitudinal adiposity trajectories. Our results demonstrate that both maternal and paternal distress experienced in early childhood is associated with steeper increases in BMI and FMI from age 5 to 14 years. More specifically, distress reported at age 9 months showed a greater influence over BMI and FMI trajectories as compared with distress at age 3 years. A sex-specific effect was also present, such that boys showed larger adiposity increases only in response to paternal distress, whereas girls showed increases in response to both maternal and paternal distress reported at age 9 months. In contrast to Hope et al. (20), these associations remained when adjusting for an array of socioeconomic demographic characteristics and health-related variables.

Maternal distress was more common than paternal distress (9.69% vs. 6.44%) at age 9 months; however, by age 3 years, mothers and fathers showed more similar levels of distress (10.09% vs. 9.79%). Although such variation might be due to the difference in measures used to operationalize distress at these two time points, these results suggest that mothers might be slightly more susceptible to experiencing distress during the infancy period given the substantial demands of infant feeding. Our findings are largely consistent with results of previous investigations, reiterating the influence of maternal distress on children's BMI and FMI outcomes (9). However, the present findings offer several novel insights. In contrast to Tate et al. (9), the present results highlight a greater association between parental distress and children's adiposity when distress is reported during infancy as opposed to during toddlerhood. Although the differing measures used to capture distress between these periods must be considered, this finding suggests that parental well-being is relevant to healthy weight development right from the start of life. For instance, postpartum depression has been associated with less optimal infant feeding behaviors, such as reduced breastfeeding initiation (34), which has, in turn, been associated with an increased risk of rapid weight development across infancy (35). Therefore, mechanisms that occur during infancy, such as milk feeding and introduction to solid foods, may be particularly relevant in explaining the link between parental distress and childhood adiposity trajectories. Nonetheless, as distress is socially graded, socioeconomic circumstances contributing to higher distress in early parenthood may additionally contribute to a child's risk of developing obesity through more limited opportunities for adequate nutrition and physical activity. Interventions seeking to improve weight patterning may benefit from considering mothers'

TABLE 2 Adjusted longitudinal mixed models exploring the main effect of parental distress at 9 months in relation to BMI and FMI trajectories during the 9-year follow-up period for boys and girls

	BMI trajectories (5-14 years)				FMI trajectories (7-14 years)			
	Girls		Boys		Girls		Boys	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Baseline								
Intercept (5 years and 7 years)[a]	16.58	15.77 to 17.38	16.83	16.02 to 17.63	3.62	2.94 to 4.30	3.27	2.67 to 3.87
No parental distress	–	–	–	–	–	–	–	–
Maternal-only distress	0.02	−0.20 to 0.25	0.08	−0.16 to 0.33	0.09	−0.10 to 0.28	0.11	−0.11 to 0.33
Paternal-only distress	0.01	−0.23 to 0.26	−0.11	−0.34 to 0.11	0.02	−0.20 to 0.25	−0.01	−0.22 to 0.19
Both parents distress	0.06	−0.58 to 0.71	0.07	−0.65 to 0.79	0.10	−0.44 to 0.64	0.13	−0.28 to 0.55
Rate of change								
Slope (time)	0.18	0.15 to 0.21	0.16	0.12 to 0.20	0.20	0.17 to 0.23	0.26	0.24 to 0.29
No parental distress	–	–	–	–	–	–	–	–
Maternal-only distress	**0.06***	**0.01 to 0.11**	0.02	−0.02 to 0.07	**0.04***	**0.00 to 0.08**	0.01	−0.02 to 0.05
Paternal-only distress	**0.06***	**0.00 to 0.12**	**0.09***	**0.03 to 0.15**	**0.05***	**−0.02 to 0.10**	**0.06***	**0.01 to 0.10**
Both parents distress	0.02	−0.08 to 0.13	0.04	−0.11 to 0.20	−0.02	−0.10 to 0.06	0.03	−0.06 to 0.12
Slope^2	0.05	0.05 to 0.05	0.04	0.03 to 0.04	0.02	0.02 to 0.02	−0.03	−0.04 to −0.03
Variance[a]								
Variance in the slope	0.11	0.10 to 0.12	0.09	0.08 to 0.11	0.06	0.05 to 0.06	0.04	0.03 to 0.05
Variance in the intercept	2.07	1.86 to 2.31	1.81	1.38 to 2.36	1.51	1.35 to 1.69	1.16	0.97 to 1.39
Covariance of slope and intercept	0.24	0.21 to 0.27	0.15	0.09 to 0.22	0.19	0.17 to 0.22	0.12	0.10 to 0.15

[a]BMI intercept centered at age 5 years; FMI intercept centered at age 7 years.
*$P \leq 0.05$.
Models adjusted for ethnicity, birth weight (centered), maternal BMI prebirth (centered), breastfeeding, family income at 9 months, paternal serious illness at 9 months, maternal serious illness at 9 months, maternal educational attainment at 9 months, paternal educational attainment at 9 months, loss of parent.
FMI, fat mass index.

and fathers' mental health in the infancy period (36). However, future investigations would benefit from more harmonized comparisons of distress, as well as unpacking the drivers and behavioral implications of parental distress in early childhood.

The present study is the first, to our knowledge, to report associations between distress experienced by fathers and childhood adiposity trajectories. Fathers' distress reported during infancy was shown to result in steeper BMI and FMI for both girls and boys, whereas mothers' distress in infancy was predictive of steeper BMI and FMI trajectories only in girls. This finding suggests that a focus on paternal well-being, in addition to but not in replacement of maternal well-being, may carry long-term benefits for child weight development. Although very few previous studies have considered distress experienced by fathers and its links to childhood weight development, some previous findings have demonstrated associations between fathers' early feeding practices, such as positive involvement in child eating and pressuring children to eat, and childhood adiposity (37).

Moreover, surrounding evidence from the gestation period has shown that poor paternal diet and stress influence subsequent metabolic functioning of children through epigenetic pathways (38). Therefore, distress experienced by fathers may play an important and underrepresented role in child weight trajectories, as it can shape feeding practices associated with child weight development as well as epigenetic pathways to disease from the start of life.

Sex-variant effects also presented themselves, such that female children were sensitive to both mothers' and fathers' distress at 9 months, whereas boys were influenced only by fathers' distress at 9 months. This finding aligns with Leppert et al.'s (21) finding that maternal stress at age 1 year was associated with BMI z scores at age 5 years for girls, but not for boys. By considering both maternal and paternal distress, it does not appear that boys are unaffected by parental distress as suggested by Leppert et al., but rather that they are specifically influenced by their father's distress levels. Although the dearth of research on paternal influences leaves it unclear as to why male children are more specifically affected by their fathers' distress in infancy, this finding again highlights the important role that fathers play in shaping the healthy growth of their children. Finally, although the combined distress categories did not yield significant influence over adiposity trajectories, these null results are likely the result of the small proportion of families with reported distress in both parents (6.89% for distress at 3 years; 1.77% distress at 9 months).

The current results also highlight an inverse association between severe parental distress at age 3 years and male BMI and FMI at baseline, age 5 years, and age 7 years, respectively. This finding suggests a potential "double burden" of parental distress, such that more severe levels
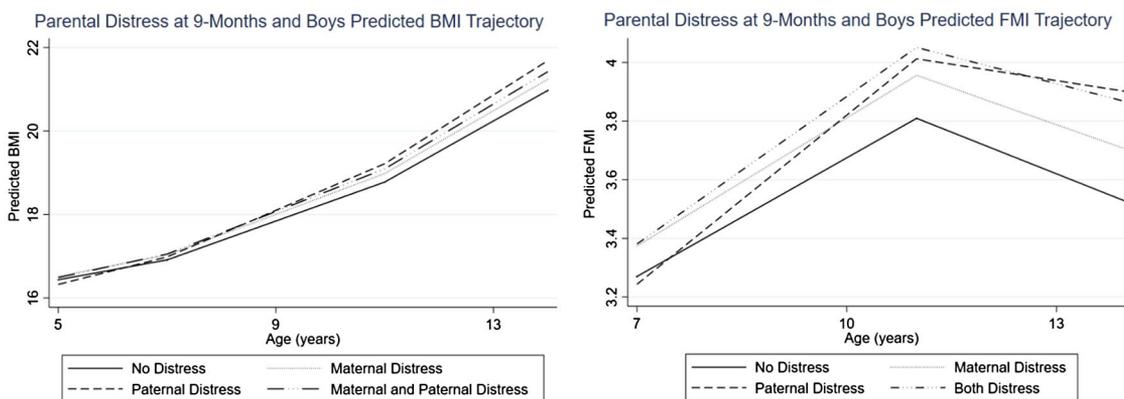
Figure 1 Parental distress at age 9 months and BMI and FMI trajectories from age 5 to 14 years girls. FMI, fat mass index.
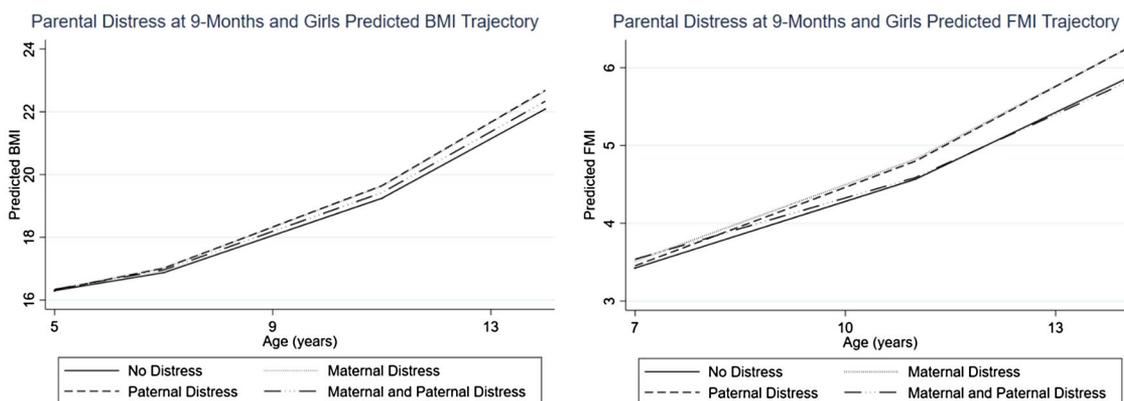
Figure 2 Parental distress at age 9 months and BMI and FMI trajectories from age 5 to 14 years for boys. FMI, fat mass index.

of distress can also result in weight faltering for children. Distress prevention, might yield benefits both for the prevention of overweight and underweight among children. However, more work is needed to clarify the varying implications of moderate and severe levels of distress on childhood weight patterning. Future studies would benefit from investigating alternative factors that might explain the associations presented. In light of the stronger associations between distress reported at age 9 months and adiposity, these factors might include infant feeding methods, responsive feeding behaviors, introduction to solid foods, and early promotion of physical activity.

The present findings must be considered in the context of their strengths and limitations. Our analysis benefits from the use of LMMs, a method that can capture the longitudinal adiposity trajectories of interest while taking intraindividual and interindividual variation into account (29). The present findings are also strengthened by the triangulation of two adiposity measures, BMI and FMI, ensuring that both changes in fat mass and fat-free mass were considered (39). Nonetheless, the current analysis is limited by the varying measure used to capture distress at 9 months (Rutter Malaise 9-Item Scale) and age 3 years (Kessler 6-Item Scale). The possibility that these two measures could capture differing levels or elements of distress

must be considered when contrasting the associations presented in the present study. Second, we limited our analysis to two-parent households in order to control for possible confounding introduced by single-parent households. Therefore, the present findings may not be applicable to families with differing household structures, such as single-parent or same-sex parent families. Moreover, the high proportion of a White ethnic group (87.69%) highlights the limited ethnic diversity of the current sample. Third, as the current investigations aimed to investigate associations, causal relations between distress and childhood adiposity cannot be inferred. Further, it is possible that parents reported higher levels of distress in response to adverse childhood weight patterning or troublesome feeding patterns, introducing the possibility of reverse causation into the results. Finally, our sample was also restricted to those with complete data for all the covariates of interest, respective distress measures, and at least one respective adiposity (BMI/FMI) measure. As longitudinal studies such as MCS are often subject to attrition biases, those with poorer health or who face more disadvantage show more missing data. Therefore, the associations presented may be underestimated by attrition biases (40).

TABLE 3 Adjusted longitudinal mixed models exploring the main effect of parental distress at 3 years in relation to BMI and FMI trajectories during the 9-year follow-up period for boys and girls

| | BMI trajectories (5-14 years) | | | | FMI trajectories (7-14 years) | | | |
| | Girls | | Boys | | Girls | | Boys | |
	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Baseline								
Intercept (5 years and 7 years)[a]	16.19	15.45 to 16.94	16.04	15.16 to 16.91	3.50	2.84 to 4.14	3.26	2.52 to 3.98
No parental distress	—	—	—	—	—	—	—	—
Maternal-only moderate distress	−0.09	−0.30 to 0.13	−0.03	−0.24 to 0.18	−0.01	−0.19 to 0.16	0.01	−0.17 to 0.19
Paternal-only moderate distress	0.06	−0.14 to 0.27	−0.13	−0.32 to 0.05	0.05	−0.13 to 0.23	−0.08	−0.22 to 0.06
Both parents moderate distress	0.07	−0.26 to 0.41	0.26	−0.14 to 0.65	0.12	−0.17 to 0.41	0.16	−0.14 to 0.47
Either parents severe distress	−0.25	−0.62 to 0.12	**−0.49***	**−0.82 to −0.14**	−0.07	−0.39 to 0.25	**−0.39***	**−0.66 to −0.12**
Rate of change								
Slope (time)	0.18	0.14 to 0.21	0.15	0.11 to 0.20	0.20	0.17 to 0.23	0.26	0.23 to 0.29
No parental distress	—	—	—	—	—	—	—	—
Maternal-only moderate distress	**0.08****	**0.03 to 0.12**	0.01	−0.03 to 0.06	**0.06***	**0.02 to 0.10***	0.01	−0.02 to 0.04
Paternal-only moderate distress	0.01	−0.03 to 0.06	0.01	−0.03 to 0.06	0.01	−0.02 to 0.05	0.01	−0.02 to 0.04
Both parents moderate distress	0.04	−0.02 to 0.10	0.03	−0.05 to 0.11	0.03	−0.02 to 0.08	0.03	−0.02 to 0.07
Either parents severe distress	0.07	−0.03 to 0.17	0.03	−0.05 to 0.09	0.05	−0.02 to 0.12	0.01	−0.06 to 0.08
Slope^2	0.05	0.05, 0.05	0.04	0.03, 0.04	0.02	0.02, 0.03	−0.03	−0.04, −0.03
Variance[a]								
Variance in the slope	0.11	0.10 to 0.13	0.09	0.07 to 0.11	0.06	0.05 to 0.07	0.04	0.03 to 0.04
Variance in the intercept	2.00	1.77 to 2.26	1.80	1.32 to 2.43	1.51	1.34 to 1.69	1.24	1.02 to 1.51
Covariance of slope and intercept	0.25	0.21 to 0.28	0.16	0.09 to 0.24	0.20	0.17 to 0.23	0.12	0.10 to 0.14

[a]BMI intercept centered at age 5 years; FMI intercept centered at age 7 years.
*$P \leq 0.05$.
**$P \leq 0.01$.
Models adjusted for ethnicity, birth weight (centered), maternal BMI prebirth (centered), breastfeeding, family income 3 years, paternal serious illness at 3 years, maternal serious illness at 3 years, maternal educational attainment at 3 years, paternal educational attainment at 3 years, loss of parent. Bold indicates significant values.
FMI, fat mass index.
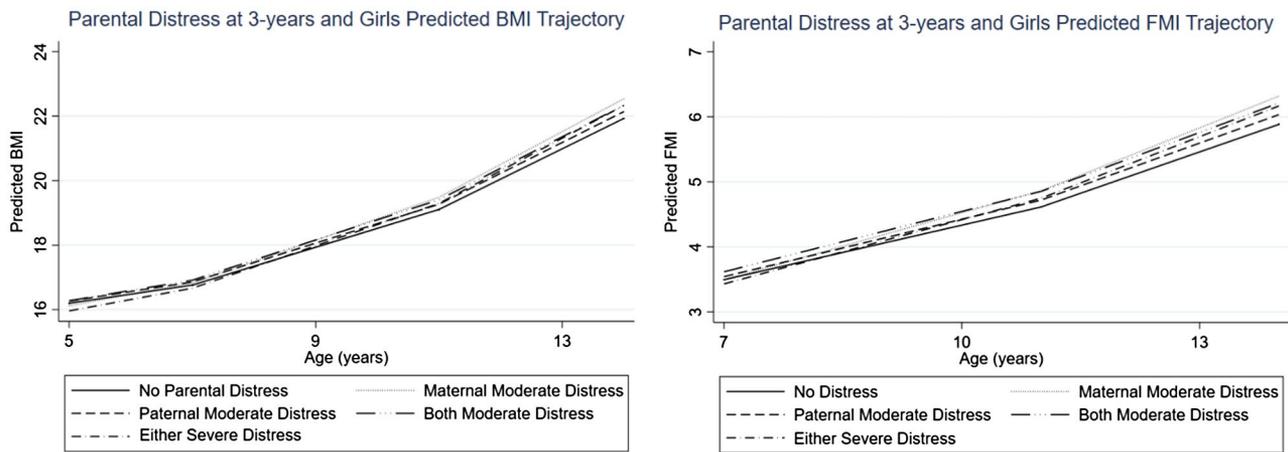
Figure 3 Parental distress at age 3 years and BMI and FMI trajectories from age 5 to 14 years for girls. FMI, fat mass index.
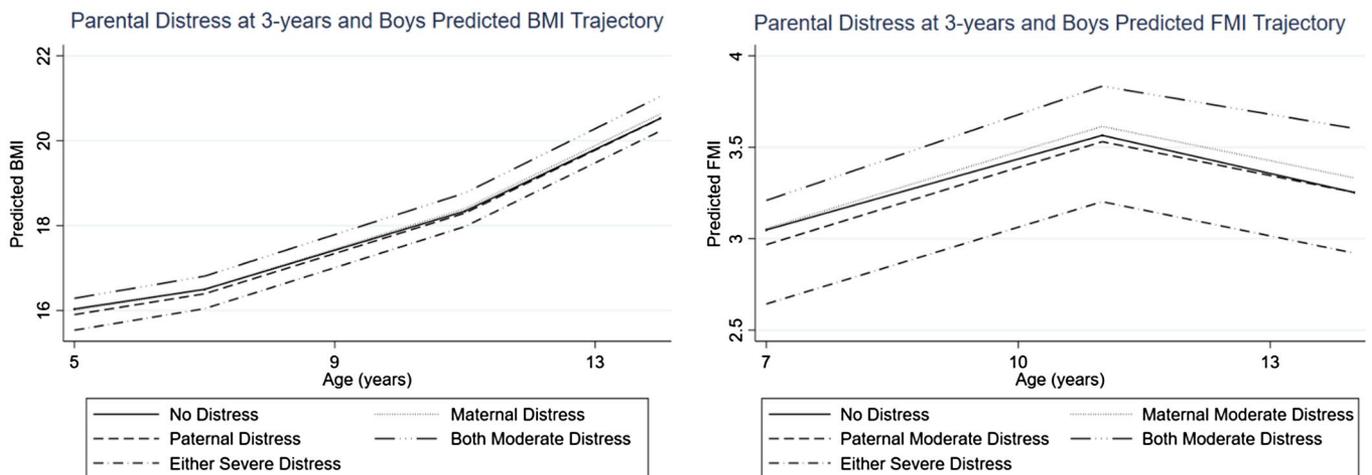
Figure 4 Parental distress at age 3 years and BMI and FMI trajectories from age 5 to 14 years for boys. FMI, fat mass index.

Conclusion

In summary, distress experienced by both mothers and fathers during infancy was associated with steeper increases in children's BMI and FMI trajectories from age 5 to 14 years. Specifically, female adiposity was influenced by both maternal and paternal distress reported during infancy, whereas male adiposity was influenced only by paternal distress reported during infancy. For distress reported in toddlerhood, only maternal distress was associated with steeper BMI and FMI trajectories and only in females. These associations were not attenuated when adjusting for relevant sociodemographic and health-related variables. Together, these findings highlight how distress experienced by both mothers and fathers, as a potential result of limited societal support and socioeconomic stress, carries long-term health implications for children. Provisions to support mothers and fathers from the start of parenthood may yield promising benefits for childhood adiposity outcomes. Nonetheless, future work is needed to

better understand the biological, social, and behavioral mechanisms which explain how and why parental distress influences children's adiposity trajectories.**O**

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Supporting information: Additional Supporting Information may be found in the online version of this article.

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