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Maternal sensitivity and intrusiveness in early childhood as predictors of children's weight at school age

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Summary

Background: While previous research indicates that low maternal sensitivity in mother-child interactions puts children at risk of overweight and obesity, maternal intrusiveness has rarely been investigated in association with children's weight. We investigated whether maternal sensitivity and intrusiveness in early childhood predict children's increased body mass index standard deviation scores (BMI-SDS) at school age. BMI-SDS are standardized for age and gender with respect to a reference standard.

Methods: At baseline (*t*1), we assessed maternal sensitivity and (non-)intrusiveness of 116 mothers with their children (48.3% female) aged 5–47 months ($M = 24.00$, $SD = 11.36$) using the emotional availability scales. We obtained anthropometric data for mothers at *t*1 by measuring height and weight in the laboratory and for children at birth assessed by medical staff. Six years later (*t*2) we obtained anthropometric data for children in the laboratory or based on parental report. Linear regression analyses were run with child BMI-SDS at *t*2 as outcome and sensitivity and (non-)intrusiveness as predictors, adjusting for confounders and exploring child age and gender as moderators.

Results: Maternal sensitivity only negatively predicted children's BMI-SDS in girls, while maternal intrusiveness predicted higher child BMI-SDS at school age regardless of child gender. The effect of maternal non-intrusiveness remained significant when controlling for confounders.

Conclusion: Maternal intrusiveness in early childhood seems to represent a risk factor for increased BMI-SDS in children, while lower maternal sensitivity tends to be a risk factor for increased BMI-SDS in girls. This may have implications for prevention or intervention programmes.

KEYWORDS
childhood obesity, childhood overweight, emotional availability, intrusiveness, maternal behaviour, sensitivity

1 | INTRODUCTION

Childhood obesity is considered a major global health challenge[1] associated with long-term morbidity and mortality.[2] Most prevention and intervention strategies targeting childhood obesity focus on altering the obesogenic lifestyle by increasing physical activities or promoting a healthy diet, or a combination of the two.[3,4] As these interventions show only limited effectiveness in randomized controlled trials,[3] and even less when implemented as scale-up interventions under real world conditions,[5] there remains a need to identify further modifiable risk factors for increased body mass index (BMI) in children, which could inform effective preventive and interventive measures in the future. While various biological, environmental and sociopsychological factors contribute to the development and maintenance of overweight and obesity in children,[2] several studies also indicate the family to be a factor of central influence.[6] Thus, it is unsurprising that previous research has not only suggested links of children's risk for overweight or obesity with specific parenting behaviours related to food consumption or physical activity,[7,8] but also has indicated links with the observed general quality of the early mother-child interaction, specifically maternal sensitivity.[9] However, previous studies have not disentangled the effect of maternal sensitivity from the potential effect of maternal intrusiveness, as these studies have often used instruments capturing aspects of both constructs in one measure. Therefore, this study aims to replicate and extend previous research by exploring both the role of maternal sensitivity and intrusiveness in mother-child interaction on children's weight in a sample from Germany.

Ever since the introduction of the maternal sensitivity construct to the field, developmental research has stressed the relevance of sensitive caregiving for a broad range of child outcomes.[10] Maternal sensitivity refers to the mother's capacity to recognize and correctly interpret the infant's cues and to respond appropriately, consistently and promptly.[11] When facing arousal, infants highly depend on their caregivers' sensitive behaviour in order to stay well-regulated. According to attachment theory, infants internalize these early caregiver relationship experiences. Consequently, these experiences serve as prototypes for regulatory strategies.[12] Empirical studies show that caregiver sensitivity positively affects self-regulatory abilities in children, such as executive functioning, emotion regulation or inhibitory control.[13–15] Moreover, such sensitive interactions support the child in developing the ability to correctly perceive inner affective states or signals and to differentiate them from hunger and satiation.[16] There is evidence that impairments in both self-regulation and the perception or understanding of inner (affective) states are associated with obesity[17–21] and that individuals with overweight compared to individuals with normal weight show higher levels of "emotional eating", i.e., eating due to distress or uncomfortable affective states in the absence of hunger.[22] It is not completely understood whether such impairments in individuals with obesity are rooted in non-sensitive experiences with their caregivers during early childhood. However, Wendland et al[23] showed that lower maternal sensitivity towards a child at the age of 6 months predicted increased BMI standard deviation scores (BMI-SDS) in girls—but not boys—at the age of 48 months. Likewise, low maternal sensitivity compared to high sensitivity towards a child at the age of 6 and 54 months, respectively, predicted a higher risk of the child having overweight or obesity at school age.[24,25] In a large cohort study, Anderson et al[9] examined the effect of maternal sensitivity in combination with child attachment security at the ages of 15, 24 and 36 months on the development of obesity in adolescence. Low relationship quality (combined score of attachment and sensitivity) of the mother-child interaction compared to high relationship quality was associated with a greater risk of developing obesity at the age of 12 to 15 years. Interestingly, lower maternal sensitivity was associated with adolescent obesity to a greater extent than an insecure attachment of the child. In contrast, in another cohort study, a significant link between the mother-infant relationship (including maternal sensitivity, responsiveness, and fostering of cognitive and socio-emotional growth) at 9 months and obesity at 5.5 years was no longer observed when maternal sociodemographic factors such as maternal education were taken into account.[26] One study even suggested more positive mother-child interactions in 2-to 3-years-old children with obesity compared to children with normal weight.[27]

While the majority of these studies seem to emphasize the importance of sensitive behaviour towards the child during early childhood for healthy weight development, the role of intrusive behaviour remains unclear. Maternal intrusiveness refers to behaviour characterized by overprotection or over-directiveness, and to behaviour interfering with or dominating the child's activities and restricting the child's autonomy.[28,29] It has been associated with a variety of negative child outcomes, such as internalizing and externalizing problems, poor academic performance and deficits in socioemotional development.[30,31] While maternal sensitivity in interaction with the child promotes the development of children's self-regulation, maternal intrusiveness appears to compromise self-regulatory capacities.[32–34] However, little is known about the effect of maternal intrusiveness on the development of overweight and obesity or increased BMI-SDS in children. Evidence from research focusing on feeding situations found observed intrusive maternal feeding behaviours to be positively associated with children's BMI-SDS.[35] In addition, a closer look at the studies that reported an effect of maternal sensitivity on children's weight revealed that a majority of these studies[9,24,25] used instruments to assess sensitivity which—besides others—did include aspects of (non-)intrusiveness (e.g., "respect for autonomy", "intrusiveness"). Hence, it is not clear whether the effect of the quality of the mother-child interaction found in these studies is attributable to sensitive behaviour or intrusive behaviour on the part of the mother. As positive and negative parenting behaviours exert unique effects on child outcomes,[36,37] gaining more knowledge about the specific associations of maternal sensitivity and intrusiveness with children's increased BMI-SDS could be helpful for tailoring prevention or intervention programmes.

Taking all this into consideration, this study aims to help fill the research gaps outlined above by analysing the effect of specific aspects of the mother-child interaction during early childhood on children's BMI-SDS at school age. First, we want to examine the effect of maternal sensitivity on children's prospective weight. In line with

previous research,[9,23] we hypothesize that lower maternal sensitivity in early childhood predicts higher BMI-SDS in children at school age. Second, we want to expand the current research on the quality of mother-child interaction and its influence on children's weight development by focusing on maternal intrusiveness as a potential risk factor. We hypothesize that higher maternal intrusiveness (i.e., lower non-intrusiveness) in the mother-child interaction predicts higher BMI-SDS in children at school age. Since high maternal BMI[38] and low maternal education in higher economic status countries,[39] as well as high children's weight at birth,[40] are considered to be determinants of increased BMI-SDS in children, we take these aspects into account as potentially confounding covariates. This specifically extends previous research that did not include maternal BMI/weight status in the analyses,[24,25] or only collected data on maternal obesity when youth were adolescent rather than in early childhood.[9] In addition, we control for demographic characteristics of the child (age, gender) and explore whether child age and child gender moderate the effects of maternal sensitivity and maternal intrusiveness on child BMI-SDS at school age.

2 | METHODS

2.1 | Sample

The current study was conducted at the IFB Adiposity Diseases Centre, University of Leipzig, investigating risk and protective factors for children's weight development in a risk group (mother and/or father with obesity, i.e., BMI ≥ 30) and a control group (both parents with normal weight).[41] Families were recruited using flyers and posters in kindergartens and at the practices of health care professionals in and around Leipzig, Germany,[42] and screened by telephone for parental weight status. Only families who met the inclusion criteria regarding parental weight status were invited to participate in the study. A total sample of $N = 209$ young children aged 5–47 months ($M = 24.87$, $SD = 11.35$) and their parents were recruited at the first point of assessment ($t1$) and were assessed repeatedly over a longer period of time. This study uses data from the first point of assessment ($t1$) and the latest assessment at school age ($t2$), which took place about 6 years ($M = 6.00$, $SD = 0.50$, range 4.92–7.17 years) after $t1$. At $t2$, 77 families had dropped out of the study (typically due to moving away, lack of time, or no reaction to our contact attempts), but $n = 132$ children aged 5 to 10 years ($M = 7.58$, $SD = 1.08$) and their mothers participated again. This subsample did not differ from the whole sample in terms of maternal education, BMI or children's age or gender and BMI-SDS at birth. For $n = 129$ children out of these 132 children, anthropometric data were obtained either by assessment in the laboratory ($n = 95$) or via parental reports ($n = 34$). Following the recommendation by Pinquart[43] regarding the investigation of associations between parenting and continuous weight data, we removed underweight children from our data, yielding a final sample of $n = 116$. Table 1 shows the descriptive characteristics of the sample. In line with the inclusion criteria mentioned above, we oversampled for mothers with obesity at $t1$. Hence, our sample included 45 (38.8%) mothers with obesity (BMI ≥ 30) and 10 (8.6%) mothers with overweight (25 ≤ BMI < 30).*

TABLE 1 Descriptive characteristics of the sample ($N = 116$)

Variables	$t1$ *M (SD)* or *N (%)*	$t2$ *M (SD)* or *N (%)*
Mothers' characteristics		
Age in years, *M* (SD)	31.48 (4.59)	37.49 (4.69)
BMI, *M* (*SD*)	28.27 (8.59)	-
Education		
Certificate of general or secondary education[a]	47 (40.5)	-
General qualification for university entrance[b]	36 (31.0)	-
University degree	33 (28.4)	-
Children's characteristics		
Age in months, *M* (*SD*)	24.00 (11.36)	96.15 (12.69)
Gender		
Male	60 (51.7)	60 (51.7)
Female	56 (48.3)	56 (48.3)
BMI-SDS	At birth 0.50 (1.34)	0.37 (0.90)
BMI	At birth 13.22 (1.69)	17.22 (2.55)
Weight status		
Obesity		7 (6.0%)
Overweight		14 (12.1%)
Normal weight		95 (81.9%)

Note: $t1$ is the baseline (average child age = 24 months) and $t2$ is the school age (average child age = 96 months).
[a]The certificate of general education is an elementary school diploma, which is obtained on successful graduation from grade 9; the certificate of secondary education is obtained on successful graduation from grade 10.
[b]This group also includes mothers with the entrance qualification for a university of applied sciences.

2.2 | Procedures

The ethics committee of the Medical Faculty, University of Leipzig approved this study. Caregivers gave their informed consent and mothers completed sociodemographic information forms at $t1$. We also assessed the anthropometric data of mothers and videotaped mother-child interactions in the laboratory at $t1$ during a free-play situation. Data on children's birth weight and birth height were taken from official booklets that included routine medical check-ups for children ("U-Heft"). At $t2$, we obtained data on children's height and weight.

*When assessing parental height and weight in the laboratory, 13 of the 116 families included in this study, did not meet the inclusion criteria which had been originally defined. In order to include as many children as possible for longitudinal analyses, we decided to include children and their mothers ($n = 7$ mothers with normal-weight, $n = 6$ mothers with overweight) of these 13 families into our analyses.

2.3 | Measures

2.3.1 | Anthropometric data

Trained personnel assessed the body weight and height of mothers at *t*1 using calibrated body scales (Kern, model MPT 300K100M) with a reading accuracy of ±0.1 kg. Mothers stood freely, without shoes. Maternal height was measured in a free-standing position with a calibrated stadiometer (Soehnle) with a reading accuracy of ±0.5 cm. None of the mothers reported being pregnant at the point of data collection. We then calculated maternal BMI at *t*1. We also collected information on children's birth weight and length from an official booklet issued by the Ministry of Health which mothers brought to the laboratory. This booklet ("U-Heft") includes data on physical development collected by medical staff during routine medical check-ups for children throughout childhood and is for the parents to take home for their records. Immediately after birth, the baby receives a first examination by medical staff (doctors or midwives) during which birth weight and length are assessed and documented accordingly in the official booklet. Based on the anthropometric data from the routine medical check-up at birth we also calculated children's BMI-SDS at birth. BMI-SDS (or BMI z scores) are standardized for age and gender with respect to a reference standard[44] and indicate the extent to which the BMI of an individual lies above or below the median BMI value, considering the individual's age and gender. According to the German reference standard including children aged 0–18 years, a BMI-SDS of 1.28 and above indicates overweight and a BMI-SDS of 1.88 and above indicates obesity. At *t*2 we obtained parental reports regarding current weight and height for all children. Ninety of 116 children were also assessed by trained personnel using the same body scales and stadiometer as used for mothers at *t*1. Whenever anthropometric data collected in the laboratory were available, we used these for the calculation of BMI-SDS at *t*2. When these data were not available—which was the case for 26 children—we calculated BMI-SDS based on parental reports of children's weight and height.[†] As the majority of children in this study did not show overweight or obesity at school age, we used child BMI-SDS as a continuous outcome measure (see statistical analyses).

2.3.2 | Maternal sensitivity and intrusiveness in mother-child interactions

We used the dimensions *sensitivity* and *non-intrusiveness* of the emotional availability scales (EAS; 4th edition[28]) to assess maternal sensitivity and (non-)intrusiveness at *t*1 based on videotaped mother-child interactions in a 16-minute free-play situation using standard and age-appropriate toys provided in the laboratory. *Sensitivity* refers to the extent to which the caregiver's affect is well regulated and authentic, and to which the caregiver is able to perceive and interpret children's cues correctly and to react to them appropriately, including adequate timing and handling of conflicts, flexibility of behaviour, creativity, and an accepting attitude towards the child. *Non-intrusiveness* refers to the absence of overly protective, suggestive, stimulating or controlling behaviour in the caregiver as well as the ability to follow the child's lead without interfering in the child's activities or impairing the child's autonomy. Both dimensions were rated on 7-point scales (1 = non-optimal, 7 = optimal) by two female coders (the senior author and another researcher) who were blind to further information about the families. Before coding the study data, the two coders had been successfully trained and accredited to use the EAS by Biringen. For 16% of the study videos inter-rater reliability between the two coders was assessed. The ICCs were ICC = 0.75 for sensitivity and ICC = 0.77 for non-intrusiveness, respectively.

2.4 | Statistical analyses

We used SPSS statistical software, version 25.0 (SPSS Inc.) for our analyses. We used correlation analyses (Pearson's *r*) to investigate associations between aspects of mother-child interaction (i.e., sensitivity and non-intrusiveness), child BMI-SDS at *t*2 and control variables. To test our hypotheses that sensitivity and non-intrusiveness would negatively predict child BMI-SDS 6 years later, we conducted separate linear regression analyses with child BMI-SDS at *t*2 as the dependent variable (as we expected multicollinearity between sensitivity and non-intrusiveness). The predictors were maternal sensitivity and non-intrusiveness. In the second step, we also included maternal BMI, and maternal education at *t*1 as well as child age at *t*1 and child gender as covariates. In the third step, we added interaction terms sensitivity × child age as well as sensitivity × child gender and non-intrusiveness × child age as well as non-intrusiveness × child gender, respectively. In the fourth step, we included child BMI-SDS at birth as an additional covariate reflecting a proxy for genetic, biological or intrauterine influences. Whenever our hypothesized effects reached significance, we also calculated effect sizes (Cohen's f^2) for these effects.[45]

2.5 | Results

2.5.1 | Descriptive analyses

The mean scale scores for sensitivity ($M = 5.01$, $SD = 0.87$) and non-intrusiveness ($M = 5.00$, $SD = 0.98$) indicate that on average the quality of the mother-child interactions in this sample tended to be moderate. Both scales covered a range from 3 to 7, suggesting that there were no mothers in this sample who showed extremely insensitive behaviour or immensely (physically) intrusive behaviours as these mothers would have received even lower scores (1 or 2).

Intercorrelations of sensitivity, non-intrusiveness and child BMI-SDS at *t*2 as well as child BMI-SDS at birth, maternal BMI, maternal

[†]There was a significant strong positive correlation between children's BMI as assessed from parental reports with children's BMI assessed in the laboratory ($r = 0.97$, $p < 0.01$).

TABLE 2 Correlation analyses (Pearson's *r*) between aspects of mother-child interaction, demographic variables and child BMI-SDS at school age and at birth

		1	2	3	4	5	6	7	8
1	Sensitivity at *t*1	1							
2	Non-intrusiveness at *t*1	0.75**	1						
3	Child BMI-SDS at birth	0.13	0.02	1					
4	Maternal BMI at *t*1	−0.04	−0.07	0.09	1				
5	Maternal education at *t*1	0.20*	0.08	−0.10	−0.27**	1			
6	Child age at *t*1	0.04	0.01	0.03	−0.06	−0.05	1		
7	Child gender	0.02	0.01	0.16	0.12	−0.30**	0.07	1	
8	Child BMI-SDS at *t*2	−0.12	−0.23*	0.26**	0.44**	−0.27**	0.18†	0.21*	1

Note: Child gender (1 = male, 2 = female). *t*1 is the baseline (average child age = 24 months) and *t*2 is the school age (average child age = 96 months).
*$p < 0.05$. **$p < 0.01$. †$p < 0.06$.

education as well as child age and child gender are presented in Table 2. There was a significant strong positive cross-sectional correlation between maternal sensitivity and non-intrusiveness in early childhood (*t*1), a small positive correlation between maternal sensitivity and maternal education, and a significant small longitudinal negative correlation between maternal non-intrusiveness in early childhood (*t*1) and child BMI-SDS at school age (*t*2). The greater the mother's intrusiveness in interactions with her child was in early childhood, the greater the BMI-SDS of her child was at school age. Moreover, child BMI-SDS at *t*2 showed a small positive correlation with child BMI-SDS at birth, a moderate positive correlation with maternal BMI, a small positive correlation with child gender and a small negative correlation with maternal education. In addition, child gender was moderately negatively associated with maternal education.

2.5.2 | Prediction of children's BMI-SDS at *t*2

By applying a regression analysis with child BMI-SDS at *t*2 as the dependent variable and maternal sensitivity as predictor, we found that maternal sensitivity did not predict children's BMI-SDS at *t*2—with or without the covariates (see Table 3). Of the covariates, maternal BMI as well as child age positively predicted children's BMI-SDS at *t*2, while there were no significant effects of maternal education and child gender (see Table 3, model 2). All variables explained 27% of the variance. When exploring whether child age or gender moderated the effect of maternal sensitivity, we only found a small significant effect for the interaction sensitivity × child gender ($f^2 = 0.04$) with all variables explaining 30% of the variance (see Table 3, model 3). Figure 1 illustrates that there was a negative association between maternal sensitivity and child BMI-SDS at *t*2 in girls but not in boys. Multiple linear regressions conducted separately for girls and boys revealed a small negative effect of maternal sensitivity on child BMI-SDS in girls ($\beta = -0.31$, $p = 0.022$, $f^2 = 0.10$) but not in boys ($\beta = 0.10$, $p = 0.438$). Hence, the lower the mother's sensitivity in the interaction with her young daughter, the higher her daughter's BMI-SDS was at

TABLE 3 Regression analyses summary for maternal sensitivity, maternal BMI, and demographic variables predicting children's BMI-SDS at school age

		B	SE	*β*
1	(Constant)	0.37	0.08	
	Sensitivity at *t*1	−0.12	0.10	−0.12
2	(Constant)	0.37	0.07	
	Sensitivity at *t*1	−0.09	0.09	−0.09
	Maternal BMI at *t*1	0.04	0.01	0.40***
	Maternal education at *t*1	−0.10	0.10	−0.09
	Child age at *t*1	0.02	0.01	0.19*
	Child gender	0.21	0.15	0.12
3	(Constant)	0.38	0.07	
	Sensitivity at *t*1	−0.08	0.09	−0.08
	Maternal BMI at *t*1	0.04	0.01	0.39***
	Maternal education at *t*1	−0.10	0.10	−0.09
	Child age at *t*1	0.02	0.01	0.19*
	Child gender	0.21	0.15	0.12
	Sensitivity × child age	−0.00	0.01	−0.01
	Sensitivity × child gender	−0.35	0.17	−0.17*
4	(Constant)	0.37	0.07	
	Sensitivity at *t*1	−0.11	0.09	−0.11
	Maternal BMI at *t*1	0.04	0.01	0.38***
	Maternal education at *t*1	−0.08	0.10	−0.08
	Child age at *t*1	0.02	0.01	0.19*
	Child gender	0.17	0.15	0.10
	Sensitivity × child age	0.00	0.01	0.00
	Sensitivity × child gender	−0.29	0.17	−0.14†
	Child BMI-SDS at birth	0.13	0.06	0.19*

Note: $R^2 = 0.01$ for model 1 ($p = 0.220$), $\Delta R^2 = 0.26$ for model 2 ($p < 0.001$), $\Delta R^2 = 0.03$ for model 3 ($p = 0.115$), $\Delta R^2 = 0.03$ for model 4 ($p = 0.023$). All independent metric variables were centred around their mean for analyses, child gender (−0.5 = male, 0.5 = female).
*$p < 0.05$. ***$p < 0.001$. †$p < 0.10$.

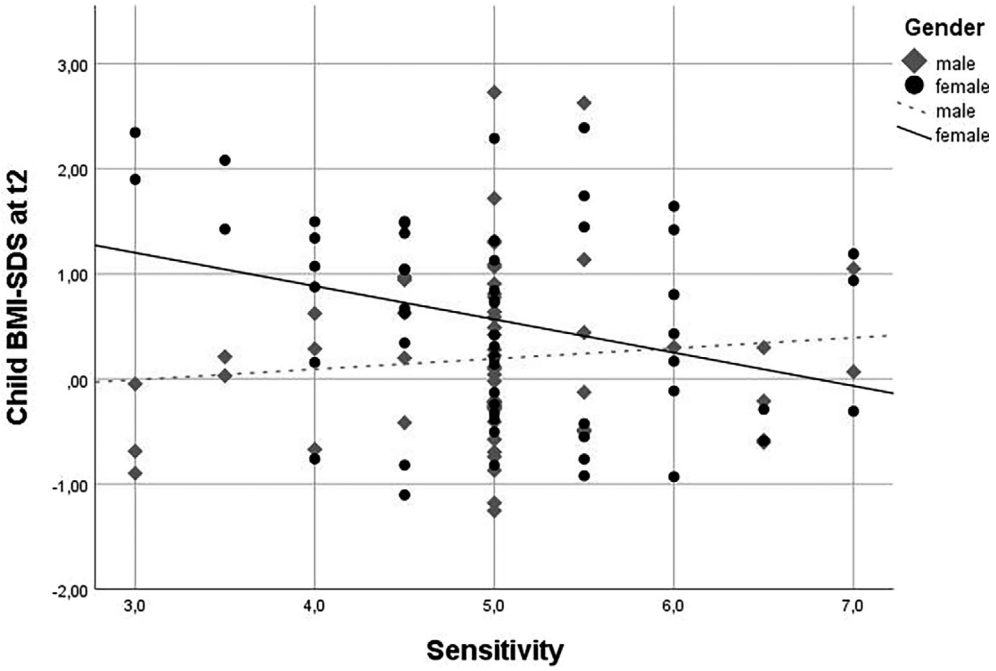

FIGURE 1 Interaction effect between maternal sensitivity × child gender on child BMI-SDS at school age

school age. The effect of maternal sensitivity in girls remained significant after covariates were added ($\beta = -0.21$, $p = 0.048$, $f^2 = 0.08$).

By applying a regression analysis with child BMI-SDS at *t*2 as the dependent variable and maternal non-intrusiveness as predictor, we found that maternal non-intrusiveness showed a small significant negative effect on children's BMI-SDS at *t*2 explaining 5% of the variance (see Table 4, model 1, $f^2 = 0.05$). Thus, the greater the mother's intrusiveness (and the lower the non-intrusiveness) in the interaction with her young child, the higher her child's BMI-SDS was at school age 6 years later. The effect of maternal non-intrusiveness remained significant ($f^2 = 0.05$) even when maternal BMI, maternal education at *t*1 as well as child age and gender were added as control variables (see Table 4, model 2). All variables explained 30% of the variance. Neither the interaction effect non-intrusiveness × child age nor non-intrusiveness × child gender were significant (see Table 4, model 3).

To examine the contribution of maternal sensitivity and non-intrusiveness to child BMI-SDS at *t*2 under consideration of child BMI-SDS at birth, we added child BMI-SDS at birth as a further covariate in the analyses. While the interaction effect sensitivity × child gender remained significant only at a trend level (see Table 3, model 4), maternal non-intrusiveness continued to significantly negatively predict child BMI-SDS at *t*2 ($f^2 = 0.06$; see Table 4, model 4). In addition, child BMI-SDS at birth positively predicted child BMI-SDS at *t*2. The effects of maternal BMI and of child age remained significant (see Table 3, model 4 and Table 4, model 4). Overall, all variables explained up to 34% of the variance.

3 | DISCUSSION

The purpose of this longitudinal study of 116 children and their mothers was to examine the effects of maternal sensitivity and maternal intrusiveness in early childhood on children's BMI-SDS at school age. Contrary to our first hypothesis, maternal sensitivity in early childhood was not related to child BMI-SDS at school age for all children but only for girls. This effect remained significant when sociodemographic variables and maternal BMI were taken into account. However, it was only significant on a trend level when controlling for child weight at birth which—along with maternal BMI—served as a proxy for genetic, epigenetic or intrauterine pathways that underlie the transmission of increased BMI-SDS from one generation to the next.[46] Supporting our second hypothesis, we found maternal intrusiveness in the early years to be a risk factor for increased BMI-SDS in children at school age even when controlling for sociodemographic variables, mothers' BMI and children's BMI-SDS at birth. Mothers' weight and children's weight at birth are well-established risk factors for the development of overweight and/or obesity in children,[38,40] and were positively associated with children's BMI-SDS at school age in this study. Moreover, child age positively predicted children's BMI-SDS at school age which dovetails increasing prevalence rates of overweight and obesity as children grow older.[47] In contrast to previous studies,[39] mothers' education was not associated with child BMI-SDS in the regression analyses.

The gender-specific effect of maternal sensitivity on child BMI-SDS in our study replicates the results of Wendland et al,[23] who found lower maternal sensitivity with 6-months-old children to put girls—but not boys—at risk for having an increased BMI-SDS at the age of 48 months. In addition, the results of our study extend the findings on associations between maternal sensitivity and child overweight or obesity reported by previous studies[9,24,25] which did not explore child gender as a potential moderator. It would be interesting to know whether gender-specific effects played a role in these studies as well. Moreover, earlier studies reporting a significant effect of

TABLE 4 Regression analyses summary for maternal non-intrusiveness, maternal BMI and demographic variables predicting children's BMI-SDS at school age

		B	SE	*β*
1	(Constant)	0.37	0.08	
	Non-intrusiveness at *t*1	−0.21	0.08	−0.23*
2	(Constant)	0.37	0.07	
	Non-intrusiveness at *t*1	−0.18	0.07	−0.20*
	Maternal BMI at *t*1	0.04	0.01	0.39***
	Maternal education at *t*1	−0.11	0.09	−0.10
	Child age at *t*1	0.02	0.01	0.19*
	Child gender	0.21	0.15	0.12
3	(Constant)	0.37	0.07	
	Non-intrusiveness at *t*1	−0.17	0.08	−0.19*
	Maternal BMI at *t*1	0.04	0.01	0.40***
	Maternal education at *t*1	−0.11	0.10	−0.10
	Child age at *t*1	0.02	0.01	0.19*
	Child gender	0.21	0.15	0.12
	Nonintrusiveness × child age	−0.00	0.01	−0.05
	Nonintrusiveness × child gender	−0.09	0.15	−0.05
4	(Constant)	0.37	0.07	
	Non-intrusiveness at *t*1	−0.18	0.07	−0.20*
	Maternal BMI at *t*1	0.04	0.01	0.39***
	Maternal education at *t*1	−0.10	0.09	−0.09
	Child age at *t*1	0.01	0.01	0.18*
	Child gender	0.16	0.15	0.09
	Nonintrusiveness × child age	-0.00	0.01	−0.05
	Nonintrusiveness × child gender	−0.05	0.15	−0.03
	Child BMI-SDS at birth	0.13	0.05	0.20*

Note: $R^2 = 0.05$ for model 1 ($p = 0.014$), $\Delta R^2 = 0.25$ for model 2 ($p < 0.001$), $\Delta R^2 = 0.01$ for model 3 ($p = 0.648$), $\Delta R^2 = 0.04$ for model 4 ($p = 0.015$). All independent metric variables were centred around their mean for analyses, child gender (−0.5 = male, 0.5 = female).
*$p < 0.05$. ***$p < 0.001$.

maternal sensitivity differed from our study regarding the instruments used and therefore the conceptualization of sensitivity. These studies used sensitivity constructs derived from combining scores for supportive presence, respect for autonomy (i.e., non-intrusiveness), and hostility,[9,24] or for sensitivity to non-distress, intrusiveness, and positive regard.[25] It can therefore not be ruled out that the effect of sensitivity found in prior studies reflects the combined influence of several different qualities of the mother-child relationship, while in this study we investigated the effects of specific qualities, namely sensitivity and intrusiveness, separately. Nonetheless, the mechanisms that underlie the gender-specific role of maternal sensitivity in the development of childhood overweight or obesity remain open.

While low maternal sensitivity appears to be a relevant risk factor for increased BMI-SDS specifically in girls, high maternal intrusiveness seems to be a relevant risk factor for boys and girls similarly. This is in line with former research reporting mothers' intrusive prompts to eat to predict increased BMI-SDS in children.[35] Considering the high correlation between sensitivity and (non-)intrusiveness, it seems to be surprising that only intrusiveness predicted child BMI-SDS regardless of child gender. While intrusiveness refers to deficits in the ability to "give autonomy" to the child by following the child's lead and finding appropriate ports of entry, sensitivity refers to appropriate affect and responsivity of the adult. Based on the results of this study, it seems that the controlling behaviour that constitutes intrusiveness is a potential risk factor for overweight or obesity in children, while sensitive maternal behaviour tends to be protective for overweight or obesity development specifically in girls. There are several potentially related mechanisms that may explain the effect of higher maternal intrusiveness on increased BMI-SDS in children. While for children with disabilities directiveness has been found to be useful as it potentially clarifies what is needed in a particular situation,[48] for typically developing children, controlling or intrusive behaviours on the part of the mother has been found to predict poor academic, social, emotional and behavioural child outcomes.[30,31] As mentioned above, maternal intrusiveness compromises children's development of self-regulation,[14,32,34] which can put them at risk of developing overweight and obesity.[20,21] In addition, higher maternal intrusiveness in early childhood has been shown to predict higher stress in children, as measured by salivary cortisol and alpha-amylase levels.[49] Stress can result in an increased consumption of (comfort) food, or eating in the absence of hunger,[50] and also fosters the accumulation of fat in visceral depots.[51] Mothers who are intrusive might also be more likely to adopt controlling feeding practices. Some studies,[52] but not others[8] indicate that controlling feeding practices contribute to excess weight in children, as they may disrupt children's responsiveness to internal hunger and satiety cues.[53] However, little is yet known regarding associations between the observed emotional quality of the mother-child interaction in general, and specific feeding practices. Understanding the potential pathways by which maternal intrusiveness affects children's weight development would be a relevant step for future research.

Despite several strengths, such as the longitudinal design, the assessment of sensitivity and (non-)intrusiveness in mother-child interactions using a reliable and valid observational method, and obtaining objective height and weight measurements in a laboratory setting (rather than from mothers' reports), there are also several limitations to this study.

First, there are limitations resulting from characteristics of the sample investigated in this study: This sample included mothers who voluntarily participated and who mainly had high levels of education. These mothers might be more sensitive and less intrusive towards their children compared to the general population, which could constrain the generalizability of our findings. Similarly, the generalizability of our results could be limited by oversampling of mothers with obesity. The majority of children in this study did not show overweight or obesity at school age, so we used child BMI-SDS as a continuous outcome measure, which might limit the clinical significance of this study. Future research will have to show whether maternal (non-)intrusiveness predicts

overweight and/or obesity in children. Another limitation relates to the small sample size in this study, which constrained the statistical power but was still adequate to enable the detection of small effects. Though effect sizes of maternal sensitivity and intrusiveness were only small, this does not necessarily imply a lack of clinical significance of the effects found, since even small effects that accumulate over time can be significant for developmental processes.[54]

Second, this study focused only on the quality of interaction between children and their mothers from Germany, and did not extend to fathers or to mothers from different cultures. Fathers can positively affect their children's development already in early childhood and at preschool age[33,55] and are often characterized as being more physical, playful, challenging and activating than mothers during interactions with their children.[56,57] With this in mind, it would be interesting to investigate whether paternal insensitivity and intrusiveness have an equally unfavourable effect as maternal insensitivity and intrusiveness on children's weight development. Moreover, we cannot rule out the possibility that intrusiveness might have significantly different meanings depending on the mothers' cultural background,[29] which might limit the generalizability of our results to families from other cultures. Taken together, there is a need for a replication of the results in future studies using more diverse samples.

Third, though children's behaviours and characteristics shape the way caregivers treat their children,[58] it was beyond the scope of this study to specifically consider any bidirectional relations between mothers and children. We can therefore not exclude that there are certain characteristics of or behaviours by the child which may have triggered certain maternal behaviours considered as being more or less sensitive or intrusive. However, the observational measure (i.e., the EAS) used in this study to assess sensitivity and (non-)intrusiveness captures this bidirectional relationship by taking the perspectives of both parts of the dyad into account when evaluating maternal or child behaviours (i.e., the caregiver cannot look good without the child[59]).

Fourth, the design of this study did not allow us to assess genetic and biological factors that contribute to the development of increased weight in children. However, by including maternal BMI and child BMI-SDS at birth in our analyses we sought to capture potential genetic or biological influences on child weight development at least partially.

Lastly, despite its longitudinal design, this study does not allow us to infer causality. Causality could be inferred only if the manipulation of the independent variable examined in this study (e.g., reduction of maternal intrusiveness through an intervention in a randomized controlled trial) leads to a change in the dependent variable (e.g., decrease in child BMI-SDS) and if alternative variables or explanations for the effect can be ruled out.[60] It is up to future studies to replicate the results found in this study and to examine the potential causal relationship of sensitivity and intrusiveness with increased child BMI-SDS in interventional designs by taking into account potential gender-specific effects.

To conclude, despite these limitations, the present study contributes observational, longitudinal data to the growing body of research on the quality of mother-child interaction and children's weight development. As so far only few aspects of the parent-child relationship have been found to predict children's overweight and/or obesity development, most prevention and intervention programmes still focus on immediate changes in diet, physical activity, or eating behaviour, showing limited effectiveness even when parents are included.[3] However, there is growing evidence that programmes to support positive parenting are beneficial in obesity prevention or intervention.[61,62] Accordingly, the results of our study emphasize the relevance of investigating low maternal sensitivity and high maternal intrusiveness as risk factors for the development of increased BMI-SDS in children, and support the notion that examining multiple facets of the parent-child relationship is a promising approach to identifying specific entry points for parent-centred prevention or intervention measures. These results also indicate that the simple use of only the sensitivity construct or a composite variable combining scores for sensitivity and intrusiveness would not have revealed the importance of maternal intrusiveness specifically in affecting increased child BMI-SDS. If the results reported in this study can be replicated in more diverse samples in the future, they could inform the development of new or extension of existing programmes.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to report. Z.B. wishes to disclose a potential conflict of interest, and she therefore, distances herself from actual data analyses, and has a management plan with her university.

AUTHOR CONTRIBUTIONS

All authors have made substantive intellectual contributions to this project. **Franziska Schlensog-Schuster** and **Sarah Bergmann** led the writing of this manuscript and conducted the analyses and interpretation of the data. **Zeynep Biringen** made substantial contributions to the interpretation and discussion of the data. **Kai von Klitzing** is the principal investigator and has overall responsibility for the study. He conceived and designed the study together with the collaborating investigator **Annette M. Klein**. All authors contributed to the definitive writing of the paper and gave their final approval of the submitted and published versions.

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