ORIGINAL ARTICLE

Emotion Identification in Preschool and Early Adolescent Body Mass Index: Exploring the Roles of Depressive Symptoms and Peer Relations

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Abstract
The ability to identify and label emotions may represent an early-life risk factor that relates to excess weight gain during childhood. The current study investigates the relationships between preschool emotion identification and early adolescent body mass index (BMI), as well as the mediating role of two variables: depressive symptoms and peer relations. In a longitudinal study, preschoolers completed an emotion identification task, and parents completed psychiatric assessments and a peer-relations questionnaire about their child. BMI percentile was measured at later time points in early adolescence. Poor emotion identification during preschool predicted increases in BMI percentile over time, with greater deficits in emotion identification ability relating to steeper increases in BMI percentile across early adolescence. Peer relations in preschool partially mediated the relationship between preschool emotion identification ability and adolescent BMI. This study provides novel information about potential targets for early interventions in the service of obesity prevention.

Keywords Emotion identification · Depression · Peer relations · Obesity · Preschool

Obesity in adolescence often persists into later life and creates risk for adverse health outcomes [1–3]. Current treatments of obesity largely focus on lifestyle changes and are minimally effective [4]. Since obesity is difficult to treat once established, prevention may provide a more promising therapeutic avenue [5] if early-life modifiable risk factors for obesity could be identified. Early childhood may be a particularly valuable time for intervention, given the potential for greater neuroplasticity of the developing brain.

Previous work relates early-life emotion identification, the ability to accurately label facial emotions, to weight status and increases in body mass index (BMI) across development [6–9]. Specifically, while one study observed no differences between youth with obesity and youth of normal weight in emotion identification ability [10], three other cross-sectional studies found that children with overweight or obesity were less accurate than children of lower weight in naming the emotions displayed by others [6, 8, 9]. Further, preliminary longitudinal research links such deficient abilities to increases in BMI across childhood [7]. Thus, existing research relates emotion identification ability to obesity.

Compared to findings on this bivariate association, less is known about the developmental relationships among a web of risk factors potentially related to both emotion identification and obesity. Of note, early-life emotion identification can be identified as young as 3 months old [11]. As such, difficulties in this skill may initiate a pathway toward obesity through associations with other, modifiable, later-manifesting risk factors, specifically depressive symptoms and peer relations, each of which could provide a target for prevention efforts.

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Depressive symptoms could be one possible mediator of the relationship between emotion identification and BMI. Consistent with this possibility, many studies find emotion-identification deficits in Major Depressive Disorder [12–14]. Moreover, some, but not all [15], studies find that Major Depressive Disorder in childhood predicts high BMI in adulthood [16]. Finally, differences in emotion identification have been identified in youth at high-risk for depression [17], suggesting that emotion identification difficulties may predict risk trajectory of depression and persistence of depression over time [18].

As with depressive symptoms, poor peer relations may represent another potential mediator of the relationship between emotion identification and BMI. Indeed, independent lines of research link poor peer relations to emotion identification deficits in children [19] and increases in weight status [20–22]. Similarly to depressive symptoms, emotion identification difficulties may represent an early-life risk factor for negative peer relations, as inaccuracies in emotion identification have been shown to predict negative peer relations over time [19]. Ultimately, work is needed to solidify understanding of the temporal relationships among early-life emotion identification, depression, peer relations, and later weight status. Such work may provide targets for earlier interventions that could alter the developmental trajectory to obesity. Justification for such interventions would be supported if emotion identification could be linked to overweight status through these mediators.

The current study utilizes data from a longitudinal study to investigate how deficits in emotion identification, depressive symptoms, and poor peer relations during preschool age relate to BMI across development. The study examines preschool emotion identification ability and depressive symptoms at an initial time point, preschool depressive symptoms and peer relations at a later time-point, and early adolescent BMI at two even later final time points. Thus, the study investigates possible mediational relationships among these four variables. Previous studies in this sample examined the relationship between emotion identification and BMI across childhood [7], and the current report extends these findings from preschool age into early adolescence. We also extend previous findings by examining the independent relationships that early emotion identification abilities, early depressive symptoms, and early peer relations may show with weight status in early adolescence.

The study tests two main hypotheses. First, poorer emotion identification ability during preschool is expected to be associated with higher adolescent weight status and to be predictive of larger increases in BMI across early adolescence. Second, both greater depressive symptoms and poorer peer relations in early-life are expected to mediate the relationship between worse emotion identification ability in preschool and higher BMI in early adolescence.

Method

Participants

Participants were enrolled in the Preschool Depression Study, conducted at the Early Emotional Development Program at the Washington University School of Medicine in St. Louis. The Preschool Depression Study is a longitudinal study of preschoolers and their families with an oversampling of children with depressive symptoms [23]. A prior study examined associations with emotion identification and BMI in this sample, as reported elsewhere [7], and the current report describes secondary analyses from this sample. Unlike the prior study, the current study links emotion identification data from preschool age to data on BMI in early adolescence.

Participants were excluded for chronic medical illnesses, neurological problems, pervasive developmental disorders, or language and/or cognitive delays, and they were recruited from pediatricians' offices, daycare centers, and preschools in the St. Louis Metropolitan area [24]. The current study utilizes 231 participants ($n = 123$ male; $n = 106$ minority race) who completed annual behavioral assessments over the course of 10 years, including assessments of emotion identification ability, BMI, depressive symptoms, and peer relations. The current study includes four different time points. The first two time points were categorized as representative of preschool age ($M = 4.53$ years, $SD = 0.80$; $M = 5.56$ years, $SD = 0.80$), and the second two time points were categorized as representative of early adolescence ($M = 10.22$ years, $SD = 0.90$; $M = 11.20$ years, $SD = 0.89$). Parental consent and child assent were conducted prior to participation. The Washington University School of Medicine's Institutional Review Board approved all procedures.

Measures

Emotion Identification

Emotion identification was assessed through the Penn Emotion Differentiation Test (KIDSEDF) [25] at time one, the first preschool time point. This test contained 24 items measuring children's ability to identify happy and sad faces. Children were shown pairs of faces expressing either happiness or sadness at varying intensity on a computer screen and were asked to determine which face expresses that emotion more intensely. Composite scores were created for the total number of correct responses, whereby higher scores represent more correct responses. This measure has demonstrated adequate reliability and

validity amongst children and adolescents [26] and used as an index of treatment response in preschoolers [27, 28]. In the current sample, reliability was adequate (for happy faces: $\alpha = 0.61$; for sad faces: $\alpha = 0.63$).

BMI

Trained research assistants assessed participants' height and weight, measured without shoes, at times three and four, both during early adolescence. BMI percentile was calculated using the Centers for Disease Control and Prevention growth charts [29]. BMI was adjusted for age and sex by following information on the Centers for Disease Control and Prevention website. 35% of the sample was characterized as overweight or obese at time three and 34% of the sample was characterized as overweight or obese at time four.

Peer Relations

The Health Behavior Questionnaire is a parent report measure that aims to assess behavior in children ages 4–8 years old [30]. The questionnaire contains multiple sections that measure children's mental health, physical health, social functioning, and school functioning. This study selectively examined children's social functioning through scores on the Peer Relations section, rated in eight items from the Peer Acceptance and Rejection subscale and three items from a Bullied by Peers subscale. This section included items like "Is picked on by other children"; "Is liked by other children who seek him/her out to play;" "Avoids peers;" "Prefers to play alone;" "Is considerate of others' feelings" and "Offers to help other children/peers who are having difficulty with a task." Both the Peer Acceptance and Rejection and Bullied by Peers subscales have demonstrated adequate cross-informant agreement among mother, father, and teacher reports [30]. Parents or guardians were instructed to rate the extent to which certain statements represent the social functioning of their child by providing a score of 1, "not at all like" to 4, "very much like." Scores from every item were added in order to generate a composite value, whereby higher scores were representative of better peer relations. Parents/guardians completed the Peer Relations section at time two, the second preschool time point. In the current sample, internal consistency was good ($\alpha = 0.88$).

Depressive Symptoms

The Preschool Age Psychiatric Assessment was used to assess psychiatric symptoms at time one and time two during preschool [31, 32]. These assessments contain developmentally appropriate questions that address diagnoses based on the *Diagnostic and Statistical Manual of Mental Disorders, 4th Edition* (DSM-IV) criteria for a disorder in childhood.

For the purpose of the present report, DSM-IV symptoms for the following disorders was assessed: depression modified for preschool onset [33], attention deficit disorder, externalizing (oppositional defiant, and/or conduct disorder), and internalizing (posttraumatic stress disorder, generalized anxiety and separation anxiety). All diagnostic interviews were audiotaped and reviewed for reliability using established methods previously reported [34]. A depression severity score was created by calculating the number of items from the major depressive disorder module endorsed by the caregiver and/or child during each assessment. The depression severity score from times one and two was used analyses described below. Inter-rater reliability among clinicians was high for a diagnosis of depression ($\kappa = 1.0$; ICC $= 0.98$).

Income-to-Needs Ratio

Primary caregivers reported family income at times one and two. The early income-to-needs ratio (e.g., between ages 3 and 6) was computed as the total family income at baseline divided by the federal poverty level, based on family size, at the time of data collection [35]. This score was used a covariate in the analyses described below.

Statistical Analyses

All analyses were conducted using SPSS version 24 (IBM, Armonk, New York).

Repeated data on all covariates, main predictors (e.g. emotion identification ability, peer relations, depressive symptoms), and the outcome variable (BMI percentile) were available; therefore, we analyzed change in BMI percentile across time (i.e. using each adolescent assessment) using multilevel linear mixed (MLM) models [36] to account for dependencies due to repeated measurements. Preschool emotion identification ability, preschool depressive symptoms, and preschool peer relations were evaluated as a predictors of both the main effect and slope (rate of change) in BMI percentile across time. Fixed effects were included for time (i.e., within-individual change in BMI percentile across the assessments), correct emotion identification, preschool depressive symptoms, preschool peer relations, and the interactions between time and each predictor to examine the influence of these factors on changes in BMI percentile over time. All models included sex, ethnicity, and family income-to-needs ratio as covariates. All continuous predictors were mean-centered. Random effects for the BMI percentile intercept and slope for time were included to account for individual variability in mean levels of BMI percentile and rate of change in BMI percentile.

Multiple mediation analyses were used to test whether depressive symptoms and peer relations at time two mediated the effects of emotion identification on BMI percentiles

at time three and time four. Mediation analyses controlled for age, sex, ethnicity, income-to-needs ratio and depressive symptoms at time one. Two multiple mediations were conducted using the PROCESS macro [37, 38]: one with time three BMI percentile as the outcome variable and one with time four BMI percentile as the outcome variable.

Results

The current study contains a diverse sample of participants in terms of demographic features (54% male; 46% minority race) representative of the St. Louis metropolitan area. Descriptive statistics and bivariate correlations between measures are provided in Table 1.

We examined preschool emotion identification ability, depressive symptoms, and peer relations as predictors of the level and change in BMI percentile across early adolescence, controlling for the following covariates: sex, ethnicity, and family income-to-needs ratio. There were main effects for time, income-to-needs, ethnicity, depressive symptoms, and emotion identification ability (Table 2). There was a significant interaction between time and emotion identification ability, indicating that preschoolers with worse emotion identification ability showed the steepest increase in their BMI percentile over time (Fig. 1). To aid in the interpretation of this effect, we tested the significance of the simple slopes at $1SD$ below the mean, mean, and $1SD$ above the mean of preschool emotion identification ability. The simple slope was 21.06 at $-1SD$ ($p = .01$), 9.39 at the mean of emotion identification ability ($p = .17$), and 11.58 at $+1SD$ ($p = .09$). Thus, at lower levels of emotion identification ability, the slope of BMI becomes more strongly positive, indicating a stronger rate of increase in BMI percentile when compared to children with average or high levels of emotion identification ability. No significant interactions were found between depressive symptoms and time or peer relations and time.

Multiple Mediation Analyses

Multiple mediation analyses controlled for age, sex, income to needs ratio, and time one depressive symptoms. Multiple mediation analyses showed that that total indirect effect of time one emotion identification on time three BMI percentile was significant [point estimate $= -0.08$, 95% CI (-0.17, -0.02)]. Time one emotion identification was not associated with time two depressive symptoms [$a_1 = -0.01$, SE $= 0.01$, $p = 0.36$, 95% CI (-0.04, 0.01)] but was positively associated with time two peer relations [$a_2 = 0.01$, SE $= 0.00$, $p = 0.01$, 95% CI (0.00, 0.02)]. Time two depressive symptoms did not predicted time three BMI percentile [$b_1 = -0.31$, SE $= 0.78$, $p = 0.69$, 95% CI (-1.85, 1.23)],

Table 1 Means, standard deviations, and intercorrelations between measures

|	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. T1 child age	4.53 (.80)									
2. Gender	−0.02	123 (male)								
3. Ethnicity	0.02	−0.03	106 (minority)							
4. T1 income to needs	−0.02	−0.02	−.57**	2.03 (1.17)						
5. T1 depressive symptoms	0.07	−0.04	0.10	−0.189**	2.58 (1.84)					
6. T2 depressive symptoms	0.18**	−0.02	−0.02	−0.045	.44**	1.98 (1.60)				
7. T1 emotion understanding	−0.01	0.07	−0.05	0.079	−0.19**	−0.13+	11.98 (3.80)			
8. T2 peer relations	−0.13+	0.08	−0.244**	0.294**	−0.23**	−0.30**	0.11	3.50 (.53)		
9. T3 BMI percentile	0.06	−0.05	0.17*	0.047	0.14+	0.07	0.17*	−0.21**	63.18 (28.79)	
10. T4 BMI percentile	0.10	−0.00	0.23**	−0.054	0.05	0.06	−0.01	−.25**	.847**	63.78 (28.61)

$N = 231$, $M(SD)$

$^+p < .10$; $^*p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 2 Fixed effects estimates from multilevel models predicting change in BMI percentile from emotion identification, peer relations, and depressive symptoms

	B	SE	t	df	p
Intercept	−77.29	59.93	−1.29	92.94	.20
Time	16.32	7.19	2.27	76.14	.03
Income to needs	5.65	2.07	2.73	246.54	.01
Sex	1.86	3.95	.47	247.26	.64
Ethnicity	−12.11	4.78	−2.54	246.06	.01
Peer relations	12.25	14.45	.85	95.29	.40
Depressive symptoms	8.07	4.21	1.92	100.70	.06
Emotion identification	5.99	1.79	3.34	99.96	.001
Time×peer	−2.34	1.73	−1.35	75.47	.18
Time×emotion Identification	−0.58	0.21	−2.73	77.34	.01
Time×depressive symptoms	−0.68	0.49	−1.39	88.94	.17

however time two peer relations did positively predicted time three BMI percentile [$b_2 = -7.77$, SE = 2.39, $p < 0.000$, 95% CI (−12.58, −3.18)]. Time one emotion identification had a significant positive total effect on time three BMI percentile [$c = 1.12$, SE = 0.27, $p < .000$, 95% CI (0.60, 1.64)]. With the addition of time two depressive symptoms and time two peer relations to the model, the direct effect of emotion identification on BMI percentile was also significant [$c' = 1.20$, SE = 0.27, $p < .000$, 95% CI (0.67, 1.72)]. The specific indirect effect of time one emotion identification on time three BMI percentile through depressive symptoms was not significant [point estimate = 0.00, 95% CI (−0.01, 0.06)], whereas the specific indirect effect of time one emotion identification on time three BMI percentile via peer relations was significant [point estimate = −0.08, 95% CI (−0.17, −0.02)]. The findings indicate that peer relations partially mediated the relationship between emotion identification and BMI percentile. Figure 2 displays results of the multiple mediation analyses examining depressive symptoms and peer relations at time two simultaneously as mediators of the

Fig. 1 Model-implied trajectories of BMI percentiles at low, medium, and high levels of preschool emotion identification ability

Model Implied Trajectories of BMI Percentile by Preschool Emotion Identification Ability
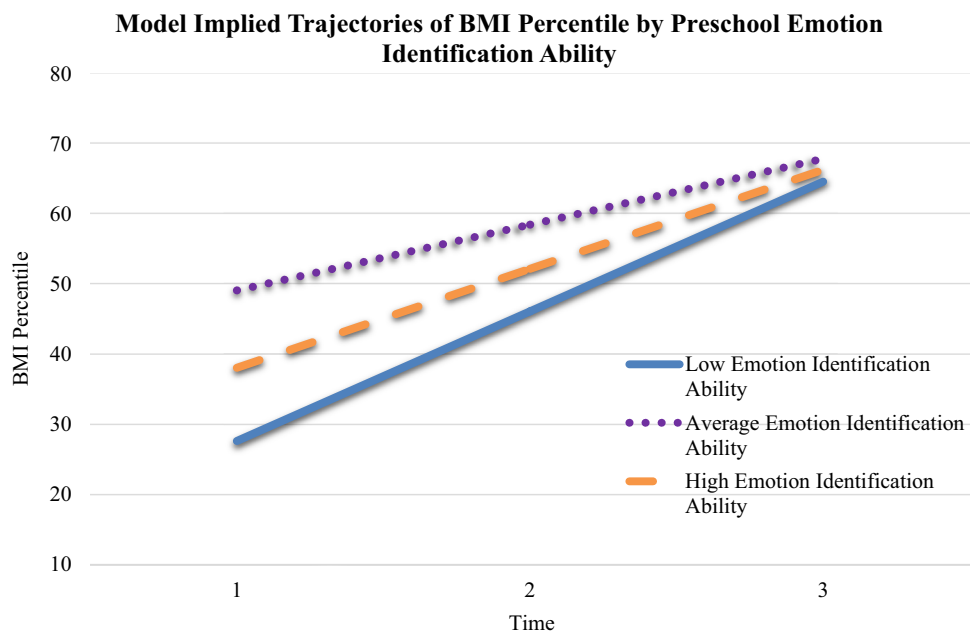
Fig. 2 Multiple mediation model for time one emotion identification and time three BMI percentile via time two depressive symptoms and peer relations. $^+p<.10$; $^*p<.05$; $^{**}p<.01$; $^{***}p<.001$
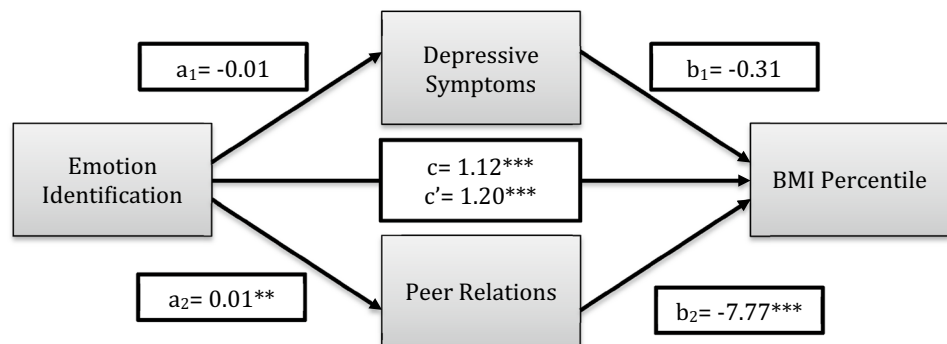
relationship between time one emotion identification ability and time three BMI percentile.

Multiple mediation analyses showed that that total indirect effect of time one emotion identification on time four BMI percentile was significant [point estimate $= -0.21$, 95% CI $(-0.35, -0.11)$]. Time one emotion identification was not associated with time two depressive symptoms [$a_1 = -0.01$, SE $= 0.01$, $p = 0.28$, 95% CI $(-0.04, 0.01)$] but was positively associated with time two peer relations [$a_2 = 0.02$, SE $= 0.00$, $p = 0.01$, 95% CI $(0.01, 0.02)$]. Time two depressive symptoms did not predicted time four BMI percentile [$b_1 = 0.14$, SE $= 0.79$, $p = 0.85$, 95% CI $(-1.41, 1.70)$], however time two peer relations positively predicted time four BMI percentile [$b_2 = -13.41$, SE $= 2.49$, $p < 0.000$, 95% CI $(-18.30, -8.52)$]. Time one emotion identification did not have a significant total effect on time four BMI percentile [$c = 0.13$, SE $= 0.28$, $p = 0.64$, 95% CI $(-0.42, 0.69)$]. With the addition of time two depressive symptoms and time two peer relations to the model, the direct effect of emotion identification on BMI percentile was still not significant [$c' = 0.34$, SE $= 0.28$, $p = 0.23$, 95% CI $(-0.21, 0.89)$]. The specific indirect effect of time one emotion identification on time four BMI percentile though depressive symptoms was also not significant [point estimate $= 0.00$, 95% CI $(-0.05, 0.02)$], whereas the specific indirect effect of time one emotion identification on time four BMI percentile via peer relations was significant [point estimate $= -0.20$, 95% CI $(-0.35, -0.11)$]. The findings indicate that peer relations partially mediated the relationship between emotion identification and BMI percentile. Figure 3 displays results of the multiple mediation analyses examining depressive symptoms and peer relations at time two simultaneously as mediators of the relationship between time one emotion identification ability and time four BMI percentile.

Discussion

In a sample of youth oversampled for depressive symptoms, we found that deficits in emotion identification ability during preschool were associated with a greater BMI in early adolescence and predicted a greater change in BMI across two time points in early adolescence. Additionally, we found a significant positive association between preschool depressive symptoms and adolescent BMI, as well as a significant association between early-life peer relations and adolescent BMI, such that children with better peer relations during preschool were less likely to have overweight or obesity in early adolescence. Lastly, peer relations partially mediated the relationship between early emotion identification ability and early adolescent BMI.

Results supported the proposed hypotheses, as deficits in emotion identification during preschool age were related to a higher BMI in early adolescence and predicted a larger change in BMI across early adolescence. This association was also relevant to clinically meaningful categories; adolescents with obesity appeared to have worse preschool emotion identification ability than participants with a healthy weight. These findings extend previous literature on the relationship between emotion identification and weight status. Notably, while a previous report in this sample has demonstrated a connection between deficits in emotion identification and increases in BMI across childhood [7], the current study extends such prior findings by examining this relationship beginning from preschool age into early adolescence. Findings also suggest possible mechanisms for this effect.

The current study aimed to test the hypothesis that children's depressive symptoms and peer relations play a role in the risk trajectory between emotion identification and BMI, as previous research has indicated that depressive symptoms and peer relations may relate to emotion identification [12, 19] and predict increased BMI [16, 21]. The current study examines the roles of these risk factors in the connection between emotion identification and weight status, and mediational models suggested that the association between

Fig. 3 Multiple mediation model for time one emotion identification and time four BMI percentile via time two depressive symptoms and peer relations. $^{+}p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$
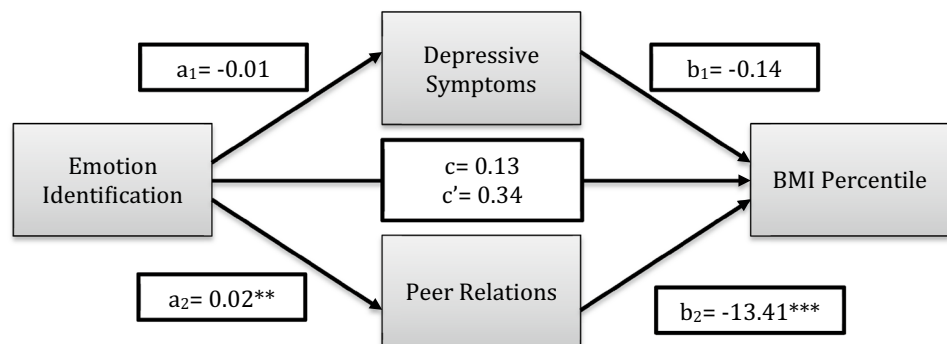
emotion identification and BMI was at least partially mediated by depressive symptoms and peer relations.

These results help to isolate which among a group of modifiable risk factors may represent promising targets for future interventions in the service of obesity prevention. Since greater depressive symptoms, poorer peer relations, and emotion identification abilities were all connected to BMI later in life, these three risk factors may represent reasonable targets for intervention efforts. Moreover, the current study also found relations for specific risk factors assessed at specific points in time. As a result, research isolating the time course over which each risk factor predicts later weight status may further isolate targets and timing for preventative interventions. It is possible that early identification and improvement of emotion identification ability may prevent a maladaptive pathway towards worsening depressive symptoms, peer relations, and excess weight gain over time.

The current findings may be viewed within the context of research on stress, which suggests that children may consume food to cope with stress. Independent lines of research link stress to emotion processing and poor peer relations [39, 40]. For example, one line of work links stress exposure to biases in emotion identification in children [39], whereas a second line of research links stress exposure to difficulties in peer relations [40]. Finally, a third line of work connects stress exposure to increased food consumption [41]. For instance, following exposure to stress, children with overweight tend to consume greater amounts of high density salty foods when compared to individuals with a healthy weight [41]. The current study connects early emotion identification ability to later peer relations and BMI. Prior work suggests that these relations could arise through effects of stress exposure on maladaptive coping and increased food consumption.

The current study adds to the extant literature by providing longitudinal findings, extending the data from preschool age into early adolescence. As a result, it is possible to show that deficits in emotion identification, depressive symptoms, and poor peer relations all may contribute to greater increases in BMI across development and notably during the key period of adolescence. This is significant because adolescence is a transformative period whereby obesity tends to persist. Individuals with overweight in adolescence may be more likely to have overweight in adulthood [42]. As such, targeting risk factors that may lead to obesity in adolescence could help to prevent obesity later in life as well.

Alongside these strengths, there are some limitations to the current study that must be considered. First, it was not possible to account for genetic, family, and lifestyle influences, such as parental obesity and availability of healthy foods. These factors may also be contributing to the development and prevalence of obesity in the current sample. The current study also examined associations over time among four indices: emotion identification, depressive symptoms, peer relations, and BMI. However, all four indices were not assessed at every time point. Ideally, future research would provide such comprehensive assessments. Lastly, the emotion identification task only accounted for the identification of happy and sad faces. As such, it is possible that findings may change with a task that involves a broader range of emotions to identify.

Findings from the current study can be used to inform efforts to prevent obesity and suggest that targeting emotion identification abilities, depressive symptoms, and peer relations at particular time points in development may be fruitful. Interpersonal Psychotherapy has been shown to be effective for the treatment of depression in youth [43, 44], and more recent research has focused on Interpersonal Psychotherapy for the prevention of obesity and excess weight gain over time [45]. Consistent with these findings, this therapy focuses on aspects of emotion and social relationships. The utility of this therapy for obesity prevention could arise from its targeting of correlated stress-related factors, including emotion identification abilities and the quality of relationships, specifically with peers.

Finally, the results of the current study may inform the timing of specific preventive interventions that target obesity. Future interventions may focus on the early identification and improvement of emotion identification deficits. Such a focus is relevant both due to the current findings and due to prior research noting relations among emotion identification, stress responsivity, depressive symptoms, and excess weight [16, 39]. Thus, improving emotion identification could influence a pathway towards depressive symptoms, stress responsivity, and excess weight gain. Targeting novel early-life risk factors in development may be essential in order to prevent excess weight gain in children and adolescents.

Summary

Prior research has established a relationship between emotion identification and BMI across childhood. The current study extends these findings from preschool age through early adolescence and examines possible mechanisms. Specifically, we assessed the temporal relationships among emotion identification, depressive symptoms, and peer relations in preschool, and BMI in early adolescence. Results indicated that emotion identification in preschool was associated with adolescent BMI and predicted increases in BMI across early adolescence. Higher depressive symptoms and poorer peer relations during preschool were also associated with higher BMI in early adolescence. Finally, peer relations and depressive symptoms in preschool partially mediated the relationship between

preschool emotion identification ability and early adolescent BMI. Such findings may be used to inform understanding of the relationship between emotion identification deficits and increased BMI, as well as appropriate obesity prevention interventions.

Compliance with Ethical Standards

Conflict of interest The authors have no conflict of interest to declare.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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