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ORIGINAL ARTICLE

Interactions of approach motivation and self-regulation in relation to obesity in children

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Abstract

Background Motivation and self-regulation are two psychological systems that have been shown to be related to childhood obesity.

Objective This study evaluated independent and interactive associations of approach-oriented motivation (i.e., drive and reward responsiveness) and self-regulation (i.e., self-control and behavioral regulation) in relation to age- and sex-adjusted body mass index-*z* scores (BMI-*z*) in children.

Methods Children (55% female; $M_{age} = 12.5$ years $\pm .93$) completed questionnaires assessing motivation and self-regulation, and anthropometric measurements were taken by research staff cross-sectionally.

Results Regressions revealed no independent associations of approach motivation or self-regulation and BMI-*z*. There were interactions between the drive facet of approach motivation, which assesses motivation to follow goals, and self-regulation in relation to BMI-*z*. Children with lower motivation to follow goals and lower self-regulation had higher BMI-*z*, and children with lower motivation to follow goals and higher self-regulation had lower BMI-*z*. Children with higher motivation to follow goals had similar BMI-*z* at all levels of self-regulation.

Conclusion For children with low motivation to follow goals, self-regulation may be an important buffer of high BMI-*z*.

Level of evidence Level V: cross-sectional descriptive study.

Keywords Motivation · Self-regulation · Obesity · Children · Weight

Introduction

Overweight and obesity are becoming increasingly prevalent in children [1]. Due to this alarming increase in the prevalence of childhood obesity and the poor outlook of current treatments, there have been calls to elucidate novel psychological phenotypes associated with overweight and obesity, which could potentially lead to personalized treatment development [2, 3]. Psychological phenotyping of obesity involves the elucidation of measurable psychological characteristics that distinguish individuals of varying weight statuses [2]. Thus, identifying phenotypes can explain variability in weight outcomes. Two psychological systems that play an important role in behavioral functioning include motivation and self-regulation [4]. Individual differences in motivation and self-regulation may independently and interactively serve as phenotypic traits that affect children's body weight, although more research is needed to explore this supposition.

Motivation, self-regulation, and body weight

Gray's model of reinforcement sensitivity states that behavior is mediated by two independent brain systems: the behavioral inhibition system (BIS) and the behavioral activation system (BAS) [5]. The BIS is sensitive to aversive cues such as punishment or no reward, and the BAS is sensitive to signals of reward and is involved in approach behavior [6].

This article is part of topical collection on topical collection on personality and eating and weight disorders.

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Research has found positive associations between approach motivation and body mass index (BMI) in school-age children (5, 7, 8). Considering that food has a rewarding value, it is believed that the BAS is involved in impulsive eating behaviors, which may in turn be associated with obesity [5].

Self-regulation refers to the cognitive processes that are related to monitoring and controlling thoughts and goal-directed behaviors [9], and self-regulation goes through major developmental changes throughout childhood [10]. Specifically, behavioral regulation is a component of self-regulation and involves inhibitory control (i.e., suppression of actions that are inappropriate in a given context and interfere with goal-driven behavior) and self-monitoring (i.e., ability to keep track of behavior and performance). Several reviews have shown that children with obesity demonstrate poorer inhibitory control [9, 11], and poorer inhibitory control has been shown to predict pediatric obesity longitudinally [12]. Relatedly, self-control, conceptualized as a trait measure of self-regulation, involves individuals' ability to control impulses and behaviors [13]. In a longitudinal cohort study, degree of self-control predicted a variety of health and life outcomes including physical health, substance dependence, personal finances, and criminal offending outcomes [14]. Furthermore, a prospective longitudinal cohort studyof 1061 children found that children who exhibited poor self-regulation had higher BMI-*z* scores and more rapid increases in BMI-*z* scores over a 9-year period compared to children with better self-regulation [15].

Interactions among approach motivation and self-regulation

Research on motivation and self-regulation has typically studied the two systems separately; however, it is likely that these systems interact with one another to predict outcomes and symptom presentation [16]. Some research has begun elucidating interactive associations among these constructs but primarily in relation to psychopathology and related symptoms. Studies have yet to examine interactions between these two systems in pediatric obesity. Therefore, we draw on research on pediatric psychopathology to inform this study.

One study of adolescents found an interaction between fear-related motivation and planning ability (i.e., a component of self-regulation) in relation to depressive symptoms [17]. Specifically, planning ability weakened/buffered the association between strong motivation to avoid aversive stimuli and high depressive symptoms [17]. Furthermore, Rhodes et al. [16] found that low approach motivation prospectively predicted increases in depressive symptoms at high levels of self-regulation; depressive symptoms were similar at all other levels of approach motivation and self-regulation. However, high approach motivation prospectively predicted increases in delinquency among those low in self-regulation [16]. In a separate study consisting of two related experiments, undergraduate students higher in approach motivation had greater optimism and attentional breadth after they exercised self-control compared to those that did not exercise self-control [18]. Overall, results do not show a clear pattern of relationships between motivation and self-regulation. Interactions may differ depending on outcomes (i.e., depression versus delinquency), operational definition of motivation or self-regulation, and measure used.

Current study

In general, the extant literature has shown positive bivariate associations between approach motivation and self-regulation and BMI-*z* in children. Research has not yet examined interactions between these constructs in relation to BMI-*z* in children. However, evidence from the psychopathology literature suggests that interactions may exist [17, 18]; although patterns of interactions have differed in studies. Therefore, the purpose of the current study was to examine how psychological phenotypes associated with motivation and self-regulation interact in relation to BMI-*z* in children using data from the Mothers and Their Children's Health (MATCH) study. It was hypothesized that there would be significant relationships for approach motivation and self-regulation, such that higher approach motivation and lower self-regulation would be associated with higher BMI-*z* scores. Due to the underdeveloped literature on this topic, interaction effects were exploratory.

Methods

Participants and procedures

The sample included 150 children from the final assessment wave of the MATCH study. The MATCH study is a 3-year longitudinal investigation of how mother and child psychosocial, behavioral, and physiological factors contribute to obesity risk in mother and child dyads [19], and this current report is one of several papers from the MATCH study. In the MATCH study, mothers–child dyads completed a host of measures, but the current paper only focuses on children. Participants were recruited from elementary schools and after-school programs in the greater Los Angeles area through informational flyers and in-person research staff visits. Detailed eligibility criteria can be found in Dunton et al. [19].

The study was approved by the appropriate institutional review boards. Parental consent and child assent were

obtained prior to participation. During data collection, participants completed paper-and-pencil questionnaires. Children completed questionnaires assessing age, self-regulation, approach motivation, and self-control. Mothers reported their child's race/ethnicity and biological sex at birth. In addition, research staff took anthropometric measures with a portable stadiometer and electronically calibrated digital scale. Body mass index (BMI; kg/m^2) and CDC age- and sex-specific BMI *z* scores were determined using Epi Info, (CDC, Atlanta, GA). Monetary incentives were provided for participation in the study.

Measures

Behavioral inhibition system/behavioral activation system scale (BIS/BAS) [6]

Approach motivation was assessed by the BIS/BAS, and this study used only two of the three BAS subscales: drive and reward responsiveness. Consistent with other research [20], the fun seeking subscale showed poor reliability ($\alpha = .49$), and thus, it was not used. The BAS subscales assess activity in the behavioral activation system, which is sensitive to signals of reward, nonpunishment, and escape from punishment. The drive subscale ($\alpha = .74$) consists of four items that measure persistent pursuit of desired goals, and the reward responsiveness subscale ($\alpha = .72$) consists of five items that assess positive responses to the occurrence or anticipation of reward. Response options for all items ranged from 1(*very true for me*) to 4 (*very false for me*). Higher scores indicated greater approach motivation.

Most of the published literature thus far has utilized a modified "age-downward" version of the BIS/BAS for children, which has simplified wording on several items [21]. However, a separate study of children utilized the original BIS/BAS scales similar to the current study. The original BAS scales correlate with related constructs, such as extraversion, reward dependence, and novelty-seeking [8].

Self-control scale (SCS) [22]

The SCS assessed degree of self-control over thoughts, emotions, and impulses [22]. An adapted 10-item version of the Brief SCS was used. The following five items were not included in the adapted version: "I am lazy", "I do certain things that are bad for me, if they are fun", "I wish I had more self-discipline", "Pleasure and fun sometimes keep me from getting work done", and "I have trouble concentrating". The following two items were added to the adapted version: "I get distracted easily" and "I do things that feel good in the moment but regret later on". In addition, the Brief SCS used the items "I refuse things that are bad for me" and "People would say that I have iron self-discipline", while the adapted version used the items "I refuse things that are bad for me, even if they are fun" and "People would say that I have very strong self-discipline".

Response options for items ranged from 1 (*not at all like me*) to 5 (*very much like me*). Higher scores on the original SCS correlated with a higher grades, better adjustment, higher self-esteem, and better interpersonal skills evidencing predictive validity [22]. Possible self-control scores for the adapted Brief SCS ranged from 1 to 5 with higher scores indicating greater self-control. The Cronbach's alpha was .74.

Behavior rating inventory of executive function, second edition—self-report (BRIEF2-SR) [23]

The self-report BRIEF2-SR was used to measure children's executive functioning. The present study used the Behavioral Regulation Index (BRI; $\alpha = .81$), which captures the ability to regulate and monitor behavior effectively. The BRI is a composite of the eight-item inhibit and five-item self-monitor subscales. Response options for items ranged from 1 (*never*) to 3 (*often*). Higher scores indicated lower levels of behavioral regulation. Previous research has shown good psychometric properties of the BRIEF in children as well as distinctiveness of the BRI superordinate subscale [24, 25].

Statistical analyses

Demographics, descriptive statistics and bivariate correlations were calculated among study variables. The SPSS PROCESS macro [26] was used to examine interactions between facets of approach motivation (i.e., drive and reward responsiveness) and self-regulation (i.e., behavioral regulation and self-control) in relation to BMI-*z* scores. Variables were centered to reduce multicollinearity. BMI-*z* was adjusted for age and sex and so these were not included as covariates. Results were similar in unadjusted models and models adjusted for Hispanic ethnicity; thus, unadjusted models were retained. Separate multiple regressions were calculated for each facet of approach motivation and self-regulation in relation to BMI-*z* scores, which resulted in four models. False discovery rate (FDR) significance was used to correct for multiple comparisons [27]. Interaction *p* values from the four models were used to calculate FDR *p* values. The FDR significance level was set at .10, which has been recommended for exploratory research [28].

Results

Table 1 displays sample demographics. Children had a mean age of 12.5 years (SD = 0.93) and were diverse with regard to demographic characteristics. Bivariate correlations and

Table 1 Participant demographics and characteristics ($N = 150$)

Variable	*n* (%)
Child sex	
Male	67 (44.7)
Female	83 (55.3)
Child race[a,b]	
White or Caucasian	66 (44.0)
Black or African American	26 (17.3)
Asian	20 (13.3)
Native Hawaiian or Pacific Islander	4 (2.7)
American Indian or Alaska Native	8 (5.3)
Other	59 (39.3)
Child ethnicity[b]	
Hispanic/Latino	86 (57.3)
Not Hispanic/Latino	63 (42.0)
Type of household[b]	
Single parent	42 (28.0)
Dual parent	105 (70.7)
Annual household income[b]	
Less than $44,999	44 (29.3)
$45,000–$74,999	31 (20.6)
$75,000–$114,999	41 (27.4)
Greater than $115,000	32 (21.3)
Child BMI-*z* category	
Underweight	3 (2.0)
Normal weight	93 (62.0)
Overweight	24 (16.0)
Obese	30 (20.0)

[a]Participants were able to select more than one racial category

[b]Data missing on variable

Table 2 Pearson correlations and descriptive statistics of study variables

	1	2	3	4	5
1. BAS drive	–	.41***	.11	−.12	.03
2. BAS-reward responsiveness		–	−.02	.10	−.11
3. BRI			–	−.54***	.16
4. SCS				–	−.13
5. BMI-*z*					–
M	10.57	17.46	20.26	3.41	.54
SD	2.66	2.23	4.54	.66	1.10

Higher BRI scores = lower behavioral regulation; Higher SCS scores = higher self-control

BAS behavioral activation scale, *BRI* behavioral regulation index, *SCS* self-control scale, *BMI-z* body mass index *z*-scores

*$p < .05$, **$p < .01$

descriptive statistics are displayed in Table 2. None of the facets of approach motivation or self-regulation were related to BMI-*z*. Correlations among BAS and self-regulation measures were null to weak (rs between −.12 and .11).

The multiple regression analyses for all four models are presented in Table 3. Similar to the bivariate correlations, there were no main effects of approach motivation or self-regulation in any of the four models that were tested. However, significant interactions were found between BAS drive and behavioral regulation and BAS drive and self-control. The interactions were plotted at one SD above and one SD below the mean and are displayed in Figs. 1 and 2, respectively.

For behavioral regulation, conditional effects analyses revealed that, at higher levels of behavioral regulation (−1*SD*), there was a positive association between BAS drive and BMI-*z*, $t = 2.08$, $p = .04$, 95% CI [.01, .19]. At lower levels of behavioral regulation (+1*SD*), there was a trend for a negative association between BAS drive and BMI-*z*, $t = -1.84$, $p = .07$, 95% CI [−.18, .01]. Inspection of the interaction plot also showed that low-behavioral regulation and low BAS drive was associated with the highest BMI-*z* scores, and high-behavioral regulation and low BAS drive was associated with lowest BMI-*z* scores.

For self-control, conditional effects' analyses revealed that, at higher levels of self-control (+1*SD*), there was a trend for a positive association between BAS drive and BMI-*z*, $t = 1.94$, $p = .06$, 95% CI [−.002, .20]. Inspection of the interaction plot showed that low self-control and low BAS drive was associated with the highest BMI-*z* scores, and high self-control and low BAS drive was associated with lowest BMI-*z* scores.

Discussion

The current study evaluated interactions among approach motivation and self-regulation in relation to BMI-*z* scores in children. There were no bivariate associations between approach motivation or self-regulation and BMI-*z*. These findings are inconsistent with some previous studies that have found significant positive associations between these variables in children [e.g., 7, 15]. Differences may be due to variations in sample composition, age of children, measures, and reporter (parent versus child). However, the results showed that the interactive relation of motivation and self-regulation was significantly associated with BMI-*z* scores. This is the first study to our knowledge to identify interactions among motivation and self-regulation in relation to children's BMI-*z*. Patterns elucidated by these interactions may provide insight into obesity-related psychological phenotypes.

The drive facet of approach motivation, measured with the drive subscale of the BAS, interacted with both behavior regulation and self-control in relation to BMI-*z* in a similar

Table 3 Summary of multiple regressions of approach motivation and self-regulation in relation to BMI-*z* scores

Model	*B*	*SE*	*t*	*p*	Model	*B*	*SE*	*t*	*p*
1					2				
BAS Drive	.01	.03	.19	.85	BAS Drive	.01	.03	.33	.75
Behavior regulation	.03	.02	1.63	.11	Self-control	− .19	.14	− 1.38	.17
Interaction	− .02	.01	− 2.76	.007*	Interaction	.13	.05	2.47	.01*
3					4				
BAS RR	− .04	.04	.29	.29	BAS RR	− .04	.05	− .76	.45
Behavior regulation	.04	.02	.08	.08	Self-control	− .21	.14	− 1.47	.14
Interaction	− .004	.01	.63	.63	Interaction	.06	.07	.90	.37

BAS behavioral activation scale, *RR* reward responsiveness

*False discovery rate *p* value < .10

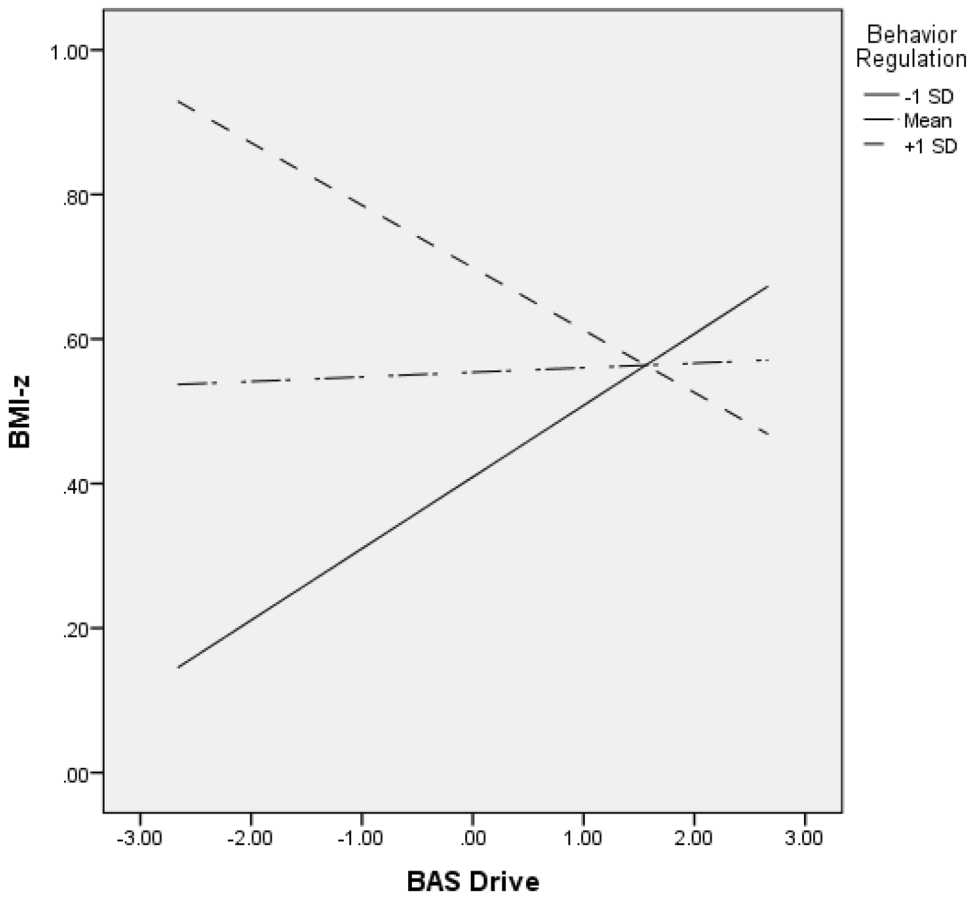

Fig. 1 Two-way interaction of BAS drive and behavior regulation in relation to BMI-*z* scores in children. High and low levels of the variables are plotted at + 1 and − 1 standard deviation from the mean. *+ 1SD* low-behavioral regulation, *− 1SD* high-behavioral regulation

pattern. Children with high levels of self-control regulation and low levels of drive (i.e., motivation to follow one's goals) had relatively low BMI-*z* scores, and oppositely, children with low levels of self-regulation and low motivation to follow one's goals had relatively high BMI *z* scores. Therefore, self-regulation abilities appear to buffer the effect of low motivation to follow one's goals on weight. The combination of low motivation to follow one's goals and low self-regulation may reflect a psychological phenotype, where children have low motivation to move towards goals and have low self-control. These children may have less ability to control impulses to eat, may not have a desire to control what they eat, and may not be open to approach of healthy foods and exercise, which leads to weight gain over time. It will be important to examine eating patterns such as unplanned or uncontrolled eating and restrictive eating as mediators between psychological factors and children's BMI-*z* in future studies [29, 30].

Among those high in self-regulation, higher drive, or motivation to follow one's goals, was positively related to

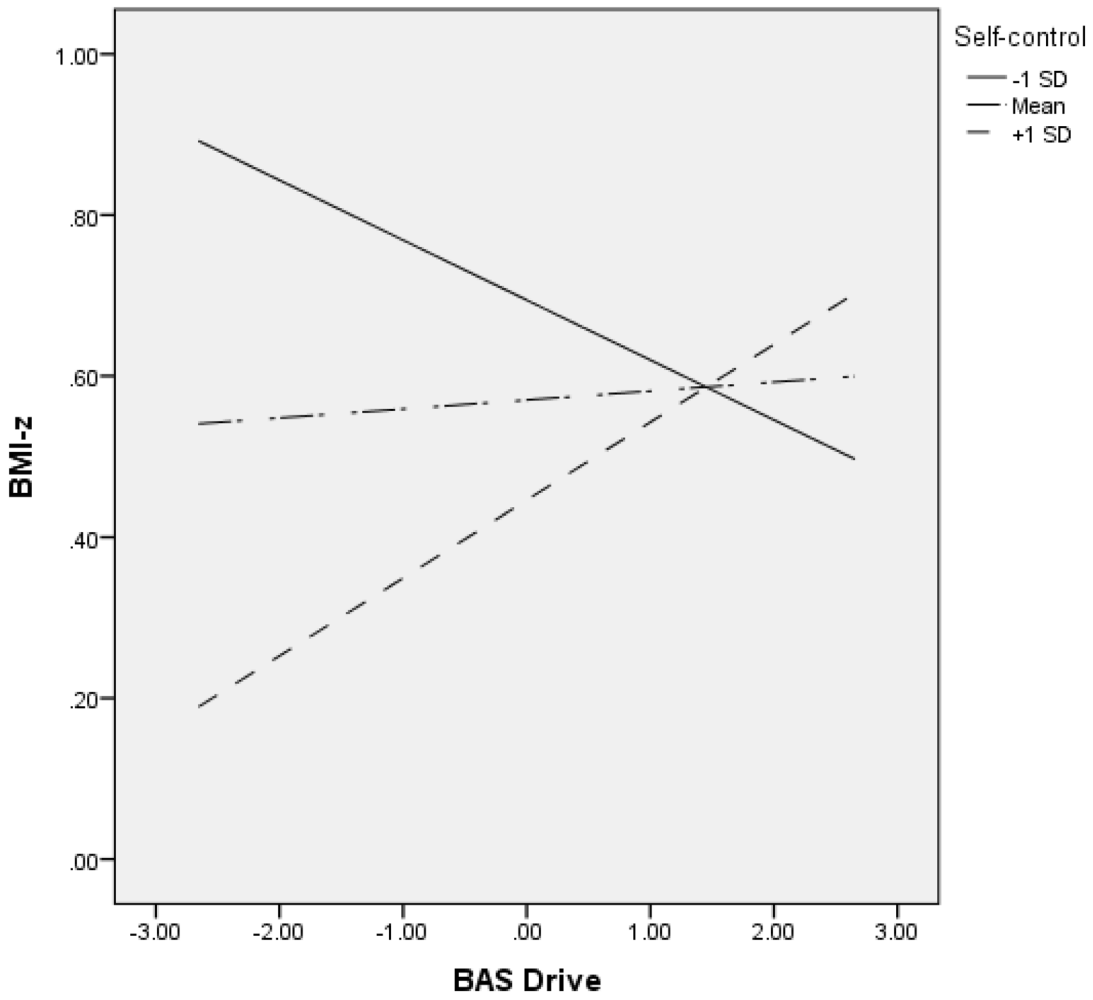

Fig. 2 Two-way interaction of BAS drive and self-control in relation to BMI-*z* scores in children. High and low levels of the variables are plotted at + 1 and − 1 standard deviation from the mean. + *1SD* high self-control, − *1SD* low self-control

BMI-*z* scores. There is evidence that motivation to follow one's goals, and not reward responsiveness, is positively associated with activation in reward-related brain regions in response to monetary rewards and palatable foods [31–33]. Therefore, higher motivation to follow one's goals may be associated with more consumption of highly palatable foods, which could increase body weight. At low levels of self-regulation, there was a trend for a negative association between motivation to follow one's goals and BMI-*z*, such that children with more motivation to follow their goals had a lower BMI-*z*. Higher motivation to follow one's goals may be protective of higher weight in children who are low in self-regulation. While these children are generally poorer at self-regulation, increased drive may help them compensate by increasing motivation toward reaching goals. These goals may include sport and exercise goals (e.g., making sports teams, increasing activity) and healthy eating goals (e.g., trying not to overeat, eating healthier foods). Therefore, these results suggest that the impact of motivation to follow goals on BMI-*z* depends on levels of self-regulation, and health behaviors (e.g., food consumption, physical activity) associated with motivation to follow one's goals may vary depending on self-regulation levels, although high motivation to follow goals generally leads to comparable weights regardless of levels of self-regulation.

Strengths of the current study include a diverse sample of boys and girls, use of validated psychological measures, and objective anthropometric assessment. A number of limitations exist, however. This study utilized cross-sectional data, and thus, directional of relationships cannot be assumed. For example, weight may have an effect on children's motivation and self-regulation. In addition, cross-sectional data precluded examination of mechanisms relating motivation and self-regulation to BMI-*z* scores. Future studies should examine eating and activity as mediators of psychological phenotypes and obesity risk. All constructs were assessed with self-report measures, which limits understanding of the biological basis of findings. Future research should

also utilize cognitive tasks and neuroimaging to elucidate brain regions and cognitive functions that may explain these interactions. Eating disorders were not assessed and thus we cannot characterize the prevalence of eating disorders in this sample or how eating disorder symptoms affect results. Finally, motivation and self-regulation may vary across the day, and thus, future research should examine how individual fluctuation in motivation and self-regulation may be associated with BMI-*z* in children.

The results of this study elucidated several possible phenotypic profiles of BMI-*z* in children. Self-regulation may be a particularly important correlate of BMI-*z* in children at low levels of motivation to follow one's goals. Overall, approach motivation and self-regulation scores may provide insight into phenotypic profiles of BMI-*z* in children. Understanding of how these psychological factors develop and change throughout childhood may have implications for weight and related behavior change preventions and interventions. Children with obesity display patterns of low motivation and self-regulation, which may reduce the success of intervention programs. For example, low self-regulation may make it difficult to inhibit urges to consume unhealthy foods or to plan and follow-through with structured physical activities, which may be further heightened if motivation is low. It may be necessary for weight management programs for children to enhance motivation to engage in healthful behaviors (e.g., discussing health and wellness benefits) and to offer self-regulation skills (e.g., planning, monitoring, and mindfulness), particularly for children low in motivation and self-regulation.

What is already known on this subject?

Motivation and self-regulation have been shown to be important processes associated with obesity and weight regulation in children and adults.

What does this study add?

This study is the first to elucidate interactions between approach motivation and self-regulation in relation to BMI-*z* in children.

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Compliance with ethical standards

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

Ethical approval The Institutional Review Boards of the University of Southern California and Northeastern University approved this study. 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 Parental consent and child assent were obtained from all individual participants included in the study. All eligible participants completed an electronic informed consent form prior to participation in the study.

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