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ORIGINAL ARTICLE

Emotion dysregulation and pediatric obesity: investigating the role of Internet addiction and eating behaviors on this relationship in an adolescent sample

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Abstract

Objective The first aim was to investigate whether there was a mediator role of Internet addiction or uncontrolled/emotional eating on the association between emotion dysregulation and body mass index-standard deviation score (BMI-SDS). The second aim was to detect which of these variables (emotion dysregulation, Internet addiction, and uncontrolled/emotional eating) significantly affect the presence of obesity (OB).

Methods A total of 123 adolescents (OB ($n=65$, 57% of girls, mean age $=15\pm1.9$, BMI percentile between 95 and 99) and healthy control (HC) ($n=58$; 53% of girls, mean age $=15.5\pm1.8$, BMI percentile between 1 and 84) aged between 11 and 18 were recruited. Difficulties in Emotion Regulation Scale (DERS) and Internet Addiction Test (IAT) were completed by adolescents. Uncontrolled and emotional eating behaviors were measured by Three Factors Eating Questionnaire (TFE-Q)'s sub-domains.

Results There was no significant direct effect of DERS on BMI-SDS, whereas the indirect effect of DERS on BMI-SDS which was mediated by both IAT and TFE-Q was statistically significant. In logistic regression analysis, an increase by 1 point in DERS total score escalated the odds of being OB by 2%. Moreover, a 22-fold increased risk of OB has been detected in moderate/severe Internet addiction compared to no addiction.

Conclusion This cross-sectional study showed that the association between emotion dysregulation and BMI-SDS was totally mediated by internet addiction and uncontrolled/emotional eating. In addition, emotion dysregulation and Internet addiction were significant determinants of OB. A prospective study is needed to detect the causal relationship between these variables.

Level of evidence Level III, case–control analytic study.

Keywords Childhood obesity · Internet addiction · Eating behaviors · Emotion dysregulation

Introduction

World Health Organization (WHO) has been declared that childhood obesity (OB) is one of the most serious public health challenges of the twenty-first century and has become an epidemic globally [1]. Childhood OB tends to persist in adulthood, and is linked to psychological consequences and noncommunicable diseases like diabetes and cardiovascular diseases [2]. To reverse this epidemic, community-based and national-based prevention and intervention programs have been implementing, and WHO has proposed global targets [1, 3]. However, the complex multifactorial etiology of OB challenges the effectiveness of these programs. Thus, elucidating underlying factors associated with childhood OB is

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of utmost importance to improve treatment and prevention strategies.

Gratz and Roemer [4] describe emotion regulation as correctly identifying, understanding, and being aware of emotions. Moreover, emotion regulation involves the ability to adjust emotional arousal and to accomplish goal-directed behaviors regardless of emotional state [4]. Emotion dysregulation (ED) has been conceptualized as difficulties in monitoring, evaluating, or adjusting emotional reactions [5]. ED is a trans-diagnostic factor playing a key role in the development and maintenance of eating disorders [6]. To date, a number of studies have indicated problematic emotional processing in OB [7]. The most consistently reported emotion regulation difficulties in individuals with OB are alexithymia (i.e., difficulties in identifying feelings), decreased awareness of emotions, and problems in using appropriate strategies to cope with negative emotions [7].

To better comprehend OB and weight gain, there is also merit in focusing on two dysfunctional eating behaviors: eating in emotional situations rather than hunger or appetite (emotional eating) and loss of control over eating (uncontrolled eating) [8]. Although a typical response to a negative emotion or stress is gastric immobility and suppression of hunger, this mechanism is reversed in emotional eating [9]. The theory of emotional eating proposes that eating may constitute a regulation mechanism for negative emotions [11]. The theory assumes that negative emotions trigger overeating (i.e., eating a large amount of food) or binge eating (i.e., eating a large amount of food with a loss of control) [11]. Overeating or binge eating down-regulates negative emotions in the short term. However, a decrease in negative emotions reinforces the usage of emotional eating, which causes the persistence of it [11]. Emotional eating has been found to be associated with weight gain and OB in longitudinal studies [12, 13]. In a prospective study, van Strien et al. [14] demonstrated that overconsumption of food is more strongly related to weight gain in case of a high degree of emotional eating. Emotional eating may be related to dietary restrain or independent of dieting [9]. When it is independent of dieting, it can occur as an outcome of emotion regulation difficulties [9]. Consistent with these, two adult studies [15, 16] have shown the mediational role of emotional eating on the association between ED and body mass index (BMI). However, as far as we know, this pathway has not been investigated in adolescents.

Uncontrolled eating is a key aspect of binge eating disorder and bulimia nervosa [17]. It differentiates from binge eating with a nuance: Both binge eating and uncontrolled eating require the loss of control over eating, whereas objective overconsumption of food is also needed in binge eating [17]. Given the fact that overconsumption of food is a relative concept in childhood, uncontrolled eating has become a clinical focus in the literature [18]. Similar to emotional eating, uncontrolled eating in youth predicts excessive weight gain [19]. Another shared feature of uncontrolled eating with emotional eating is that ED may be a contributory factor in the onset and maintenance of uncontrolled eating [20]. Kelly et al. [18] reported that youth with self-reported uncontrolled eating and high parent-reported ED had significantly higher BMI than those with low parent-reported ED. Since their study [18] was conducted on a community sample, they suggested a future study investigating whether their findings could be generalized to clinical sampling. Moreover, they recommended utilizing a self-reported questionnaire to measure ED due to the fact that parents may be unaware of their children's emotion regulation abilities. Based on these suggestions and the dearth of studies investigating the association between ED, emotional eating, and BMI in youths, we aimed to examine whether emotional eating and uncontrolled eating mediate the association between self-reported ED and body mass index-standard deviation scores (BMI-SDS) in a clinical sample of adolescents.

Let us now turn to another etiological factor of OB: excessive Internet use and Internet addiction (IA) [22]. In a recent meta-analysis [22], compared to the lowest Internet use, the highest Internet use has been found to be associated with 47% greater odds of being obese. Moreover, the previous research has established that not only the duration of the internet but also the IA level is associated with OB [23–25]. Interestingly, data from several sources have identified that aforementioned etiological factor of OB, namely ED, is associated with IA [26, 27]. Given that Internet use provides escaping from reality and distracting from stress, Internet use can function as a dysfunctional emotional regulation strategy [28]. Similar to emotional eating, Internet use may provide relief from difficult emotions in the short-term. However, when the Internet is utilized as an emotional strategy, it is negatively reinforced and may lead to IA [28]. Although an association between IA and ED has been reported, to the best of our knowledge, there has been no study investigating the pathway between IA, ED, and BMI-SDS in adolescents.

Building on previous research in this area, this study investigated the complex relationships among BMI-SDS, ED, IA, and dysfunctional eating behaviors in a sample of adolescents. The first aim of the current study was to examine whether there was a mediator role of IA or dysfunctional eating behaviors (i.e., uncontrolled eating and emotional eating) on the association between ED and BMI-SDS. The second aim was to detect which of these variables (ED, IA, and uncontrolled/emotional eating) significantly affect the presence of OB.

Hypothesis 1: ED has a direct positive association with BMI-SDS.

Hypothesis 2: IA has a direct positive association with BMI-SDS.

Hypothesis 3: Dysfunctional eating behaviors, namely, emotional eating and uncontrolled eating, have direct positive associations with BMI-SDS.

Hypothesis 4: ED has an indirect association with BMI-SDS through emotional eating/uncontrolled eating or IA**.**

Hypothesis 5: ED, IA, and uncontrolled/emotional eating significantly affect the presence of OB.

Methods

Sample characteristics and assessment

Using G*power 3.1. program, a power analysis was applied (alpha 0.05, power of 0.85, 1:1 ratio) to calculate the minimum sample size for the current study. The expected mean (SD) values of scales [Three Factors Eating Questionnaire (TFE-Q), Difficulties in Emotion Regulation Scale (DERS), and Internet Addiction Test (IAT)] were determined based on the literature. The minimum sample size for overall individuals was calculated as **32** based on TFE-Q scale (for OB Mean = 50.8, SD = 8.4, for healthy control (HC) Mean = 41.8, SD = 9.5, d = 1.00) [30]; **12** based on DERS total score (for OB Mean = 78.4, SD = 14.3; for HC Mean = 57.2, SD = 7.4, d = 1.85) [27]; **88** based on IAT score (for OB Mean = 39.8, SD = 20.1; for HC Mean = 29.6, SD = 14.8, d = 0.57) [24]. Thus, a minimum sample size of 44 subjects in each group (OB and HC) was determined.

The eligibility of adolescents with OB who had admitted to the Ministry of Health Ankara City Hospital Department of Pediatric Endocrinology between August 2019 and February 2020 was assessed according to inclusion and exclusion criteria.

The inclusion criteria for the OB group were: (1) between the ages of 11 and 18; (2) BMI-SDS ≥ +2 (BMI percentile ≥ 95); and (3) adolescent and parent were willing and able to give informed consent. All participants were evaluated by a specialist in child endocrinology and a specialist in child psychiatry. Those with OB due to syndromic and endocrinological causes and patients who were taking drugs which may cause OB (e.g., glucocorticoids, anticonvulsants like carbamazepine and valproate, anti-depressants, anti-psychotics, or anti-histaminic) were excluded. Moreover, we excluded patients with autism spectrum disorder or intellectual disabilities.

The healthy control (HC) group was recruited from the hospital staffs' children who did not have any psychiatric complaints or history. The inclusion criteria for the HC group were as follows: (1) between the ages of 11–18; (2) BMI-SDS < +1 (BMI percentile < 85); (3) adolescent and parent were willing and able to give informed consent. The exclusion criterion for the HC was the presence of any psychiatric disorder or chronic medical disease. Similar to the OB group, all participants in the HC group was assessed by both a specialist in child endocrinology and a specialist in child psychiatry. Fifty-eight adolescents were recruited as the HC group.

Body weight measurements were conducted after an 8-h fasting period, barefoot, and with their daily clothes on, weight and height were measured with the patient barefoot with the Seca 274 Stadiometer (Hamburg, Germany) with 1 mm accuracy. Since the growth patterns of boys and girls differ, evaluating of BMI of children is more complicated than and different from adults [31]. Both age and sex should be considered when evaluating BMI in children. Therefore, we calculated all participants' BMI-SDS (z-scores of BMI) according to age and sex based on Neyzi's reference values for weight, height, and BMI in Turkish children [32].

Both of the groups (HC and OB) were screened for psychiatric diagnosis via K-SADS-PL (Schedule for Affective Disorders and Schizophrenia for School-Aged Children, Present and Lifetime Version) in the Ministry of Health Ankara City Hospital Department of Child and Adolescent Psychiatry. When an adolescent in the OB group was diagnosed with a psychiatric disorder via K-SADS-PL, we also verified the diagnosis based on the Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-5). Afterward, the eligible adolescents from both of the groups according to the inclusion and exclusion criteria completed TFE-Q, DERS, and IAT.

The Ethics Committee of the Ministry of Health Ankara City Hospital approved the current study (E1/199/2019). Patients and parents were verbally informed on the design of the study, and written informed consent forms in accordance with the Declaration of Helsinki were obtained from both of them.

Materials

Schedule for affective disorders and schizophrenia for school-aged children, present and lifetime version (K-SADS-PL)

A semi-structured interview, the K-SADS-PL, is used to assess and to diagnose major psychiatric disorders in children and adolescents based on the DSM-IV-TR criteria. The Turkish reliability and validity of the K-SADS-PL was conducted by Gökler et al. [33]. While applying K-SADS-PL, the combination of answers of adolescent, parent, and physician leads to the decision of the presence and severity of symptoms.

Three factors eating questionnaire (TFE-Q)

This 18-item questionnaire is utilized to assess three eating behaviors of individuals: cognitive restriction capacity, uncontrolled eating, and emotional eating. Kirac et al. [34] conducted the Turkish validity and reliability of the TFE-Q in adults, and they found that the TFE-Q had high reliability and good validity. The higher scores in a subscale represent that respective eating behavior (i.e., cognitive restraint, uncontrolled, or emotional) is more greatly used. Only uncontrolled eating and emotional eating subscales of TFE-Q were utilized for our study. The uncontrolled eating and emotional eating subscales demonstrated adequate internal consistency for each group (uncontrolled eating Cronbach's a for OB = 0.806, for HC = 0.85; emotional eating Cronbach's a for OB = 0.93, for HC = 0.82).

Difficulties in emotion regulation scale (DERS)

DERS was developed by Gratz and Roemer [4] to assess the regulation of negative emotional states of individuals. This 36-item scale is a 5-point Likert-type questionnaire and it contains six subscales: (1) lack of awareness of emotional responses (awareness); (2) lack of clarity of emotional responses (clarity); (3) non-acceptance of emotional responses (non-acceptance); (4) limited access to effective strategies (strategies); (5) difficulties in controlling impulsive behavior when experiencing negative affect (impulse); and (6) difficulties in engaging goal-directed behavior when experiencing negative affect (goals) [4]. Turkish validation and reliability was investigated by Saritas et al. [35]. A higher score in DERS indicates more severe emotional regulation difficulties. Cronbach's alpha for both OB and HC on the DERS subscales ranged from 0.62 to 0.83.

Internet addiction test (IAT)

IAT consisting 20-items rated on a 6-point-Likert scale to evaluate problematic Internet use. The higher scores in IAT represent more problematic Internet use: lack of addiction (0–19), mild signs of addiction (20–49), moderate signs of addiction (50–79), and severe addiction (80–100). The Turkish version of the IAT had high validity and high reliability [36]. Based on Young's recommendation [21], six subscales of the IAT were calculated: salience, excessive use, anticipation, neglect of work, neglect of social life, and lack of control. Cronbach's alpha for both OB and HC on the IAT subscales ranged from 0.60 to 0.75.

Statistics

We first compared the groups (OB and HC) in terms of demographics and scales (TFE-Q, DERS, and IAT). The Chi-square was utilized to assess if there is a significant difference between qualitative variables (i.e., gender and IAT categories). Normality of the quantitative variables was determined via histogram, skewness, kurtosis, normality plots, and the Kolmogorov-Smirnov test. All variables except uncontrolled eating scores presented a non-normal distribution. Independent sample t test was utilized in case of normal distribution (i.e., TFE-Q uncontrolled eating). We used Mann–Whitney U test in non-normally distributed quantitative data [i.e., age, the educational level of parents, weekly internet use time (hours), DERS, and IAT]. Afterwards, Spearman correlation test was conducted to determine the correlation between the variables. A multivariate logistic regression analysis was applied to detect which of the factors (DERS, IAT, TFE-Q-uncontrolled, and TFE-Q-emotional) significantly affect the presence of OB. Their 95% confidence intervals *(CI)* were calculated. The results were adjusted to gender and age.

To measure correlations between variables, Partial Least Square (PLS) Pathway Analysis was performed via Smart-PLS-3. This method was selected because of three reasons: (1) our small sample size, (2) a lack of multivariate normality in our data, and (3) the exploratory nature of our study [37]. As a rule of thumb, minimum sample size should be at least ten times the number of receiving causal arrows of the dependent variable with the largest number those incoming arrows in a PLS model [38]. Since our dependent variable (BMI-SDS) had three incoming arrows, we needed at least 30 subjects to fulfill this criteria. Thus, our sample size ($n = 123$) was enough to conduct a PLS pathway analysis. We calculated the Mardia's multivariate skewness and kurtosis via the software available at: https://webpower.psychstat.org/models/kurtosis/results.php?url=bdc7deba145690fb58ca519cd242f006. The results confirmed that our data were not multivariate normal (Mardia's Skewness $\beta = 11.6$, $p < 0.001$; Mardia's Kurtosis $\beta = 53.4$, $p = 0.002$).

Data were analyzed by IBM SPSS Statistics 22 for Mac and SmartPLS-3. Statistical significance was set at $a < 0.05$. Holm–Bonferroni Correction was used to decrease type-1 error in case of multiple comparisons. Holm's adjusted alpha level was calculated via an excel calculator form by Gaetano [39]. Effect sizes were calculated for significant pairwise comparisons using Rosenthal's r for Mann–Whitney U tests, Cramer's V for $\chi 2$, and Cohen's d for independent sample t test (0.1–0.29 = small, 0.3–0.49 = medium, ≥ 0.5 = large).

Results

Sample characteristics of the groups (OB and HC) and the current psychiatric disorders of the OB group

After Holm's Bonferroni correction, the participants' median age and gender distribution and parents' educational level were not statistically different between OB and HC (Table 1). Compared to the HC group, the OB group had significantly higher time spent on the Internet ($z = -5.910$, $p < 0.001$) and higher IAT scores ($z = -4.369$, $p < 0.001$). Total DERS score of the OB group was significantly higher than those of the HC group, yielding a medium effect size ($z = -3.661$, $p = 0.03$, $r = 0.33$). Merely, three subscales of the DERS were statistically different between the groups (OB and HC): impulse ($z = -3.241$, $p = 0.01$), strategy ($z = -3.126$, $p = 0.02$),

Table 1 Comparison of groups (OB and HC) in terms of socio-demographic measures and scales

	OB group	HC group	Statistics					
	($n=65$)	($n=58$)	X^2, t, z	p	Holm's adjusted alpha levels	Rank	Outcome of Holm's correction	Effect size
Age (median (IQR), mean ± SD)	14.9 (2.6), 15 ± 1.9	16.5 (2.1), 15.5 ± 1.8	− 2.197[a]	0.02	0.12	12	Non-significant	n.s
Gender (girls (n (%))	37 (56.9)	31 (53.4)	0.150[b]	0.69	0.96	17	Non-significant	n.s
Education level of mothers (median (IQR), mean ± SD)	8 (7), 8.5 ± 3.6	5 (9), 7.1 ± 5.3	− 1.849[a]	0.06	0.25	14	Non-significant	n.s
Educational level of fathers (median (IQR), mean ± SD)	11 (5), 10 ± 4	11 (7), 9.5 ± 4.2	− 0.703[a]	0.48	0.96	16	Non-significant	n.s
Duration of Internet use (hour/week) (median (IQR), mean ± SD)	28 (28), 30.4 ± 20.2	9 (14), 12.2 ± 13.9	− 5.910[a]	< 0.001	< 0.001	2	Significant	0.53
BMI-SDS (median (IQR), mean ± SD)	2.38 (0.67), 2.5 ± 0.5	− 0.51 (1.3), − 0.5 ± 0.8	− 9.558[a]	< 0.001	< 0.001	1	Significant	0.86
TFE-Q scores								
Uncontrolled eating (mean (SD))	40.8 (19.6)	30.4 (19)	3.195[c]	0.002	0.02	8	Significant	0.74
Emotional eating (median (IQR), mean ± SD)	33 (66), 39.9 ± 36.3	1 (33), 18.4 ± 23.8	3.083[a]	0.002	0.02	10	Significant	0.27
DERS scale (median (IQR), mean ± SD)								
Total score	83.5 (29.7), 88.8 ± 22.4	72 (23), 73.9 ± 10.6	− 3.661[a]	< 0.001	0.001	5	Significant	0.33
Non-acceptance	12 (9), 12.8 ± 5.5	9 (6.5), 10.9 ± 5.1	− 1.921[a]	0.05	0.25	13	Non-significant	n.s
Goals	15 (8.7), 15.1 ± 4.9	12 (5.5), 12.5 ± 4.7	− 2.661[a]	0.008	0.05	11	Non-significant	n.s
Impulse	14 (6), 14.8 ± 5.6	11 (6), 11.7 ± 4.4	− 3.241[a]	0.001	0.01	7	Significant	0.29
Awareness	16 (7), 15.9 ± 5	15 (6), 14.7 ± 3.9	− 1.453[a]	0.14	0.42	15	Non-significant	n.s
Strategies	15.5 (11), 18.3 ± 7.5	12 (8), 14.2 ± 5	− 3.126[a]	0.002	0.02	9	Significant	0.28
Clarity	12 (6), 11.9 ± 3.9	9 (5.5), 9.6 ± 3.2	− 3.294[a]	0.001	0.01	6	Significant	0.29
The total score of IAT (median (IQR))	34 (32), 37.9 ± 20.8	21 (20), 20.8 ± 13.1	− 4.369[a]	< 0.001	< 0.001	3	Significant	0.39
IAS categories								
No addiction [n (%)]	16 (24.6)	27 (46.6)	22.878[b]	< 0.001	< 0.001	4	Significant	0.41
Mild addiction [n (%)]	28 (43.1)	30 (51.7)						
Moderate or severe addiction [n (%)]	21 (32.3)	1 (1.7)						

OB Obesity, *NW* Normal weight, *IQR* Interquartile range, *TFE-Q* Three factors eating questionnaire, *DERS* Difficulties in emotion regulation scale, *IAT* Internet addiction test, *BMI-SDS* body mass index-standard deviation scores

[a]Mann–Whitney U test

[b]Chi -square

[c]Independent sample t test

and clarity ($z = -4.369$, $p = 0.01$), with small effect sizes. Adolescents with OB had significantly higher scores of TFE-Q-uncontrolled eating ($z = 3.195$, $p = 0.02$) and TFE-Q-emotional eating than HC ($z = 3.083$, $p = 0.02$).

Nearly half of the OB group (47.7%, $n = 31$) had at least one current psychiatric disorder according to the K-SADS-PL interview. Anxiety disorder (18.5%, $n = 12$) and attention deficit and hyperactivity disorder (ADHD) (16.9%, $n = 11$) were the most frequent psychiatric disorders in adolescents with OB. Other current psychiatric disorders among the OB group were as follows: binge eating disorder (9.2%, $n = 6$), major depressive disorder (7.7%, $n = 5$), obsessive compulsive disorder (3.1%, $n = 2$), disruptive disorders (4.6%, $n = 3$), tic disorder (1.5%, $n = 1$), learning disorder (3.1%, $n = 2$), and gender dysphoria (1.5%, $n = 1$). Given the fact that ED, IA, and eating behaviors may also be associated with psychiatric disorders besides OB, we excluded adolescents with OB who had a current psychiatric disorder and re-performed group comparisons. We found that significant differences between the groups were survived, although we excluded cases with OB who had a current psychiatric disorder (for IAT $z = -2.395$, $p = 0.017$; for DERS total $z = -2.379$, $p = 0.017$; for DERS clarity $z = -2.279$, $p = 0.023$; for DERS strategy $z = -2.572$, $p = 0.01$; for DERS impulse $z = -2.492$, $p = 0.01$; for TFE-Q emotional eating $z = -2.973$, $p = 0.003$; for TFE-Q uncontrolled eating $t(90) = 2.746$, $p = 0.007$).

Correlates of BMI-SDS and OB

Spearman correlation analysis was conducted to the whole group (the combination of the OB and HC groups). We found that BMI-SDS was positively correlated with TFE-Q-uncontrolled eating ($Rho = 0.326$, $p < 0.001$), TFE-Q-emotional eating ($Rho = 0.254$, $p = 0.005$), IAT total score ($Rho = 0.332$, $p < 0.001$), and DERS total score ($Rho = 0.304$, $p < 0.001$) (Table 2).

Conducting logistic regression analysis, we found that only DERS total score and moderate/severe IA significantly determined the presence of OB in our sample (Table 3). The binary logistic regression model explained 40% of the variance, and it correctly classified 74.2% of the patients, with a sensitivity of 68.8% and specificity of 80%. According to the model, an increase by one point in DERS total score escalated the odds of being OB by 2% (Table 3). A 22-fold increased risk of OB has been detected in moderate/severe IA compared to no addiction in logistic regression analysis (Table 3).

Measurement (outer) model assessment

To assess the convergent validity of our model, reflective indicator loadings, average variance extracted (AVE), Rho A, and composite reliability (CR) were conducted using SmartPLS-3 (Table 4). Each indicator loading should be ≥ 0.7, and the CR and Rho_A of the variables should be measured ≥ 0.7 to establish convergent validity [37, 40]. Two subscales of DERS (non-acceptance and aware) and two subscales of IAT (lack of control and neglect social life) were removed from the construct's structure, since their factor loadings were below 0.7 and dropping them improved our composite reliability [37]. The AVE of all reflective constructs were above 0.5 [38].

To investigate discriminant validity, the Heterotrait–Monotrait Ratio (HTMT) was utilized (Table 5). The results showed that all values were below the critical value of 0.85 [37].

Table 2 Correlations of BMI-SDS ($N = 123$)

	(1)	(2)	(3)	(4)	(5)	(6)
(1) BMI-SDS	1.000					
(2) TFE-Q uncontrolled	0.326** < .001	1.000				
(3) TFE-Q emotional	0.254** 0.005	0.575** < .001	1.000			
(4) IAT total score	0.332** < 0.001	0.203* 0.02	0.284** 0.001	1.000		
(5) DERS total	0.304** 0.001	0.206* 0.02	0.362** < 0.001	0.451** < 0.001	1.000	
(6) Age	− 0.171 0.05	− 0.214* 0.01	0.007 0.94	− 0.194* 0.03	−0.095 0.30	1.000

TFE-Q Three factors eating questionnaire, *DERS* Difficulties in emotion regulation scale, *IAT* Internet addiction test, *BMI-SDS* Body mass index-standard deviation scores

*$p < 0.05$

**$p < 0.01$ Spearman correlation

Table 3 Multivariate logistic regression analysis for the assessment of determinants of OB

	B	S.E	Sig	Exp (B)	95% C.I. for EXP (B)	
					Lower	Upper
No addiction (IAT < 20)			0.013			
Mild addiction (IAT = 20–49)	– 0.132	0.482	0.785	0.877	0.341	2.254
Moderate/severe addiction (IAT > 50)	3.111	1.117	0.005	22.435*	2.512	200.329
TFE-Q-uncontrolled	0.010	0.013	0.453	1.010	0.984	1.037
TFE-Q-emotional	0.017	0.009	0.053	1.017	1.000	1.034
DERS total score	0.028	0.013	0.035	1.029*	1.002	1.056
Gender (Girls)	0.076	0.463	0.870	1.079	0.435	2.673
Age	– 0.147	0.117	0.212	0.864	0.686	1.087
Constant	– 1.084	2.182	0.619	0.338		

TFE-Q Three factors eating questionnaire, *DERS* Difficulties in emotion regulation scale, *IAT* Internet addiction test

Logistic regression analysis; $*p < 0.05$

Table 4 Measurement model

	Items	Loadings	AVE	CR	Rho_A	Outer VIF
DERS	DERS clarity	0.764	0.667	0.889	0.839	1.505
	DERS impulse	0.874				2.320
	DERS strategy	0.856				2.236
	DERS goals	0.767				1.724
IAT	Excessive	0.920	0.766	0.929	0.905	3.806
	Salience	0.910				3.745
	Anticipation	0.842				2.351
	Neglect work	0.824				1.856
TFE-Q	Emotional eating	0.906	0.759	0.863	0.721	1.379
	Uncontrolled eating	0.835				1.379
BMI-SDS	–	1.000	1.000	1.000	1.000	1.000

Items removed = indicator loadings were below 0.7 = DERS non-acceptance, DERS aware, IAT lack of control, IAT neglect social life

TFE-Q Three factors eating questionnaire, *DERS* Difficulties in emotion regulation scale, *IAT* Internet addiction test, *BMI-SDS* Body mass index-standard deviation scores

Table 5 Discriminant validity (HTMT)

Constructs	(1)	(2)	(3)
(1) BMI-SDS			
(2) DERS	0.357		
(3) IAT	0.391	0.524	
(4) TFE-Q	0.425	0.350	0.312

TFE-Q Three factors eating questionnaire, *DERS* Difficulties in emotion regulation scale, *IAT* Internet addiction test, *BMI-SDS* Body mass index-standard deviation score

Structural (inner) model assessment

According to Garson [37], the variance inflation factor (VIF) coefficient above 4 may cause problematic multicollinearity. Since the highest outer (vertical) VIF coefficient was 3.806 and the highest inner (lateral) VIF coefficient was 1.315, multicollinearity was not a problem in our model. 22.6% of the variance of BMI-SDS was explained by IA, emotional/uncontrolled eating, and ED according to the results of pathway analysis.

The evaluation of the path coefficients in our research model (Fig. 1) showed that IA level and emotional/uncontrolled eating had a significant direct effect on BMI-SDS, which supported our Hypotheses 2 and 3 (Table 6). There was no significant direct effect of DERS on BMI-SDS ($B = 0.100$, $t = 1.191$, $p = 0.23$) whereas the indirect effect of DERS on BMI-SDS which was mediated by IAT and TFE-Q was statistically significant (Indirect effect $B = 0.185$, $t = 3.959$, $p < 0.001$; Total effect $B = 0.285$, $t = 3.955$, $p < 0.001$). Based on these findings, although Hypothesis 1 was rejected, Hypothesis 4 was supported.

Discussion

To the best of our knowledge, this is the first study aiming to explore whether IA or uncontrolled/emotional eating mediates the relationship between ED and BMI-SDS in a clinical adolescent sample. In addition, we aimed to detect which of these variables (ED, IA, uncontrolled eating, or emotional eating) significantly affect the presence of OB.

In the present study, compared to HC, adolescents with OB reported significantly higher levels of difficulties in emotion regulation, especially in controlling impulse, accessing effective emotion regulation strategies, and recognizing emotions. Moreover, a 2% increased risk of OB detected in every 1-point increase in DERS total score (e.g., a 10-point increase in DERS total score was associated with a 20% increased risk of OB). Consistent with these findings, the

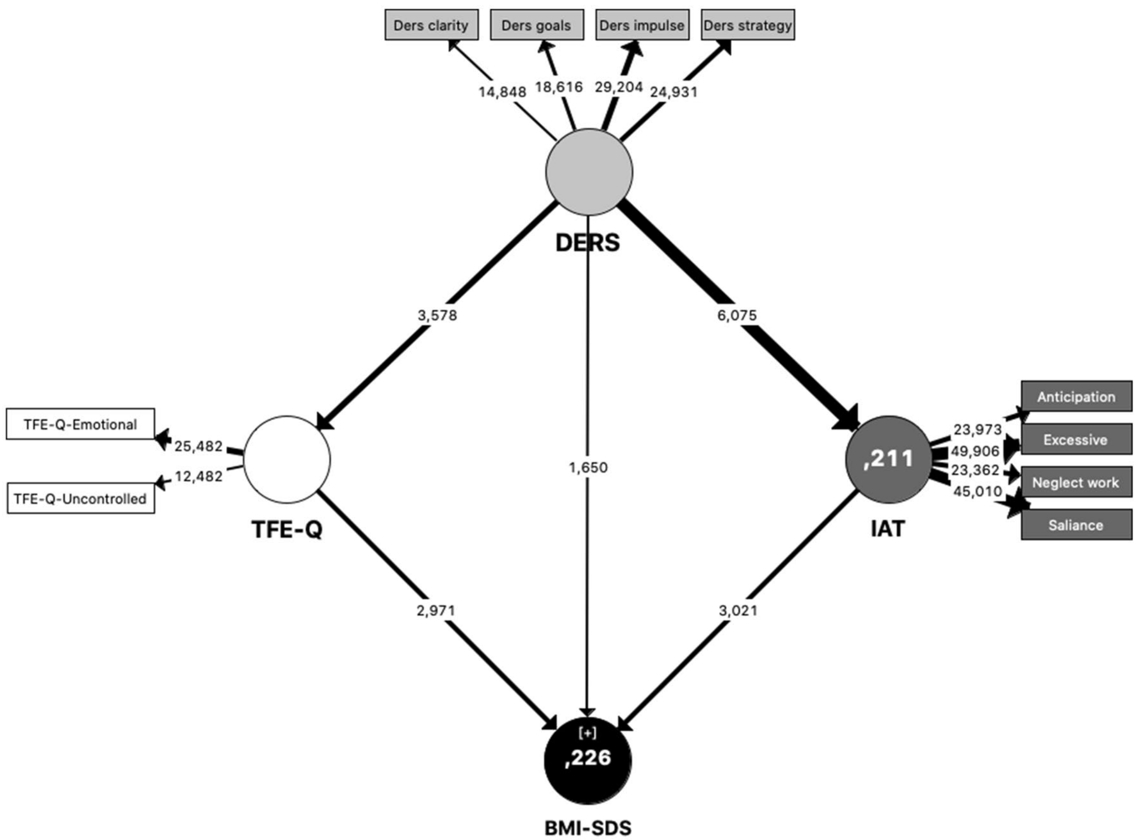

Fig. 1 Hypothesis testing (Bootstrapped *t* estimates). *TFE-Q* Three factors eating questionnaire, *DERS* Difficulties in emotion regulation scale, *BMI-SDS* Body mass index-standard deviation score, *IAT* Internet addiction test

Table 6 Structural model testing for direct and indirect effects and the mean of the bootstrapped samples with bootstrapped *t* test estimates and *p* values for BMI-SDS

Hypothesis	Relationship	Std. Beta	Std. Error	[*t* value]	Decision	f^2	q^2	95% CI	5% CI
H 1	DERS—> BMI-SDS	0.144	0.087	1.650	Not supported	0.016	0.003	0.290	0.002
H 2	IAT—> BMI-SDS	0.247	0.082	2.996**	Supported	0.059	0.048	0.365	0.086
H 3	TFE-Q—> BMI-SDS	0.247	0.079	3.146**	Supported	0.072	0.047	0.366	0.104
H 4a	DERS—> IAT—> BMI-SDS	0.115	0.041	2.731**	Supported	–	–	0.187	0.045
H 4b	DERS—> TFE-Q—> BMI-SDS	0.071	0.030	2.311**	Supported	–	–	0.122	0.027

TFE-Q Three factors eating questionnaire, *DERS* Difficulties in emotion regulation scale, *IAT* Internet addiction test, *BMI-SDS* Body mass index-standard deviation score

*$p<0.05$, **$p<0.001$; R^2 (BMI-SDS = 0.226, IAT = 0.225, TFE-Q = 0.091); Q^2 (BMI-SDS = 0.182, IAT = 0.157, TFE-Q = 0.043)

meta-analysis by Fernandes et al. [7] showed that individuals with OB had difficulties in identifying feelings, emotional awareness, and using appropriate emotional regulation strategies when compared with a control group. We also found that uncontrolled and emotional eating totally mediated the association between ED and BMI-SDS. The pathway between dysfunctional eating behaviors, ED and BMI-SDS may be an outcome of low parenting quality early in life (Fig. 2a) [9]. Not surprisingly, parenting styles play a fundamental role in children to gain self-regulation abilities [41]. For children to acquire adaptive emotion regulation and self-regulation skills, caregivers should correctly read and mirror their children's emotions and respond to them in ways that alleviate this distress in a secure parent–child attachment [5]. Repetitive inappropriate responses of caregivers (i.e., being neglectful, hostile, or overprotective) may cause poor interoceptive awareness (poor awareness of feelings of hunger/satiety and of emotions) and self-regulation difficulties in their children [10]. Furthermore, emotional eating, as a dysfunctional emotion regulation mechanism,

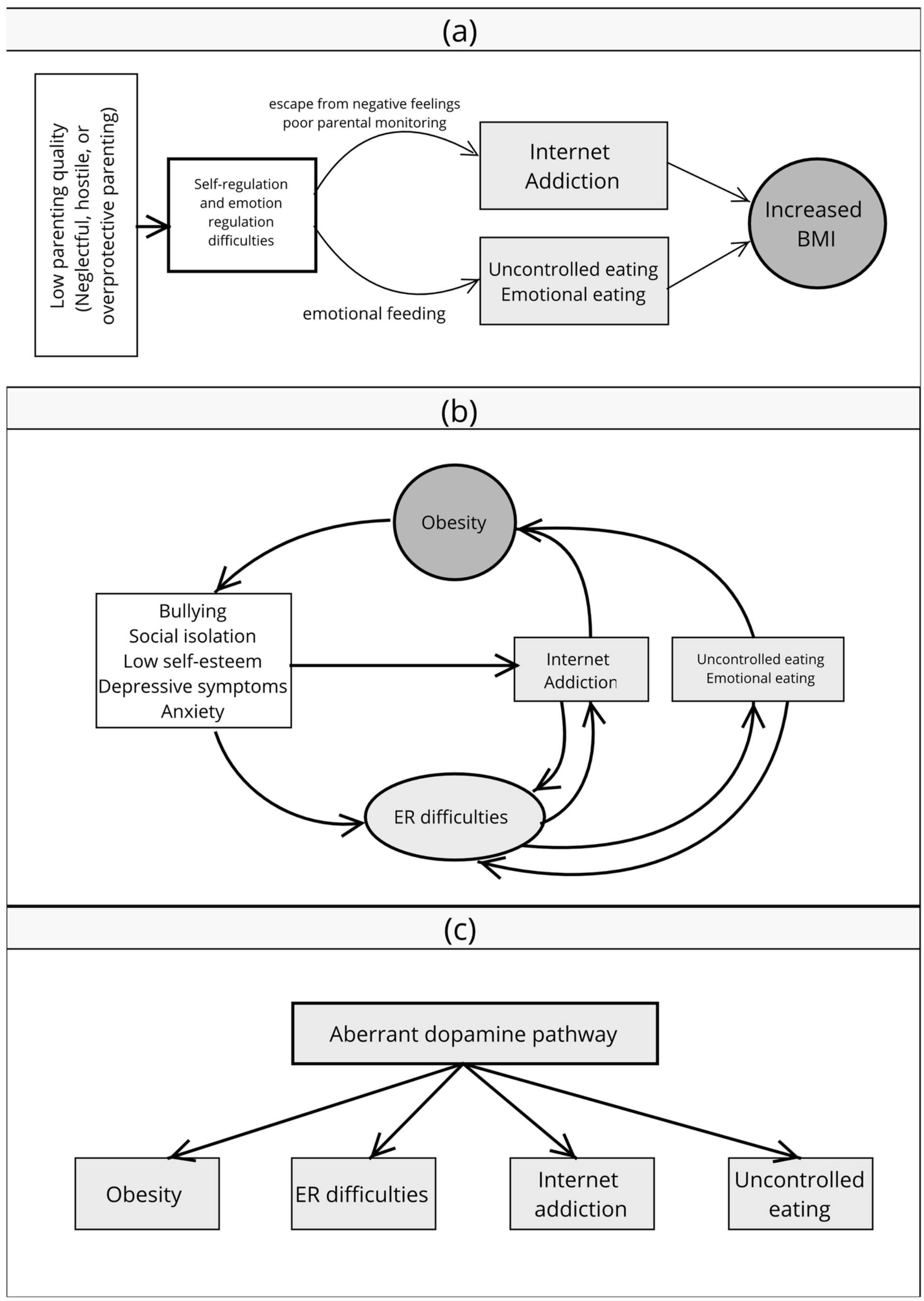

Fig. 2 Theories explaining possible causal relationship between emotion dysregulation, Internet addiction, uncontrolled/emotional eating, and obesity. *BMI* Body mass index, *ER* emotion regulation

can be taught by parents if they offer food to soothe their children's negative emotional state (i.e., emotional feeding) [42]. Consequently, in case of low parenting quality, children may have difficulties in being aware of their emotional and hunger/satiety state, controlling their impulses, and reaching appropriate emotion regulation strategies. When eating is offered as a way to alleviate their negative emotions, emotional eating begins to be used as a coping mechanism for negative emotions. Since these children have problems with self-control, loss of control over eating can be triggered in negative emotional states. And both of these dysfunctional eating problems may cause increased BMI in these children [12, 43].

Of note, we also found a full mediational effect of IA on the relationship between ED and BMI-SDS. Furthermore, moderate/severe IA was associated with a 22-fold increased risk of OB compared to no-risk for IA. In line with our findings, independent association of IA with BMI [24] and with OB [23, 25] have been demonstrated in adolescents. Our results were also consistent with Petteroruso et al.'s study [44], reporting that young adults with IA had a higher level of ED, especially in controlling impulse, accessing appropriate emotion regulation strategies, and accepting emotions, than those with no-risk for IA. However, the current study is the first one examining the pathway between IA, ED, and BMI. Similar to emotional/uncontrolled eating, low parenting quality can explain to the association between ED, IA, and BMI-SDS (Fig. 2a). Neglectful, rejecting, overprotective, or punitive parenting styles were found to be related to IA in adolescents [45, 46]. As mentioned in the previous paragraph, low parenting quality may cause emotion and self-regulation difficulties in children. When a child has self-regulation difficulties, she/he could have a great tendency to utilize the Internet as an escape from negative emotions [47]. Since parental monitoring is usually compromised in low parenting quality, parents who have dysfunctional parenting styles are also likely to be unable to monitor the Internet use of their children and establish appropriate boundaries to it [48]. As a consequence, ED and consequent IA may develop in children whose parents have inadequate parenting skills. Once IA is occurred, reduced physical activity, increased tendency in consuming unhealthy food, irregular dietary behavior, and poor sleep quality could cause weight gain and OB in adolescents [29, 49]. Importantly, a number of studies have shown that poor parenting practices are also associated with OB. For instance, neglected children had a ninefold greater risk of adult OB than averagely groomed children [50]. Rhee et al. [51] reported that children whose mothers were neglectful or permissive were twice likely to be OB than those whose mothers were authoritative. Moreover, in a recent review [52], it has been demonstrated that permissive parenting is consistently associated with increased child BMI. Thus, it would be a fruitful area for future studies to work whether ED, IA, and dysfunctional eating behaviors play mediational roles between low parenting quality and childhood OB.

Although we demonstrated that ED had a total indirect relationship with BMI-SDS through IA and dysfunctional eating behaviors, because of the cross-sectional design of our study, it was impossible to determine a causal relationship between these variables. Thus, a reverse relationship is also possible (Fig. 2b). Compared to their healthy peers, children with obesity are more exposed to bullying, which have lower levels of self-esteem and higher isolation, all of which could cause anxiety and mood disorders [53]. To cope with anxiety and depression, children with OB may utilize emotional/uncontrolled eating or the Internet as dysfunctional emotion regulation strategies. Consistent with this assumption, in Li et al.'s meta-analysis [54], it was demonstrated that anxiety and depression positively predicted IA in adolescents. Moreover, increased anxiety and depression were associated with emotional eating in overweight youngsters [55].

Furthermore, shared neurobiological mechanisms could explain the association between ED, BMI-SDS, IA, and dysfunctional eating behaviors (Fig. 2c). The dopaminergic pathway modulates reward sensitivity and motivation, and is associated with conditioning, self-control, stress reactivity, and interoceptive awareness [56]. Abnormalities in the dopaminergic pathway have been found in IA [57], overeating [58], and OB [56]. Brain regions in the dopaminergic pathway such as the amygdala, anterior cingulate cortex, orbitofrontal cortex, ventral striatum, and dorsolateral prefrontal cortex play a key role in emotion regulation [59]. Therefore, the aberrant dopaminergic pathway may cause IA, uncontrolled eating, OB, and ED.

The major limitation of this study was the cross-sectional design, which hindered us to determine the causal relationship between the variables. Small sample size was another drawback; thus, it is not enough to make generalizations. Since we did not use a randomization technique while constructing both of our groups, this might have caused biased results. Moreover, we recruited adolescents with OB who had a current psychiatric disorder other than autism spectrum disorder or intellectual disability. Although all of our significant findings were survived between the groups even if we excluded the adolescents with OB with current psychiatric disorders, current psychiatric disorders might have been a confounding factor. Furthermore, we utilized self-reported questionnaires and self-reported Internet use time while collecting data. Therefore, a large-scale longitudinal study in which objective measurements are used and samples are randomized should be planned to enlighten the causal relationship between pediatric OB, ED, IA, and dysfunctional eating behaviors. Notwithstanding these limitations, this work offers a possible mediational effect of uncontrolled/

emotional eating and IA on the relationship between ED and BMI-SDS.

Our study may provide some implications for clinical practice. First of all, we found that one in three adolescents with OB had moderate or severe IA and nearly half of them had at least one psychiatric disorder. This finding shows the importance of screening for IA and comorbid psychiatric disorders in treatment programs for OB. Second, it seems that a module focusing on improving emotion recognition, developing appropriate emotion regulation skills, and increasing awareness and mindfulness of individuals not to act upon impulses may be important in prevention and treatment programs for OB. To the best of our knowledge, although OB intervention programs aimed to enhance coping ability with negative emotions to mitigate emotional or uncontrolled eating [60], none has been focused on the effect of enhancing emotion regulation skills on IA and Internet use time. Since decreased Internet use time would contribute to weight loss, this would be a fruitful area for further work.

In conclusion, when compared with their healthy peers, adolescents with OB have higher ED which is associated with increased BMI-SDS through IA and dysfunctional eating behaviors. Furthermore, an increase by one point in ED scores is associated with a 2% increased risk of being OB. Compared to adolescents with no-risk for IA, those with moderate/severe IA have a 22-fold increased risk for OB. It seems that inserting a module focusing on improving emotion recognition, developing appropriate emotion regulation skills, and increasing awareness and mindfulness of individuals not to act upon impulses can contribute to prevention and treatment programs for OB. A future large-scale prospective study using objective measurements is needed to shed light on the causal relationship between BMI-SDS, ED, IA, and dysfunctional eating behaviors.

What is already known about this subject?

Previous studies have investigated the association between obesity and emotion dysregulation, uncontrolled/emotional eating, internet addiction, and physical activity, separately. However, any of them have investigated the complex relationship between BMI-SDS, emotion dysregulation, internet addiction, and dysfunctional eating behaviors in a clinical adolescent sample.

What this study adds?

To the best of our knowledge, this is the first study demonstrating the total indirect relationship between emotion dysregulation and BMI-SDS, which was mediated by Internet addiction. Although obesity intervention programs aimed to enhance coping ability with negative emotions to mitigate emotional or uncontrolled eating, none has been focused on the effect of enhancing emotion regulation skills on IA and Internet use time. Since decreased Internet use time would contribute to weight loss, this would be a fruitful area for further work.

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Compliance with ethical standards

Conflict of interest The authors declared no conflict of interest.

Ethical approval The Ethics Committee of the Ministry of Health Ankara City Hospital approved the current study (E1/199/2019). Patients and parents were verbally informed on the design of the study, and written informed consent forms in accordance with the Declaration of Helsinki were obtained from both of them.

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