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Emotion regulation, emotional eating and the energy-rich dietary pattern. A population-based study in Chinese adolescents

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ABSTRACT

Research investigating the influence of emotion regulation (ER) strategies on emotional eating and diet among Chinese adolescents is scarce. The aim of this study was to test associations between two ER strategies (suppression/cognitive reappraisal), emotional eating, and an energy-rich dietary pattern. A total of 4316 adolescents from 10 high schools were surveyed. Dietary patterns were derived using factor analysis. Bivariate correlations were analyzed to examine associations between ER strategies, emotional eating behavior and an energy-rich dietary pattern, by gender. The mediating effect of emotional eating in the relationship between ER and energy-rich food consumption by gender was estimated using structural equation modeling. A higher level of suppression, but no lack of cognitive reappraisal, was associated with emotional eating in boys and girls. A higher level of suppression and lack of cognitive reappraisal were associated with a greater intake of energy-rich foods in girls only. Emotional eating mediated the relationship between a higher level of suppression and a greater intake of energy-rich food in girls. This study revealed significant associations between two ER strategies and an energy-rich dietary pattern in girls, and provided evidence that higher levels of suppression may put girls at risk for emotional eating, potentially affecting the energy-rich dietary pattern.

1. Introduction

The food environment has changed dramatically, with an influx of hyperpalatable foods engineered in ways that appear to get the better of the rewarding properties of traditional foods (e.g., vegetables, fruits, whole grains) by increasing fat, sugar, salt, flavors, food additives, and energy to high levels (Nielsen & Popkin, 2003). Many developing countries, including China, are faced with the challenge of overconsumption of high-kilojoule, low-nutrient foods, due in part to changes in global food production (Irizarry et al., 2010). This unhealthy dietary pattern is related to unfavorable outcomes, such as obesity in genetically at-risk groups (Lake & Townshend, 2006). Because many children and adolescents maintain a healthy weight in the current "obesogenic" environment, some researchers, especially those investigating children and adolescents, have emphasized the influence of self-regulation skills in obesity (Duckworth, Tsukayama, & Geier, 2010; Evans, Fuller-Rowell, & Doan, 2012; Francis & Susman, 2009; Seeyave et al., 2009; Tsukayama et al., 2010) and obesity-related dietary intake (Frankel et al., 2012; French et al., 2012) in the Western society. The assumption is that individual differences in self-regulation (e.g., self-control, delay of gratification) may be one factor that contributes to lower kilojoule consumption despite significant environmental pressure to overconsume. However, the concept of self-regulation is closely related to the behavioral aspects of self-regulation. A broad, generalized aspect of self-regulation (i.e., not just behavioral), emotion regulation (ER), appears to be a primary self-regulation skill (Tice, 2000). Studies have extended previous findings by documenting the association between obesity (Graziano, Calkins, & Keane, 2010) and obesity-related dietary pattern (Gerrits et al., 2010; Wills et al., 2007; Isasi, Ostrovsky, & Wills et al., 2013), and deficits in ER.

Broadly speaking, ER refers to the conscious or unconscious attempt of an individual to modify the magnitude and/or type of emotional experience or the event itself, in response to emotion-eliciting events (Campbell-Sills & Barlow, 2007; Thompson, 1991). Adaptive ER may increase general feelings of efficacy, which could lead, in turn, to healthier lifestyle (e.g., healthy dietary pattern or

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increased physical activity) (Wills, Pokhrel, Morehouse, & Fenster, 2011). Maladaptive ER, on the other hand, may be associated with an increased vulnerability to negative emotions (reviewed by Aldao, Nolen-Hoeksema, & Schweizer, 2010) where food is used to cope with negative emotions, a response known as emotional eating (Adam & Epel, 2007; Dallman et al., 2003; Loxton, Dawe, & Cahill, 2011; Michels et al., 2012). An often-mentioned explanation for emotional eating is that it is a consequence of the inability to regulate emotion effectively in response to emotional events where food is used to reduce negative emotions (Heatherton, &Herman, 1991). In particular, it has been suggested that emotional eating increases the consumption of high fat, sweet and energy-rich food in adults (Konttinen et al., 2010; Nguyen-Michel et al., 2007) as well as in youth (Elfhag, Tholin, & Rasmussen, 2008; Michels et al., 2012; Goossens et al., 2009). Theoretically, emotional eating may serve to regulate emotion (Macht, 2008), however none of the above-mentioned studies examining the association between ER and an energy-rich dietary pattern included measures of emotional eating. Prior research has established a strong direct link between ER strategies and emotional eating in adult and child populations (Harrist et al., 2013; Spoor et al., 2007). For example, Spoor et al. (2007) indicated that, in adults, an inability to regulate emotional stress leads to maladaptive coping strategies such as emotional eating. Harris et al. (2013) found that dysregulated emotional expression or suppression in children was related to emotional eating. However, it remains unclear whether ER may contribute to emotional eating in adolescents.

ER can be understood as the process whereby we manage our own emotions (Koole, 2009). Two well examined processes or strategies in current literature are cognitive reappraisal and suppression, which were developed based on Gross's process model of emotion regulation (1998, 2001). Specifically, cognitive reappraisal, a prototypical adaptive ER strategy, entails changing the way in which a situation is construed with the aim of decreasing its emotional effect. It is regarded as an adaptive strategy because it reduces the negative experience that results from the emotion, without additional costs (Gross & John, 2003). A prototypical example of maladaptive ER is the suppression or inhibition of emotions (Gross & John, 2003), because these inhibit the expression of emotions but not the experience of them (Gross, 2002). The question of what consequences cognitive reappraisal and suppression was tested initially in a cross-sectional study (Gross & John, 2003) using undergraduate samples. Gross and John (2003) reported that individuals differ in their use of cognitive reappraisal and suppression, and that these differences relate in predictable ways to psychological functioning. Given that the physical and psychosocial transformations experienced during adolescence are accompanied by strong emotions (Michels et al., 2012) and many of the neural and cognitive systems thought to control emotion mature during this period (Goossens et al., 2009), ER has become an important topic for research into adolescence. Of note, some studies also examined the use of two strategies of ER based on Gross's (1998) process-oriented model in adolescent population, and showed that suppression and cognitive reappraisal would predict adolescents' psychological distress (Boyes, Hasking, & Martin, 2015; Zhao & Zhao, 2015). Moreover, Gullone, Hughes, King, and Tonge (2009) tested Gross's process model of ER in 9- to 15-year-old children and adolescents, and found suppression use was lower for older participants compared to their younger peers, and reappraisal use in older participants was stability over time. In this study, therefore, we focus on these two domains of ER, and investigate the relationship between ER strategy, emotional eating and an energy-rich dietary pattern in Chinese adolescents. Furthermore, the potentially mediating effect of emotional eating that could explain the relationship of emotion dysregulation with the consumption of unhealthy energy-rich food, will be tested.

2. Methods

2.1. Participants

We utilized the baseline data from an ongoing 2-year longitudinal study in Xuzhou city in China, in order to assess the role of ER strategy in obesity and obesity-related behavior in urban adolescents. The study population comprised students aged 11–17 years at urban junior and high schools. Xuzhou is located in the northwest of Jiangsu Province, with a recorded history spanning 4000 years. With an area of 11 258 km^2, of which 963 km^2 constitutes the urban area, Xuzhou has a total population of over 8 million. Cross-sectional survey data were used to obtain a random sample of adolescents in the 7th and 10th grades in five junior high and five senior high schools, respectively, using multistage cluster sampling, in October 2013. Five districts in urban areas in Xuzhou were selected and one junior high and one senior high school in each district were randomly sampled. In each of the selected schools, all students in Grade 7 and Grade 10 were selected, a total of 5003 subjects (2171 boys and 2145 girls). Informed consent was obtained from all participants and their parents, and the research protocol was approved by the Ethics Committee of the Anhui Medical University.

2.2. Instruments

Anthropometric data were obtained concurrently, with weight and height measured by the department for elementary and middle school student health care, a government department that monitors student health in Xuzhou city through annual physical examination. Weight was measured to the nearest 0.1 kg using a standardized digital scale. Height was measured to the nearest 0.1 cm with a manual height board. Body mass index (BMI) was calculated by dividing the participant's weight in Kilograms by height in meters squared (kg/m^2). Rather than using absolute BMI, we used a BMI z-score because doing so provided an indirect age- and sex-specific measure of relative adiposity (Must & Anderson, 2006). The self-administered questionnaires requested socio-demographic information, and information on emotional eating, emotion regulation (suppression and cognitive reappraisal), depressive symptoms and food consumption and are described further.

2.2.1. Emotion regulation questionnaire

The Emotion Regulation Questionnaire (Gross, 2002) was used to measure individual differences in the use of expressive suppression and cognitive reappraisal as ER strategies. It contains 10 items (e.g., “I control my emotions by not expressing them” to measure expressive suppression, and “I control my emotions by changing the way I think about the situation I'm in” to measure cognitive reappraisal) presented as statements, and participants indicate to what extent they agree on 7-point Likert scales ranging from 1 “strongly disagree” to 7 “strongly agree”. The questionnaire shows good reliability, and both convergent and discriminant validity (Gross & John, 2003). Cronbach's alpha for the study was 0.82 for the suppression subscale and 0.85 for the cognitive reappraisal subscale.

2.2.2. Dietary assessment

Habitual dietary patterns were assessed by a comprehensive self-administered food frequency questionnaire (FFQ), which was designed to measure the dietary habits of adolescents. The number of times each food or food group was consumed per week was

determined. According to the dietary features of the target population, the FFQ was modified on the basis of a previous questionnaire (Wang et al., 1998) and included 36 foods items most commonly consumed by Chinese adolescents during the year prior to the study (Weng et al., 2012). Each item represents a food group and students were asked to indicate the frequency of consumption during the previous 7 days that best described their intake. There were five frequency options, ranging from "never" to "9 or more times" per 7 days, excluding alcoholic beverages. Each option was scored as follows: "never eat" = 0; "1–3 times" = 1; "4–5 times" = 2; "6–8 times" = 3; and "more than 8 times" = 4. The FFQ focused only on the frequency of each food item and information on portion size was not included.

2.2.3. Emotional eating behavior

The Dutch Eating Behavior Questionnaire (van Strien, 1986) was used to assess emotional eating. It is a 33-item self-reported questionnaire that contains 5-point Likert scales ranging from 0 (never) to 4 (very often), measuring three unhealthy eating behaviors. It demonstrates high sensitivity and specificity; reported Cronbach's alpha coefficients are in the range of 0.79–0.95 (Goldfield et al., 2010). Emotional eating (13 items) is defined as a tendency to use food to cope with negative emotions (e.g., "Do you have the desire to eat when you are irritated?"). Cronbach's alpha for the study was 0.81 for the emotion eating subscale.

2.3. Procedure

The participants completed the survey questionnaires anonymously and voluntarily during one 45 min class period, following which the questionnaires were deposited in a locked box outside the classroom to ensure confidentiality. The self-report questionnaires were administered by undergraduate and postgraduate students majoring in Child and Adolescent Health Care; they were trained beforehand, and available onsite to answer questions and deal with critical incidents. Of 5003 potential subjects, 469 students did not participate, including 124 who declined to participate and 201 absent for other reasons, and 144 students who were ill. A total of 218 questionnaires were incomplete (more than 15% of information was missing or the questionnaire was completed with random responses). Finally, 4316 valid questionnaires were collected.

2.4. Missing values

Participants were excluded from the main analysis if they had more than 15% items with missing values or had responded randomly. The 218 excluded students were more likely to be boys ($P < 0.001$) and were older (13.4 vs. 12.9 years, $P < 0.001$) compared with the final sample, but did not show significant differences in BMI (20.6 vs. 20.7 kg/m^2, $P = 0.134$) and family income ($P = 0.178$).

2.5. Data analysis

Statistical analyses were performed using SPSSv17.0. Factor analysis, a principal component analysis of food frequency consumption data, was conducted based on the 36 food groups to determine dietary patterns based on FFQ; factors were rotated by varimax rotation, and two dimensions were extracted from the rotated component matrix. Both dimensions had eigenvalues exceeding 1. A criterion for inclusion in the constructed indices was that the single group of food items had a value of 0.2 or more in the rotated component matrix. Inter-item reliability for each factor was assessed by Cronbach's alpha coefficients (Cronbach's alpha for the FFQ was 0.818 in the present study). The two factors according to the eigenvalues in the scree plot accounted for 33.98% of the variance in the dietary information. The two factors were labelled as 'energy-rich' and 'nutrient-dense', and scores were saved as variables in the data set. One index, labeled nutrient-dense, was composed mainly of staple foods, gruel (millet or rice gruel), oatmeal, whole grains, sweet potato, fresh yellow or red vegetables, fresh green leafy vegetables, fruit, milk, soya milk, soya products, pork/beef meat and poultry. The other index, labeled energy-rich, was composed mainly of western fast foods, Chinese fast foods, bread, toasted meat, fried meat, fried vegetables, fried pasta, preserved fruit, desserts, pancake, chocolate, candy, carbonated beverages, flavored milk drinks, synthesized fruit/vegetable juice, nuts and ice cream. Food consumption scores for each group of food items were totaled to form new scores for the two indices.

Chi-square analysis was used to test for differences in variables between genders. Differences in the means between genders were tested using *t*-tests. As gender differences have been observed in comfort/unhealthy food preferences (Wansink, Cheney, & Chan, 2003) further analyses were stratified accordingly. Bivariate correlation analysis was used to examine the relationship between scores for cognitive reappraisal, suppression and emotional eating, and the two dietary pattern indices, stratified by gender. To test our hypotheses, structural equation modeling techniques (path analyses) were estimated using AMOSv17. Before running individual models, data centralization was performed. In particular, the "model indirect" command was used in AMOS to test the significance of indirect effects. Overall model of fit was judged on the basis of the following fit indices: the Tucker–Lewis Index (TLI; values of $\geq$0.90 indicate good fit), the Comparative Fit Index (CFI; values of $\geq$0.90 indicate good fit), the Root Mean Square Error of Approximation (RMSEA; values of $\leq$0.08 indicate good fit), and the Standardized Root Mean-Square Residual (SRMR; values of $\leq$0.08 indicate good fit) (Kline, 2005). This procedure uses bootstrapping (Williams & Mackinnon, 2008) to calculate indirect effects using 1000 samples. In all path models, covariates include age, BMI z-score, parental education and family income.

3. Results

Two dietary patterns were extracted from 36 food groups in the FFQ using principal component analysis: nutrient-dense foods and energy-rich foods. The factor-loading matrices of component for the two dietary patterns are listed in Table 1. Differences in sociodemographic and anthropometric characteristics, cognitive reappraisal, suppression, emotional eating and dietary patterns between genders are shown in Table 2. Significant gender differences were observed for age, BMI, family income, the two ER strategies and emotional eating behavior. In addition, boys consumed energy-rich food more frequently than girls ($P < 0.001$), while no gender difference was found for nutrient-dense food consumption ($P = 0.861$).

Table 3 presents coefficients of bivariate correlation between scores of all variables, stratified by gender. In boys, cognitive reappraisal had a significant negative correlation with the scores for the nutrient-dense dietary pattern but not for the energy-rich dietary pattern. Correlations between suppression and nutrient-dense and energy-rich dietary pattern scores were not significant. Suppression was significantly and positively associated with emotional eating, but the association between cognitive reappraisal and emotional eating was not significant. In addition, emotional eating was not significantly associated with the energy-rich or nutrient-dense dietary pattern scores. In girls, cognitive reappraisal was significantly negatively and positively associated with energy-rich and nutrient-dense food consumption, respectively. Suppression was significantly positively and negatively associated with

Table 1
The 36 foods items in the food frequency questionnaire, with examples.

Foods item	Energy-rich foods	Nutrient-dense foods
Staple foods (for most Chinese)	–	0.46
Chinese traditional congee	–	0.59
Porridge	–	0.54
Whole grains	–	0.52
Sweet potato	0.34	0.56
Pork/beef	0.28	0.50
Poultry	–	0.46
Fish and fish products	–	0.61
Egg	–	0.67
Soya products	0.31	0.51
Soya milk	–	0.55
Milk	–	0.79
Fresh yellow or red vegetables	–	0.73
Fresh green leafy vegetables	–	0.65
Fresh fruit	–	0.51
Western fast foods[a]	0.56	–
Chinese fast foods[b]	0.45	–
Bread (White bread, toast)	0.66	–
Toasted meat	0.57	
Fried meat	0.65	–
Fried vegetables[c]	0.63	–
Fried pasta	0.56	–
Preserved fruit	0.64	–
Sweet course	0.70	–
Ice cream	0.61	–
Chocolate	0.62	–
Candy	0.70	–
Carbonated beverages	0.72	–
Flavored milk drink	0.58	–
Synthesizedfruit/vegetable juice	0.60	0.28
Nuts	0.59	0.28
Pancake[d]	0.41	–

Note: Food items with absolute values < 0.20 (organ meat, sausage, yoghurt, tea) were not listed in the table, for simplicity.
[a] Hamburger, pizza.
[b] Steamed stuffed bun, Chinese hamburger.
[c] Potato, sea tangle, soya products.
[d] Chinese oil cake, batter cake.

energy-rich and nutrient-dense food consumption, respectively. Suppression was significantly positively associated with emotional eating, although the association between cognitive reappraisal and emotional eating was not significant. In addition, the correlation between emotional eating and energy-rich food consumption was positive and significant among girls (Table 3).

We focused on the energy-rich dietary pattern outcome in the final mediation model. Bivariate associations revealed a significant relationship between higher levels of suppression and higher energy-rich food consumption in girls; girls with more emotional eating consumed energy-rich food more frequently, and girls with higher levels of suppression also reported higher levels of emotional eating. The next step in our analysis considered our mediation model by gender: ER (suppression) → emotional eating → energy-rich foods consumption (Fig. 1). In the path model, the covariates included age, BMI-z score, parental education level, family income and depressive symptoms. In the final mediation model, path estimates supported direct associations between suppression and energy-rich food consumption in girls ($P < 0.001$), between suppression and emotional eating in both genders ($P < 0.001$), and between emotional eating and consumption of energy-rich foods in girls ($P < 0.001$). The total effect of suppression on energy-rich food consumption in girls was significant ($P < 0.001$), and direct effect was reduced (Fig. 1). Support was also found for an indirect path from suppression to consumption of energy-rich food through emotional eating (i.e., higher level of suppression → higher level of emotional eating → higher energy-rich food consumption), and the hypothesized indirect effect was significant ($\beta = 0.10$, $P < 0.01$) in girls. Fit statistics suggested that the model fit the data well: $\chi^2 = 7.754$, $P = 0.10$, TLI = 0.976, CFI = 0.998, RMSEA < 0.01, SRMR = 0.010. Table 4 shows estimates for statistical controls in three models for energy-rich food consumption outcome by gender. With respect to consumption of energy-rich food, sociodemographic characteristics including age, BMI-z score, parental education, and family income accounted for

Table 2
Characteristics of participants (boys: n = 2171; girls: n = 2145).

Variable	Boys	Girls	*F*	*p*
	Mean ± SE	Mean ± SE	*F*(1,4315)	
Age	13.6 ± 1.7	13.5 ± 1.6	9.42	0.002
Cognitive reappraisal	4.54 ± 1.08	5.12 ± 1.35	30.47	<0.001
Suppression	3.65 ± 1.26	3.21 ± 1.02	31.32	<0.001
Emotional eating	18.19 ± 10.19	23.83 ± 12.27	141.11	<0.001
BMI	21.14 ± 4.06	20.01 ± 3.38	100.12	<0.001
BMI z-score[a]	0.12 ± 0.99	0.00 ± 0.85	79.17	<0.001
	Yes (n, %)	No (n, %)		
Paternal education level			*F*(2,4314)	
Junior high school or less	814(52.3)	742(47.7)	3.29	0.145
Senior high school	782(49.7)	792(50.3)		
College or higher	575(48.5)	611(51.5)		
Maternal education level				
Junior high school or less	983(51.8)	915(48.2)	6.94	0.115
Senior high school	786(49.9)	769(50.1)		
College or higher	422(47.8)	461(52.2)		
Family income				
Low	198(57.1)	149(42.9)	19.96	0.012
Middle	1536(49.2)	1587(50.8)		
High	437(51.7)	409(48.3)		
Energy-rich dietary pattern[b]			*F*(1,4315)	
≥4th quartile	592(54.9)	487(45.1)	11.90	<0.001
<4th quartile	1579(48.8)	1658(51.2)		
Nutrient-dense dietary pattern[b]				
≥4th quartile	540(50.0)	539(50.0)	0.04	0.861
<4th quartile	1631(50.4)	1606(49.6)		

[a] A z-score is defined as the number of standard deviation units from the mean or reference value.
[b] Dietary pattern index score for frequency of consumption was used.

Table 3
Correlation coefficients between variables according to gender.

	1	2	3	4	5
1. Cognitive reappraisal	–	0.109***	0.022	−0.057**	0.111***
2. Suppression	0.117***	–	0.291***	0.141***	−0.091**
3. Emotional eating	0.019	0.217***	–	0.117***	−0.065**
4. Scores of the energy-rich dietary pattern	−0.032	−0.031	0.033	–	−0.003
5. Scores of the nutrient-dense dietary pattern	0.110***	−0.030	−0.016	−0.002	–

Note: $^{**}P < 0.01$, $^{***}P < 0.001$.
Coefficients for boys are below the diagonal line and for girls are above the diagonal line.

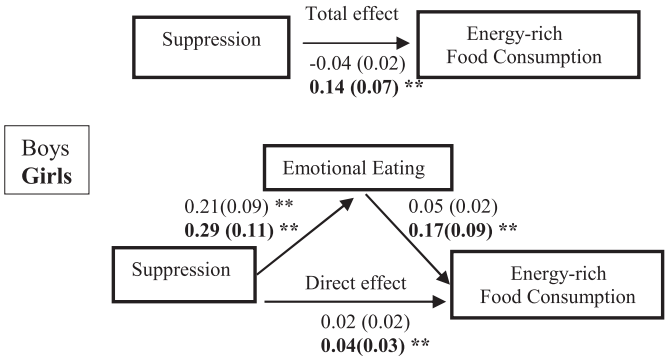

Fig. 1. Tests the associations of suppression with the mediator (emotional eating) and the outcome variable (energy-rich food consumption). Covariates include age, BMI z-score, parental education and family income. Estimates for boys are above, and for girls are below (bold). Standard errors are given in parentheses. $^{**}P < 0.001$.

11% of the variance, $F(5,2140) = 5.97$, $P < 0.001$ (Table 4, Model 1). Suppression was significantly related to energy-rich food consumption and direct effect explained 5% of additional variance, $F(6,2139) = 4.74$, $P < 0.001$ (Table 4, Model 2). The total effect of suppression in the final mediation model explained 6% of additional variance for energy-rich food consumption. The full mediation model for energy-rich food consumption accounted for 18% of the variance (adjusted $R^2 = 18\%$), $F(7,2138) = 3.80$, $P < 0.001$ (Table 4, Model 3). However, the association between cognitive reappraisal and emotional eating was not significant in both genders, thus the mediated effect of emotional eating in the relation between cognitive reappraisal—energy-rich food consumption did not work. Table 5 shows estimates for the influence of sociodemographic variables and cognitive reappraisal on the energy-rich food consumption outcome.

4. Discussion

To our knowledge, this is the first study to investigate associations between ER strategy and specific dietary patterns in a large sample of Chinese urban adolescents that takes emotional eating into consideration. Our study indicated that a higher level of suppression but no deficit in cognitive appraisal was associated with a higher level of emotional eating in both genders. However, a higher level of suppression and a lack of cognitive appraisal was associated with a greater intake of energy-rich food in girls but not boys. More importantly, our evidence indicated that emotional eating mediated the relationship between a higher level of suppression and a greater intake of the energy-rich food.

We used factor analysis to identify two major dietary patterns, energy-rich and nutrient-dense, which explained 38% of the variance, and we focused on the energy-rich dietary pattern outcome. Gender differences in dietary patterns have been demonstrated; for example, previous findings have concluded that females were ambivalent towards eating snacks, perceiving snacks as unhealthy and adolescent girls are more concerned about their body image than boys, but prefer to eat, especially when under stress (Grogan, Bell, & Conner, 1997; Zellner et al., 2006). Rangan, Randall, Hector, and et al (2008) reported that, among Australian children and adolescents, boys consumed more extra food than girls. Our study also showed that boys consumed more energy-rich food than girls. In addition, our results revealed gender differences in ER strategy, with boys using more suppression and less cognitive reappraisal than girls. This may relate to previous studies that have found higher use of emotional coping strategies and social support-seeking in women (Juan Carlos et al., 2012), and the greater use of avoidant emotion-coping strategies in adolescent boys than girls (Eschenbeck, Kohlmann, & Lohaus, 2007). A gender difference in the prevalence of emotional eating was found in our study, which was in accordance with other research indicating that girls engage more in emotional eating than boys (Snoek et al., 2007; Wardle et al.,1992).

Table 4
Coefficient estimates for the variables on energy-rich food consumption by gender.

	Boys				Girls			
	β	SE	t	R^2	β	SE	t	R^2
Model 1				0.10				0.11
Age	−0.098**	0.013	−7.625		−0.115**	0.013	−8.290	
BMI z-score	−0.015	0.004	−2.227		0.118**	0.014	4.142	
Father's education	−0.021	0.024	−1.332		−0.025	0.020	−0.841	
Mother's education	−0.024	0.012	0.398		0.036	0.029	1.231	
Family income	0.189**	0.031	0.538		0.207**	0.037	7.028	
Model 2				0.10				0.16
Suppression (Total Effect)	−0.058	0.021	2.928		0.142**	0.069	5.980	
Model 3 (Full Mediation Model)				0.10				0.19

Note: Model 1 tests the contribute of sociodemographic variables (including age, BMI z-score, parental education, and family income) on the energy-rich food consumption outcome.
Model 2 tests the contribute of sociodemographic variables and suppression (total effect) on the energy-rich food consumption outcome.
Model 3 tests the contributes of the full mediation model on the energy-rich food consumption outcome.
$^{**}P < 0.001$.

Table 5
Coefficient estimates for the variables on energy-rich food consumption by gender.

	Boys				Girls			
	β	SE	t	R^2	β	SE	t	R^2
Model 1				0.10				0.11
Age	−0.099**	0.013	−8.290		−0.115**	0.013	−8.290	
BMI z-score	−0.015	0.005	−0.930		0.117**	0.014	4.142	
Father's education	−0.018	0.035	−0.841		−0.025	0.020	−0.841	
Mother's education	−0.016	0.014	−0.545		0.036	0.029	1.231	
Family income	0.219**	0.043	7.028		0.207**	0.037	7.028	
Model 2				0.10				0.13
Cognitive Appraisal	−0.021	0.011	−1.153		−0.046**	0.034	−3.741	

Note: Model 1 tests the contribute of sociodemographic variables (including age, BMI z-score, parental education, and family income) on the energy-rich food consumption outcome.
Model 2 tests the contribute of sociodemographic variables and cognitive reappraisal on the energy-rich food consumption outcome.
Standard errors are given in parentheses.
**$P < 0.001$.

Emotional eating is related to a higher consumption of sweet, energy-rich foods (Blandine et al., 2004; Nguyen-Michel, Unger, &Spruijt-Metz et al., 2007). Some studies have demonstrated that emotional eating of comfort and energy-rich foods is modified by gender, with an association with intake of sweets in women only (Michels et al., 2012), and of non-sweet energy-dense foods in men only (Nguyen-Michel, Unger, &Spruijt-Metz et al., 2007). A recent large study of 7378 men and 22 862 women found a positive association between emotional eating and energy foods intake in women only (Camilleri et al.,2014). Our results support this association between higher levels of emotional eating and greater energy-rich food consumption among girls but not boys. The observed gender-specific association between emotional eating and the energy-rich dietary pattern suggests that girls are more likely to consume energy-rich foods in response to emotion. These potentially gender-specific effects warrant further investigation.

In our findings, girls with higher suppression tended to consume more energy-rich food. Moreover, a lack of cognitive reappraisal was related to greater energy-rich food consumption in girls, which was in accordance with previous studies (Isasi, Ostrovsky, & Wills, 2013). Isasi et al. (2013) examined ER strategy in obesity-related lifestyle behaviors, including imbalanced eating among western adolescents, and found that better-adapted ER strategy was directly related to lower snack/junk food consumption in girls but not boys. These gender differences suggest that girls using maladaptive or lacking adaptive ER strategies consume higher amounts of energy-rich food, potentially contributing to obesity.

In our study, individuals in both genders with a higher level of suppression but not lacking cognitive reappraisal demonstrated higher levels of emotional eating, suggesting that the maladaptive ER strategy of suppression is necessary for the regulation of emotional eating, at least among adolescents. Importantly, a central objective of this study was to test the hypothesis that emotional eating mediated the link between ER strategy and energy-rich food consumption. Our results indicated a stronger link between a high level of suppression and a greater intake of energy-rich foods among girls, mediated by emotional eating. In boys, high level of suppression was only related to emotional eating but not the energy-rich dietary pattern; thus, the mediated effect of emotional eating in the relationship between suppression and the energy-rich dietary pattern was non-existent. These gender differences may be explained by differing dietary patterns when emotional eating occurs.

On the other hand, our findings demonstrated that a lack of cognitive reappraisal was independently directly related to greater energy-rich food consumption in girls. Thus, a lack of cognitive reappraisal, in contrast to a high level of suppression, appears to predict a differential energy-rich dietary pattern. In addition, a higher level of cognitive reappraisal was independently directly related to greater nutrient-dense food consumption in both genders (data not shown). Better ER strategy may possibly increase general feelings of efficacy, which could directly lead to healthier lifestyle (Wills, Pokhrel, Morehouse, & Fenster, 2011). However, the small effect sizes of cognitive reappraisal on nutrient-dense dietary pattern are found here that using Cohen's (1988) convention (correlation coefficients were showed in Table 3, for boys is 0.11 and for girls is 0.11), more studies are needed to replicate these findings and to better understand the relationship between cognitive reappraisal and nutrient-dense dietary pattern in adolescents. Finally, of note, higher BMI was assotiated with energy-rich dietary pattern in girls in this study. Previous studies relating dietary patterns and overweight have yielded conflicting results. For example, some investigations have shown few significant relationships between dietary patterns and overweight (Phillips et al., 2004; Forshee, Anderson, & Storey, 2008), however, some studies indicated the link between the more intake from energy-rich foods and overweight in children and adolescents (Paul, 2004; Malik, Willett, & Hu, 2009; Rosenheck, 2008; Taveras et al, 2005; Thompson et al., 2004). Given the eating frequency are difficult to define, especially in an adolescent population, interpretation of findings from dietary pattern research has proved difficult (Gatenby, 1997). Our study showed that higher BMI was related with energy-rich dietary pattern, although the positive relationship was significant only in girls, which suggests that the consumption of more energy-rich foods as an eating behavior possibly associated with the risk of becoming overweight, at least in Chinese adolescents girls.

To our knowledge, this is the first study to indicate that suppression is a critical maladaptive ER strategy linked to emotional eating in both genders, and an energy-rich dietary pattern in girls. Moreover, the results suggest that a higher level of suppression may put adolescents at a risk of emotional eating, which may then influence energy-rich food consumption, especially in girls. Future studies need to include a more accurate evaluation of dietary intake, such as 24-h dietary records, for a better understanding of these associations and gender differences. Limitations of the questionnaires should be considered. Given the variety of foods in the Chinese diet and potential difficulty for younger adolescents to recall portion size of foods they may have consumed several days before, the FFQ is designed so that interviewees can provide answers as easily as possible. Subsequently, the FFQ is limited with respect to variability of food consumption. Furthermore, the DEBQ has many questions on intention to eat in potential situations (e.g., “do you have more appetite in that situation”) as opposed to the

factual act of eating. In addition, the cross-sectional nature of the present data precludes such conclusions and longitudinal studies are needed to investigate causal process. All variables were self-reported and a complementary assessment of objective measures is desirable. Finally, the participants were racially and economically homogenous and live in close proximity to fast/convenience-food retail sources, which precludes the generalizability of these findings to diverse populations.

5. Conclusions

In conclusion, our study provided epidemiological evidence that a higher level of suppression may put adolescents at a risk of emotional eating. However, a higher level of suppression or a lack of cognitive reappraisal were independently associated with a greater intake of energy-rich foods only in girls. More importantly, our path model confirmed that the mediating effect of emotional eating could be a factor explaining the association between suppression and energy-rich food consumption in girls. Our research suggested that it is important to reduce maladaptive ER strategies and encourage adaptive ER strategies to improve the mental health and decrease the unhealthy diet of Chinese adolescents, especially girls. However, additional cohort studies are needed to confirm the causal effects of ER on specific dietary patterns, and their possible neuropsychological mechanisms.

Conflict of interest

The authors declare that there are no conflicts of interest.

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