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ORIGINAL ARTICLE

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Identification of several eating habits that mediate the association between eating behaviors and the risk of obesity

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Abstract

Objective: Eating behaviors play important roles in the development of obesity. A better knowledge of the psychological aspects of eating behaviors in individuals with and without obesity and their consequences on daily eating and lifestyle habits would be informative. The Three-Factor Eating Questionnaire (TFEQ)-R21 assesses the psychometrics of eating behavior. The objectives of the study were to establish which eating habits were or were not associated with TFEQ eating behaviors, and to quantify the extent to which those eating habits mediated the association between TFEQ eating behaviors and obesity risk.

Methods: Data were obtained from the Gene and Environment Case-Control Obesity Study from northern France. It included 2237 individuals with obesity and 403 individuals without obesity. Eating behaviors were assessed according to the TFEQ-R21. Two activity levels (physical activity and television watching) and six eating habits (e.g., plate size, having one serving or at least two servings of the main meal, …) were evaluated. Regression and mediation analyses were performed.

Results: Higher cognitive restraint, higher uncontrolled eating (UE) and higher emotional eating (EE) were associated with a higher risk of obesity, independently of each other and of age, sex, socio-economic status and physical activity. Cognitive restraint was negatively associated with having at least two servings, while UE and EE were associated with several obesogenic habits such as eating in front of the television or eating at night. Each of these obesogenic habits mediated between 3% and 20% of the association between UE or EE and obesity.

Conclusions: Psychological eating behaviors were associated with several lifestyle and eating habits in both individuals with and without obesity. Moreover, some eating habits partially mediated (between 3% and 20%) the association between TFEQ eating behaviors and obesity risk. For clinicians, this study shows that simple, easy-to-ask questions on specific daily eating habits can provide essential information to better understand and manage patients with obesity.

KEYWORDS
activity level, eating behavior, eating habits, mediation, obesity

1 | INTRODUCTION

Eating behavior is a broad term that encompasses food choice and motives, feeding practices, dieting, and eating-related problems. To better understand interactions between eating and obesity, a better knowledge of the psychological aspects of eating behaviors and their consequences on daily eating habits would be helpful.

Questionnaires have been developed to measure the psychometrics of eating behavior. The Three-Factor Eating Questionnaire (TFEQ)-R21 is a tool that helps distinguish cognitive restraint (CR, corresponding to an individual's concern over weight control, which tends to restrict eating and prevent weight gain), uncontrolled eating (UE i.e., eating more than usual due to a loss of control over intake), and emotional eating (EE i.e., over-eating in response to negative emotions).[1] The TFEQ traits are often associated with an individual's body mass index (BMI), but the results are not always consistent. For example, in the study of Löffler et al, higher scores in UE, EE and CR were significantly associated with higher BMI values in a large general population sample.[2] However in a longitudinal study conducted in a general population sample, it was shown that the association between CR differed between people with and without obesity, CR being positively associated with BMI in subjects with normal weight whereas it was not in people with overweight.[3]

In a general population sample, eating behavior was associated with different eating patterns, that is, UE was associated with higher energy intake and CR with higher consumption of healthy foods and lower energy intake.[4] Most longitudinal studies assessing the association between CR and body weight were conducted during weight reduction programs,[5–7] rather than in general population samples. Indeed, a study in healthy men and women showed that restrained eating prevented an increase in energy intake and body weight over a 6 month period.[7] Another study by McGuire et al. showed in adults with overweight that an increase in restraint over a 3 years follow-up period was related to decreases in body weight and energy intake.[6]

It has been shown that large portion sizes,[8–10] use of a large plate,[11] a low level of physical activity[12] and sedentariness[13,14] are habits associated with a greater risk of obesity. Pigeyre et al. also described that eating in a large plate and eating at night were habits mediating the association between socio-economic status and obesity risk.[11] McGuire et al. also showed in the same previous study that the increase in restraint was related to decreases in television watching, and increases in self-weighing and physical activity.[6]

In this work, a case-control study on obesity was used to explore the associations between the TFEQ eating behavior scores and six daily eating habits (plate size, the number of servings, the reasons for stopping eating, and eating in front of the television, standing up, or at night) and two activity levels (physical activity and television watching) in individuals with and without obesity. The secondary objective was to quantify these relationships, if any, by performing a mediation analysis.

2 | MATERIALS AND METHODS

2.1 | Study design

The Gene and Environment Case Control Obesity Study (GECCOS) included 2237 patients with obesity being monitored at Lille University Medical Center (Lille, France) and 403 participants with no obesity recruited at a health education center (*Centre de Prévention et d'Education pour la Santé*, Institut Pasteur de Lille, Lille, France) between 2008 and 2011. The main inclusion criteria for individuals with obesity were age 18 or over and a BMI $\geq$ 30 kg/m^2. For individuals with no obesity, the inclusion criteria were age 18 or over, a BMI $<$ 30 kg/m^2, a stable body weight (no more than a 3 kg variation in the previous 6 months), and the absence of weight gain/loss of more than 10 kg in adulthood (other than during pregnancy). The protocol was approved by the local investigational review board (*CPP Nord Ouest IV*; reference: CP05/63). All participants provided their written, informed consent.

2.2 | Eating behaviors

The Three-Factor Eating Questionnaire (TFEQ) is a self-assessment scale which was first developed in response to psychometric problems. It included 51 items and generated three scales: restraint, hunger and disinhibition.[15] Different studies could not replicate the factor structure of this questionnaire and a shortened revised 18-item version was constructed and developed three scales: CR, UE and EE.[16] The TFEQ R18 was later refined by adding three additional items to the EE domain which led to the TFEQ R21 version,[1] that was used in the present study. For the TFEQ scores, means were computed for each subscale (as long as at least half of the items have been answered) and were transformed to correspond to a 0–100 scale score.[4] In addition, several questions were asked to participants in order to assess the following eating habits: plate size used (ordinary vs. deep or large plate), the number of servings of the main meal (one portion or at least two portions), the reasons for stopping eating (being not hungry anymore, having a feeling of gastric fullness, or having an empty plate/dish), and whether or not the participants were eating in front of the television, standing up or at night (never vs. sometimes/always).

2.3 | Socio-economic status

A previously validated socio-economic score (SES; ranging from 0 to 40)[11,17] was calculated from the occupational activity, educational level, and income. Occupational activity was categorized in eight

groups, according to the French National Institute of Statistics and Economic Studies' (INSEE) nomenclature: (i) farmers (contributing 10 points to the SES); (ii) craftspeople, tradespersons and general managers (10 points); (iii) senior managers and higher/intellectual professions (0 points); (iv) mid-level professions (5 points); (v) clerical and service staff (5 points); (vi) manual workers (5 points); (vii) retirees (10 points); and (viii) other people with no professional activity (10 points). Ten points were attributed to unemployed individuals and individuals with missing data. The educational level was coded into five categories as follows: no formal education or primary school education only (10 points in the SES score); junior high (10 points); high school (5 points); a 2-year college degree (5 points); and a 3-year college degree or higher (0 points). Personal and household monthly incomes were each coded separately into four classes as follows: <€800 (10 points in the SES score); €800–€1300 (8 points); €1300–€2700 (5.5 points); and >€2700 (0 points). Five points were attributed to individuals with missing data for the educational level or the personal/household income.

The number of points for each category was summed, and individuals were then categorized into three SES groups: high (score 0–20, coded as "0"), intermediate (score 21–30, coded as "1"), and low (score 31–40, coded as "2").

2.4 | Activity level

Time spent in front of the television was an average daily time, expressed in hours per day. The evaluation of the average leisure, sport and everyday activities was performed using the validated Ricci-Gagnon self-questionnaire[18]; the score ranged from 5 (inactive) to 40 (very active).

2.5 | Clinical data

Body weight was measured in light clothes with electronic scales. Height was measured barefoot and with the head positioned in the Frankfurt plane, using a height gauge. Obesity was defined as a BMI above 30 kg/m^2.

2.6 | Statistical analysis

With the exception of the obesity risk and mediation analyses, all statistical analyses were performed separately in individuals with and without obesity. In Table 1, the two groups were compared with regard to descriptive, socio-economic, lifestyle and eating variables. A chi-squared test was applied to categorical variables. A Student's test or a Wilcoxon test was applied to quantitative variables. Correlation between eating behaviors (CR, UE and EE scores) and the continuous BMI was assessed with a Spearman test (Table 2). Logistic regressions were also performed in the two groups separately, in order to calculate the risk of presenting a given eating habit associated with a 25-point increase in the CR, UE or EE scores (Figure 1 and Table S1). Interaction with obesity was tested in the whole study by adding an interaction term in the model. A regression analysis with a general linear model was applied to quantitative variables and adjusted for age, gender, and SES (Table S2). For the risk of obesity, a logistic regression analysis was performed in the two groups combined, and the analysis was adjusted for age, gender, SES, physical activity ± TFEQ scores (Table 3). Mediation analyses were based on Sobel and bootstrap tests. Path [a] refers to the associations between a 25-point variation in CR, UE or EE behavior scores and potential mediators; Path [b] refers to associations between potential mediators and the obesity risk; Path [c] refers to the total effect of CR, UE or EE score variations on the risk of obesity. Path [c'] refers to the direct effect of the behavior score variations, adjusted for the mediators. The bootstrap method was used to estimate the proportion mediated (package "mediation"). In all analyses, the threshold for statistical significance was set to $p \leq 0.05$. Data were analyzed using the "sas7bdat", "lm.beta", "questionr", "Kendall", "tableone", and "prettyR" packages in R Studio (version 4.0.1, R Foundation for Statistical Computing, Vienna, Austria).

3 | RESULTS

3.1 | Description of sociodemographic, lifestyle and eating behaviors as a function of obesity status

The sociodemographic, lifestyle and eating behavior data for the 2237 participants with obesity and the 403 participants without obesity are summarized in Table 1. Relative to the group without obesity, the group with obesity was 3 years older ($p < 0.0001$) and included a higher proportion of females (76.7% vs. 81.4%, respectively, $p < 0.05$). Individuals with obesity had a significantly lower educational level ($p < 0.0001$) and a lower SES ($p < 0.0001$) than the participants without obesity. The three TFEQ eating behavior scores were all significantly higher ($p < 0.0001$) in participants with obesity than in participants with no obesity; in particular for EE. With regard to eating habits, the proportion of participants using a large plate or who had at least two servings was twice as high in the group with obesity as in the group without obesity. The two groups also differed significantly ($p < 0.0001$) in terms of the reasons for stopping eating: gastric fullness or having an empty plate/dish were more frequently mentioned by participants with obesity than by participants without obesity. Lastly, participants with obesity were more likely to eat in front of the television ($p = 0.01$) or at night ($p < 0.0001$) than participants without obesity.

TABLE 1 Demographic, socio-economic, lifestyle and eating habits by obesity group in the Gene and Environment Case Control Obesity Study (GECCOS) population

	Individuals without obesity (n = 403)		Individuals with obesity (n = 2237)		
	n	Mean ± SD or %	n	Mean ± SD or %	P value
Age (years)	403	39.5 ± 11.6	2234	42.7 ± 13.5	**<0.0001**
Females	309	76.7	1823	81.4	**<0.05**
BMI (kg m^2)	401	22.4 ± 2.5	2237	41.2 ± 7.7	**<0.0001**
Family history of diabetes or obesity					
Yes (%)	180	46.6	815	83.0	**<0.0001**
Socio-economic variables					
Family situation					
Single	131	32.6	585	28.7	0.16
Separated or divorced	53	13.2	300	14.7	
Married	211	52.5	1083	53.2	
Widow(er)	7	1.7	69	3.4	
Living alone (yes)	75	18.6	409	19.9	0.55
Educational level					
No formal education or primary school education only	19	4.7	350	17.4	**<0.0001**
Junior high	86	21.4	729	36.3	
High school	61	15.2	362	18.0	
A 2-year college degree	97	24.1	263	13.1	
A 3-year college degree or higher	139	34.6	305	15.2	
Socio-economic status					
High (score 0–20)	189	46.9	595	27.2	**<0.0001**
Intermediate (score 21–30)	159	39.5	894	40.9	
Low (score 31–40)	55	13.7	696	31.9	
Three-factor eating questionnaire					
Uncontrolled eating score	403	24.6 ± 17.2	2128	39.4 ± 23.3	**<0.0001**
Emotional eating score	403	26.4 ± 23.8	2130	52.7 ± 30.1	**<0.0001**
Cognitive restraint score	403	34.0 ± 19.5	2129	39.7 ± 19.1	**<0.0001**
Eating habits					
Plate size					
Normal	340	86.3	1240	73.5	**<0.0001**
Large or deep	54	13.7	448	26.5	
Number of servings					
One	346	86.5	795	73.4	**<0.0001**
At least two	54	13.3	288	26.6	
Reason for stopping eating					
I am not hungry anymore	200	50.9	342	32.2	**<0.0001**
My stomach is full	48	12.2	288	27.1	
My plate/dish is empty	145	36.9	432	40.7	
Eating in front of the TV					
Yes	261	64.9	201	74.2	**0.01**

TABLE 1 (Continued)

	Individuals without obesity (n = 403)		Individuals with obesity (n = 2237)		
	n	Mean ± SD or %	n	Mean ± SD or %	P value
Eating at night					
Yes	24	6.1	57	22.2	**<0.0001**
Eating while standing up					
Yes	97	24.2	65	24.8	0.86
Activity level					
Physical activity score (continuous variable)	403	18.3 ± 7.0	2151	13.8 ± 7.6	**<0.0001**
Watching television (h/day during the week and the weekend)	399	2.4 ± 1.7	1608	4.1 ± 2.5	**<0.0001**

Abbreviation: BMI, body mass index.

Significant p values are indicated in bold type.

TABLE 2 Correlation analyses between Three-Factor Eating Questionnaire (TFEQ) scores and the continuous BMI in individuals with and without obesity

	Individuals without obesity			Individuals with obesity		
	CR score n = 403	UE score n = 403	EE score n = 403	CR score n = 2129	UE score n = 2128	EE score n = 2130
BMI kg/m^2	0.30****	0.09	0.06	−0.06**	−0.02	0.07**
CR score	-	0.16**	0.26***	-	−0.02	0.06**
UE score	-	-	0.52***	-	-	0.63***

Abbreviations: CR, cognitive restraint; EE, emotional eating; UE, uncontrolled eating.

**$p < 0.01$, ****$p < 0.0001$.

With regard to activity level, participants with obesity had a lower physical activity score ($p < 0.0001$) and spent more time watching television during the day ($p < 0.0001$) than individuals without obesity.

3.2 | Correlation analyses

In individuals without obesity, there was a significant low correlation between CR and the BMI (rho = +0.30, $p < 0.0001$; Table 2). Furthermore, EE was two times more correlated with UE (rho = +0.52; $p < 0.0001$) than with CR (rho = +0.26; $p < 0.0001$).

Among individuals with obesity, the TFEQ eating behaviors were not correlated with BMI (rho < 0.10) but there was a moderately high correlation between EE and UE (rho = +0.63, $p < 0.0001$).

3.3 | Association between cognitive restraint and eating habits

A 25-point increase in the CR score was not associated with any eating habits in individuals without obesity, with the exception of having an empty plate or an empty dish as the reason for stopping eating (vs. not being hungry anymore; OR [95% CI] = 1.4 [1.02–1.81]; p for interaction with obesity <0.05; Figure 1 and Table S1). In contrast, a 25-point increase in the CR score in participants with obesity was associated with a lower risk of having at least two servings (OR = 0.68 [0.56–0.82]), stopping eating because of gastric fullness versus not being hungry anymore (OR = 0.76 [0.61–0.81]) and eating in front of the television (OR = 0.66 [0.47–0.92]; p interaction with obesity <0.05).

3.4 | Association between uncontrolled eating and eating habits

A 25-point increase in UE score was associated in both participant groups with nearly all obesogenic eating habits explored that is, having at least two servings, stopping eating because the plate was empty instead of not being hungry anymore, eating at night and standing up (Figure 1 and Table S1). A 25-point increase in UE score was associated with the habit of eating in a large plate instead of a normal plate size and stopping eating because of gastric fullness instead of not being hungry anymore in individuals with obesity only (OR = 1.37 [1.24–1.54] and OR = 2.27 [1.87–2.75], respectively). Last, a 25-point increase in UE score was associated with eating in front of the television in individuals without obesity only (OR = 1.62 [1.15–2.33]).

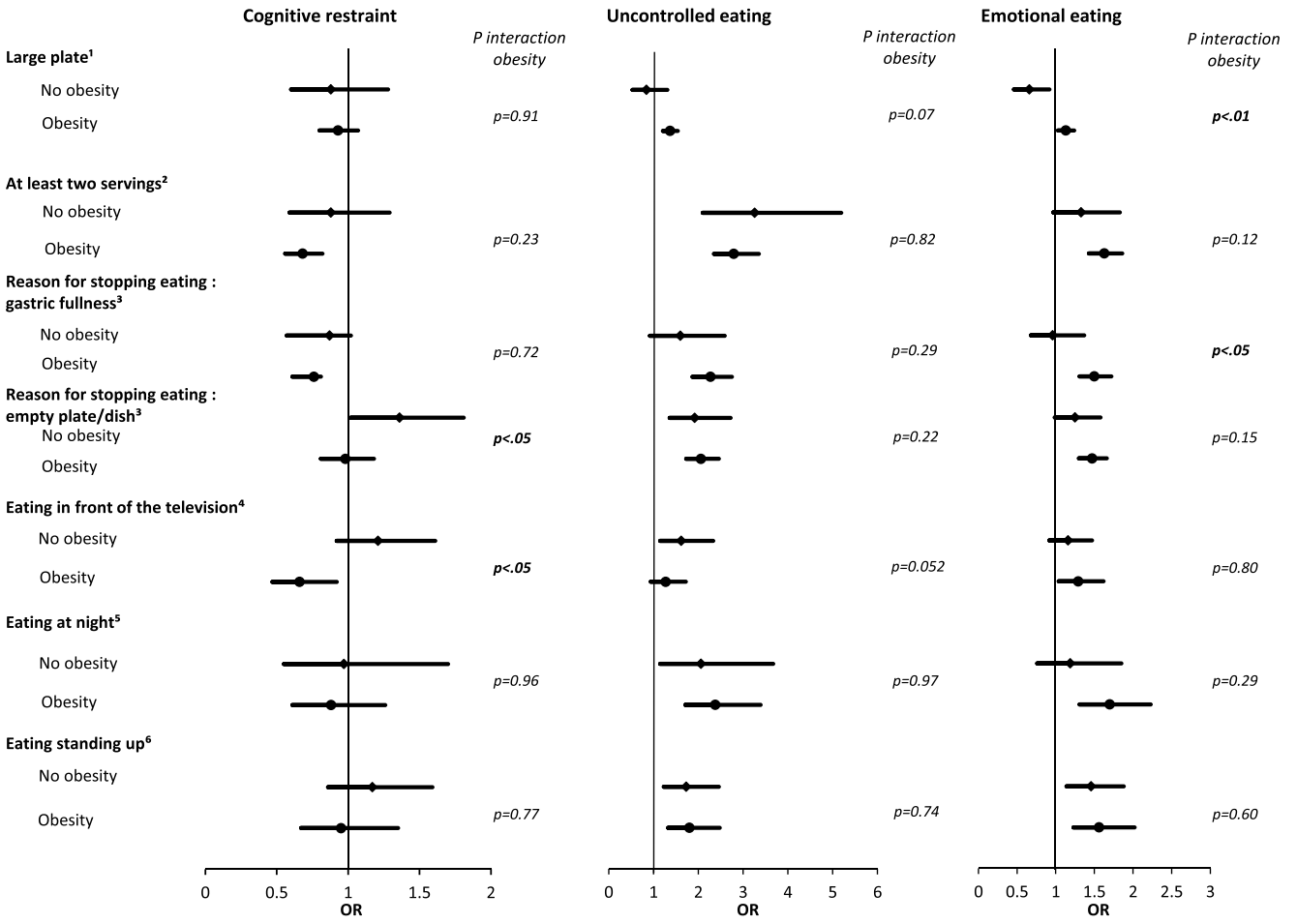

FIGURE 1 Odds ratios [95% confidence interval] for eating habits and a 25-point variation in the cognitive restraint (CR), uncontrolled eating (UE) and emotional eating (EE) scores in the GECCOS population. [1]versus normal plate; [2]versus one serving; [3]versus being not hungry anymore; [4]versus not eating in front of the television; [5]versus not eating at night; [6]versus not eating standing up. The ORs were adjusted for age, sex and socio-economic status. Significant *p* values are indicated in bold type

TABLE 3 Odds ratios of obesity

		Crude OR		Model 1[a]		Model 2[b]	
		OR [95% CI]	*P value*	OR [95% CI]	*P value*	OR [95% CI]	*P value*
Age (years)	*n = 2637*	1.02 [1.01–1.03]	**<0.0001**	-	-	-	-
Sex (male)	*n = 508*	0.75 [0.58–0.97]	**<0.05**	-	-	-	-
High SES	*n = 784*	0.56 [0.44–0.71]	**<0.0001**	-	-	-	-
Low SES	*n = 751*	2.3 [1.6–3.1]	**<0.0001**	-	-	-	-
Physical activity score	*n = 2554*	0.93 [0.91–0.94]	**<0.0001**	-	-	-	-
CR, 25-point variation	*n = 2532*	1.49 [1.29–1.71]	**<0.0001**	1.54 [1.33–1.80]	**<0.0001**	1.31 [1.12–1.54]	**<0.0001**
UE, 25-point variation	*n = 2531*	2.23 [1.95–2.57]	**<0.0001**	2.39 [2.05–2.79]	**<0.0001**	1.25 [1.03–1.52]	**<0.05**
EE, 25-point variation	*n = 2533*	2.16 [1.95–2.40]	**<0.0001**	2.34 [2.09–2.63]	**<0.0001**	2.05 [1.78–2.37]	**<0.0001**

Abbreviations: SES, socio-economic score; CR, cognitive restraint; UE, uncontrolled eating; EE, emotional eating; *n*, sample size.

[a]Adjusted for age, sex, SES and physical activity score.

[b]Adjusted for age, sex, SES, physical activity score and TFEQ traits.

Significant *p* values are indicated in bold type.

3.5 | Association between emotional eating and eating habits

In individuals with obesity, a 25-point increase in EE was associated with all eating habits: OR = 1.63 [1.43–1.86] for having at least two servings, 1.50 [1.31–1.72] for gastric fullness (p interaction with obesity status <0.05), 1.47 [1.30–1.66] for having an empty plate/dish as the reason for stopping eating, 1.29 [1.04–1.62] for eating in front of the television, 1.70 [1.31–2.23] for eating at night, and 1.56 [1.23–2.02] for eating standing up. Furthermore, a 25-point increase in EE was associated with a higher or a lower risk of eating in a large/deep plate instead of a normal plate among individuals with obesity and with no obesity, respectively (OR = 1.13 [1.03–1.24] and OR = 0.66 [0.46–0.92], respectively; p interaction with obesity = 0.01; Figure 1 and Table S1).

3.6 | Activity level with regard to eating behavior score

There was almost no association between TFEQ eating behaviors and physical activity in individuals without obesity. In contrast, in individuals with obesity, a 25-point variation in UE was associated with more time spent in front of the TV ($p < 0.001$) and less physical activity ($p < 0.01$; Table S2). In contrast, a 25-point increase in CR was associated with less time spent in front of the TV and more physical activity ($p < 0.0001$ for both; Table S2).

3.7 | Risk of obesity

Considering the whole study population, age was a risk factor for obesity (odds ratio (OR) [95% confidence interval (CI)] = 1.02 [1.01–1.03]; Table 3). Male sex and higher physical activity were associated with a lower risk of obesity (OR = 0.75 [0.58–0.97], $p < 0.05$ and OR = 0.93 [0.91–0.94], $p < 0.0001$, respectively). As previously reported in the literature, a low SES was associated with a higher risk of obesity (OR = 2.3 [1.6–3.1]; $p < 0.0001$) and a high SES was associated with a lower risk of obesity (OR = 0.56 [0.44–0.71]; $p < 0.0001$), relative to an intermediate SES. With regard to TFEQ behaviors, a 25-point increase in the CR, UE or EE score was significantly associated with a higher risk of obesity (OR = 1.49 [1.29–1.71]; $p < 0.0001$, OR = 2.23 [1.95–2.57]; $p < 0.0001$ and OR = 2.16 [1.95–2.40]; $p < 0.0001$, respectively). After adjustment for age, sex, SES, physical activity and considering the three TFEQ behaviors in the same model, a 25-point increase in the CR, UE or EE score remained strongly associated with the risk of obesity (OR = 1.31 [1.12–1.54]; $p < 0.0001$, OR = 1.25 [1.03–1.52]; $p < 0.05$ and OR = 2.05 [1.78–2.37]; $p < 0.0001$, respectively).

3.8 | Mediation analyses

Of the six variables tested, having at least two servings was identified as a competitive (protective) mediator (−14.2%, $p < 0.05$) in the association between the CR score and the risk of obesity (Table 4).

When considering the association between the UE score and the risk of obesity, the significant mediators were (i) eating in a large/deep plate (proportion mediated: 2.7%, $p < 0.0001$), (ii) having at least two servings (proportion mediated: 5.7%, $p < 0.05$), (iii) stopping eating when the plate is empty (proportion mediated: 6.7%, $p < 0.05$), (iv) stopping eating due to a feeling of gastric fullness (proportion mediated: 20.5%, $p < 0.0001$), and (v) eating at night (proportion mediated: 9.1%, $p < 0.0001$).

Lastly, the same eating habits, with the exception of eating in a large plate, were also mediators of the association between a variation in the EE score and the risk of obesity. The proportions mediated ranged from 3.1% (for stopping eating when the plate is empty) to 12.4% (for stopping eating due to a feeling gastric fullness).

4 | DISCUSSION

The present study described the association between psychological eating behaviors and eating habits as a function of obesity. These results confirmed that the level of CR, UE and EE were higher in individuals with obesity than in individuals without obesity. Interestingly, UE and EE were associated with obesogenic eating habits and activity level, and some of the associations with EE were more pronounced in individuals with obesity than in individuals without obesity. In contrast, CR was associated with healthier eating habits but in individuals with obesity only. To summarize, the risk of obesity associated with UE and EE was partly mediated by several obesogenic eating habits.

The CR, UE and EE behaviors were particularly marked in individuals with obesity and were positively and independently associated with obesity. These results are in line with cross-sectional studies[19–21] and longitudinal studies[2,6] having reported similar relationships between eating behaviors and BMI. In contrast, other studies did not observe a clear relationship between CR and obesity. e.g., in a French general population sample, restrained eating was strongly associated with adiposity in individuals with normal-weight but not in individuals with overweight.[3] In the present study, CR was not associated with any of the obesogenic eating habits explored; in fact, it was associated with a lower risk of "*having at least two servings of the main meal*" and of "*eating in front of the television*" in individuals with obesity only. Cognitive restraint was also associated with a higher level of physical activity in these individuals. Therefore, in this study, CR appeared to be associated with positive eating habits in individuals with obesity, maybe in order to prevent/limit further weight gain as described in a previous review.[22]

TABLE 4 Associations between a 25-point variation in each Three-Factor Eating Questionnaire (TFEQ) eating behavior score and potential mediators and the obesity risk

	Path a[b]		Path b[b,c]		Obesity risk, total effect (Path c[b])	Obesity risk, direct effect (Path c'[d])		Mediation ratio (%)
	OR [95% CI]	*p*-value	OR [95% CI]	*p*-value	OR [95% CI]	OR [95% CI]	*p*-value	
Potential mediators	**Cognitive restraint**							
Eating in a large/deep plate	0.95 [0.83–1.09]	0.50	-	-	-	-	-	-
Having at least two servings	0.78 [0.66–0.92]	**<0.01**	2.99 [2.15–4.23]	**<0.0001**	1.45 [1.25–1.69]	1.59 [1.35–1.87]	**<0.05**	−14.2
Stopping eating due to gastric fullness[a]	0.90 [0.75–1.08]	0.27	-	-	-	-	-	-
Stopping eating when plate/dish is empty[a]	1.15 [0.98–1.34]	0.09	-	-	-	-	-	-
Eating in front of the television	0.96 [0.78–1.19]	0.72	-	-	-	-	-	-
Eating at night	1.01 [0.76–1.36]	0.92	-	-	-	-	-	-
Eating while standing up	1.06 [0.85–1.33]	0.59	-	-	-	-	-	-
	Uncontrolled eating							
Eating in a large/deep plate	1.38 [1.22–1.55]	**<0.0001**	1.68 [1.21–2.35]	**<0.0001**	2.52 [2.17–2.94]	2.39 [2.04–2.79]	**<0.0001**	2.7
Having at least two servings	2.99 [2.55–3.51]	**<0.0001**	1.57 [1.10–2.27]	**<0.01**	2.52 [2.17–2.94]	2.11 [1.78–2.51]	**<0.05**	5.7
Stopping eating due to gastric fullness[a]	2.52 [2.10–3.03]	**<0.0001**	2.74 [1.87–4.05]	**<0.0001**	2.52 [2.17–2.94]	1.96 [1.56–2.48]	**<0.0001**	20.5
Stopping eating when plate/dish is empty[a]	2.09 [1.79–2.45]	**<0.0001**	1.40 [1.05–1.86]	**<0.05**	2.52 [2.17–2.94]	1.94 [1.62–2.35]	**<0.05**	6.7
Eating in front of the television	1.46 [1.19–1.82]	**<0.001**	1.25 [0.86–1.83]	0.24	-	-	-	-
Eating at night	2.71 [2.06–3.59]	**<0.0001**	2.89 [1.68–5.07]	**<0.001**	2.52 [2.17–2.94]	2.03 [1.63–2.56]	**<0.0001**	9.1
Eating while standing up	1.68 [1.36–2.08]	**<0.0001**	0.72 [0.47–1.08]	0.11	-	-	-	-
	Emotional eating							
Eating in a large/deep plate	1.14 [1.05–1.23]	**<0.01**	1.88 [1.35–2.62]	**<0.001**	2.38 [2.13–2.66]	2.34 [2.08–2.63]	0.14	2.5
Having at least two servings	1.70 [1.52–1.90]	**<0.0001**	1.77 [1.24–1.55]	**<0.01**	2.38 [2.13–2.66]	2.18 [1.93–2.47]	**<0.0001**	4.3
Stopping eating due to gastric fullness[a]	1.59 [1.41–1.80]	**<0.0001**	2.70 [1.84–2.01]	**<0.0001**	2.38 [2.13–2.66]	2.09 [1.78–2.46]	**<0.0001**	12.4
Stopping eating when plate/dish is empty[a]	1.46 [1.32–1.62]	**<0.0001**	1.36 [1.02–2.82]	**<0.05**	2.38 [2.13–2.66]	2.01 [1.77–2.30]	**<0.05**	3.1
Eating in front of the television	1.28 [1.10–1.48]	**<0.01**	1.22 [0.83–1.80]	0.31	-	-	-	-
Eating at night	1.84 [1.50–2.28]	**<0.0001**	3.04 [1.74–5.42]	**<0.001**	2.38 [2.13–2.66]	2.00 [1.70–2.37]	**<0.01**	6.5
Eating while standing up	1.42 [1.22–1.66]	**<0.0001**	0.69 [0.45–1.04]	0.08	-	-	-	-

[a]Versus not being hungry anymore.
[b]Adjusted for age, gender and SES.
[c]Adjusted for the TFEQ score.
[d]Adjusted for age, gender, SES and mediator.
Significant *p* values are indicated in bold type.

In contrast, UE and EE were both associated with several eating habits that lead to over-eating (i.e., *"number of servings"*, *"stopping eating when the plate is empty"*, *"eating at night"* and *"eating standing up"*). Although the type of association (i.e., mostly positive) was the same in the two groups, the associations with EE were much stronger in individuals with obesity than in individuals without. No straightforward explanation for these differences is known. However, EE has been linked to low distress tolerance[23]—a factor favoring higher responsiveness to emotional and external cues that in turn can elicit eating episodes—and a poorer-quality diet,[24] two features that can be favored in individuals with obesity. With regard to UE, associations with obesity status have been linked to three common underlying psychological traits: high reward sensitivity, low self-control, and high perceived negativity.[25] This might result in excess energy intake and thus an association with obesity. Lastly, EE was positively associated with an increase in BMI over 5 or 7 years in a Finnish population sample; the investigators interpreted the relationship as a possible link between depression and the development of obesity.[26,27] These psychological traits leading to inappropriate eating habits may be more pronounced in individuals with obesity than in individuals without obesity. Likewise, UE (but not EE) was associated with lower physical activity and more time spent in front of the television in both groups.

In order to explain the observed associations between TFEQ eating behaviors and obesity, the possible mediating role of several eating habits was tested. Interestingly, *"Having at least two servings during a meal"* was a competitive (protective) mediator of the relationship between CR and obesity; it accounted for around 14% of the association. The observation of this type of competitive mediation[28] suggests that a decrease in this eating habit among people with a high CR score may partially counter (and thus decrease) the risk of obesity. In addition, people with obesity frequently intend to eat healthier food and/or to eat less but do not succeed in doing so.[29]

In addition, most eating habits were partial mediators of the relationship between UE and EE scores and the risk of obesity—indicating that eating habits explain part of the obesity risk associated with UE and EE. As UE and EE are strongly correlated, it is not surprising to see the same habits associated with both behaviors. However, the fact that proportions mediated by the eating habits ranged from 3% to 20% suggests that other factors (alone or together) also have a role. In particular, socio-economic status,[11] other psychological factors and genetic susceptibility factors[19] might be involved. Results of this study highlighted the contrast between CR on one hand and UE and EE on the another.

The present study had several strengths, including its design, the large number of individuals with obesity, and the many everyday eating habits investigated. The study had limitations, such as the enrollment of participants in different contexts (hospital recruitment vs. the general population, respectively). However, this can also be viewed as a strength because our data may provide a broader understanding of eating habits. Although far fewer individuals without obesity than participants with obesity were included, significant associations were nevertheless detected in the former group. Furthermore, the study design prevented the establishment of causal relationships, and so further investigation is required. Lastly, the use of the mediation model was limited by the strong assumption whereby one variable has a causal effect on another; nevertheless, the literature data on eating behavior, eating habits and obesity support its model.[10,13,14,18,19,30,31]

In conclusion, the present study identified a number of lifestyle and eating habits associated with psychological eating behaviors in individuals with and without obesity. Some of these associations were more pronounced in individuals with obesity. Furthermore, some of the eating habits partially mediated the association between psychological eating behaviors and the risk of obesity. The present results suggest that CR elicits positive eating habits (such as the number of servings) that may prevent or at least limit weight gain in individuals with obesity. This study is the first to investigate the associations between well-studied eating behaviors in obesity research (but largely unknown to clinicians), and eating habits that clinicians can explore with easy-to-ask questions. The identification of the eating habits that mediate the association between TFEQ eating behavior and obesity risk could give to clinicians an indication of the factors to focus on in priority for the management of obesity and thus in order to initiate change more gradually and effectively.

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CONFLICT OF INTEREST

The authors declared no conflict of interest.

AUTHOR CONTRIBUTIONS

Estelle Aymes performed literature search, analyzed data and wrote the manuscript. Gabrielle Lisembard performed literature search, analyzed data and interpreted data. Jean Dallongeville interpreted data and wrote the manuscript. Julien Rousseaux and Marie-Pierre Dumont collected data. Philippe Amouyel designed the study. Monique Romon designed the study, collected data, interpreted data and wrote the manuscript. Aline Meirhaeghe designed the study, interpreted data and wrote the manuscript. All authors had final approval of the submitted and published versions.

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SUPPORTING INFORMATION

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