How eating behaviours associate to body composition in European adolescents: a cross-sectional analysis from the HELENA Study.

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ABSTRACT:

Background: Adolescence is a key developmental stage marked by physiological and behavioural changes. Eating behaviour, modifiable and sex-dependent, may be altered and linked to future health issues. This cross-sectional study aims to assess whether eating behaviours and body composition are associated in an adolescent sample.

Methods: Participants aged 12.5-17.5 years were recruited from 10 European cities, with valid data on age, sex, socio-demographic status, body composition and physical activity and who had also completed the specific eating behaviour questionnaire "Eating Behaviour and Weight Problems Inventory for Children". Different linear regression models were adjusted for relevant confounders, and ANCOVA models were performed.

Results: Eating Behaviours related to weight concerns, dietary restraint, emotional eating, fear of weight gain, healthy nutrition and figure dissatisfaction were strongly positively associated with higher Body Mass Index (BMI), Fat Mass Index (FMI) and Waist Circumference (WC), especially in males (betas resulting from the association between these behavioural subscales and body composition in males, ranged from 0.174 to 0.974 for BMI, 0.172 to 0.930 for FMI, and 0.128 to 0.889 for WC). The strongest association was detected in the weight concerns subscale for both males and females.

Conclusion: Eating behaviours across all domains are significantly linked to body composition, with variations depending on the specific behavioural domain and the adolescent's sex. These findings are critical for identifying specific behavioural patterns that contribute to obesity and related health issues, providing new insights for more targeted prevention strategies during this crucial stage of development.

KEYWORDS: Eating behaviour, body composition, sex-differences, adolescents, obesity.

1. INTRODUCTION

Childhood and adolescent obesity are major public health challenges, with global obesity rates in this population increasing tenfold in the past four decades (1). Excess weight in adolescence strongly predicts adult obesity and increases the risk of metabolic diseases and related morbidity (2). Obesity's multifactorial causes include modifiable lifestyle factors like eating habits (3) which are formed in childhood and continue to develop in adolescence. Healthy habits during this period can ensure long-term health (4).

Eating behaviour refers to how individuals relate to the act of eating, encompassing the patterns and habits involved in choosing, consuming, and interacting with food (5, 6). It is shaped by a complex interplay of biological, psychological, and socio-cultural aspects such as emotional state, and personal experiences (7). This may influence an individual's energy intake (8)—that was extensively studied—and the choice of one food over another, which has received more recent attention (9). Eating behaviours are increasingly recognized as key determinants of obesity, as they shape both the quantity and quality of food consumed (10). Understanding how these behaviours relate to body composition during adolescence is particularly important, as this developmental stage is marked by rapid physical and psychological changes that may influence long-term health trajectories (11).

Various tools are used to assess eating behaviour (12, 13), mostly in children and adults often to predict eating disorders and weight-related issues (14). However, at the time of the HELENA study, very few validated instruments were specifically designed for adolescents, although more have emerged in recent years (15, 16). The "Eating Behavior and Weight Problems Inventory for Children" (EWI-C) was developed with data from 966 German students aged 11-16. It allows measuring different subscales that make eating

behaviour, addressing relevant issues in the diagnosis and treatment of obesity in adolescents (17). These subscales include not only eating-related behaviours, but also parenting food practices, body image, and attitudes toward obesity or nutrition, offering a broader psychosocial perspective. These dimensions have been shown to influence adolescents' eating patterns and weight-related outcomes (18-20). Additionally, the EWI-C assesses other behavioural aspects such as food cue responsiveness, emotional eating, weight concerns or dietary restraint, which reflect different psychological and environmental influences on food intake (17). Emotional eating and dietary restraint, for instance, have been linked to increased energy intake and disinhibited eating patterns (21, 22). Furthermore, a previous study using the EWI-C questionnaire showed significant associations between behavioural subscales, such as food cue responsiveness, and increased consumption of high-energy-dense foods (23), which is also related to increased weight and body fat (24). Together, these subscales provide a comprehensive framework for understanding the multifaceted psychological, emotional, and attitudinal factors related to eating and their association with body composition in adolescents.

Evidence on sex and gender differences in psychological and attitudinal factors related to eating during adolescence is also scarce. Sexual characteristics contribute to variability in eating disorders and obesity prevalence (25), with previous studies noting sex differences in eating behaviours in preschool and school-aged children (26). Most of these studies show that females are more concerned with healthy eating and body image (27).

Several studies have examined the association between eating behaviours and body composition in school-age children (28), but few have focused on adolescents or used multiple adiposity indicators beyond body mass index (BMI). Socio-economic status (SES) and physical activity (PA) are important factors related to both body composition and eating behaviours. Lower SES has been associated with higher adiposity and less

126 healthy eating patterns, potentially due to reduced access to nutritious foods, limited
127 nutritional knowledge, and lifestyle constraints that promote the consumption of energy-
128 dense foods and lower intake of fruits and vegetables (29-31). Similarly, lower levels of
129 PA are linked to higher fat mass and lower muscle mass (32), and less healthy eating
130 patterns (33). However, despite their relevance, few studies have explicitly accounted for
131 SES and PA as potential confounders when examining the relationship between eating
132 behaviours and body composition in adolescents.
133 Therefore, the aim of the present study was to assess whether eating-related psychological
134 and attitudinal constructs and body composition are associated in adolescents and to
135 identify potential differences in these associations according to their sex. Authors
136 hypothesized that food approach behaviours, such as weight concerns, dietary restraint
137 and emotional eating, would be positively associated with body composition indicators
138 in adolescents, and that these associations would differ by sex, even after adjusting for
139 socio-economic status and physical activity.

140 ## 2. METHODS

141 ### 2.1 Study design and population.

142

143 The HELENA study (Healthy lifestyle in Europe by Nutrition in Adolescence), a
144 multicentre and cross-sectional study, was conducted in 2007-2008 to obtain standardised
145 and reliable data on the nutritional status of adolescents aged between 12.5 and 17.5 years
146 in 10 European cities: Athens (Greece), Dortmund (Germany), Gent (Belgium),
147 Heraklion (Crete), Lille (France), Pecs (Hungary), Rome (Italy), Stockholm (Sweden),
148 Vienna (Austria), Zaragoza (Spain). Eligibility criteria included adolescents not
149 participating in another study simultaneously as well as being free of any acute infection
150 of duration at least 1 week before. A total of 3,528 adolescents were included in this study

(34). The study protocol was approved by the relevant ethics committees of each participating city and followed the ethical guidelines of the Declaration of Helsinki 1964 (revision of Edinburgh 2000), the Good Clinical Practice and the legislation about clinical research in humans (35). Participants and their parents signed written informed consent. As shown in Figure 1, the final sample of the present study included 2,059 adolescents (55,3% female) with valid age, sex, and sociodemographic status data. They were also required to have valid data on body composition and complete the specific questionnaire on eating-related psychological and attitudinal constructs (EWI-C). In addition to the above, valid data on objectively measured moderate-vigorous physical activity (MVPA) was used as a covariable. The flow chart shows the selection process of the participants for the present study (Fig 1).

2.2 EWI- C questionnaire

Eating-related psychological and attitudinal constructs were assessed using the EWI-C questionnaire, designed and validated for adolescents (17). It was originally available in German and English language, however, it was later translated and culturally adapted to every language spoken in the countries included in the HELENA study (36). This instrument was selected based on its validation status and availability at the time of data collection, prior to the development of newer tools. The EWI-C consists of 60 questions assigned to 10 subscales. 1, Strength and motivation to eat: evaluates the internal drive and desire to eat (e.g., "If I see someone else eating, I start to feel hungry, even if it isn't time to eat."). 2, Importance and impact of eating: measures how eating influences daily life and emotional well-being ("I feel particularly comfortable after I have eaten."). 3, Eating as a means to coping with emotional stress: explores the use of food to manage negative emotions ("Eating makes it easier for me to overcome disappointments."). 4, Problems concerning eating and weight: identifies concerns about eating habits and body

weight ("I am constantly aware that I weigh too much."). 5, Dietary restraint: assesses efforts to control food intake, often for weight reasons ("I do not eat certain foods because they are fattening."). 6, Attitude toward healthy nutrition: reflects beliefs about healthy eating ("I make sure that I eat as many healthy foods as possible."). 7, Attitude toward the obese: examines biases or stereotypes toward individuals with obesity ("I do not like fat people."). 8, Parental pressure to eat: measures perceived pressure from parents regarding eating ("My parents always insist that I eat everything on my plate."). 9, Fear of gaining weight: captures anxiety about weight gain ("After eating I worry that I will get fat.") and 10, Figure dissatisfaction: assesses dissatisfaction with body image ("I think my thighs are too fat."). The questions have four defined response categories which were assigned values from 1 to 4: 1-Does not apply at all; 2-Seldom applies; 3-Occasionally applies; and 4- Always applies (17).

To calculate the total score for each subscale, the mean of all item responses within that subscale for each participant was computed. This approach provides an overview of the sample's scores across the different domains of eating-related psychological and attitudinal constructs.

To simplify the name of the subscales and making the article more readable, we propose abbreviated names that are displayed in Table 1.

Table 1. Equivalence in the name of the EWI questionnaire subscales.

Original subscale name	Abbreviated subscale name
EWI 1: Hunger level and susceptibility to food cues.	Food cue responsiveness
EWI 2: Importance and impact of eating on sense of well-being.	Well-being nutrition
EWI 3: Eating as a means of coping with emotional stress.	Emotional eating
EWI 4: Concerns about eating and weight.	Weight concerns
EWI 5: Dietary restraint.	Dietary restraint

EWI 6: Attitude toward healthful nutrition.	Healthy nutrition
EWI 7: Attitude toward the obese.	Obesity perception
EWI 8: Pressures to eat from parents.	Parental pressure
EWI 9: Fear of weight gain.	Weight gain fear
EWI 10: Figure dissatisfaction.	Figure dissatisfaction

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197 2.3 Anthropometric measurements

198 A team of trained professionals measured the participants' weight (kg) and height (m)
199 according to standardized methods (37). A stadiometer (SECA 225, SECA, Hamburg,
200 Germany) was used to determine height (accuracy of 0.1 cm). An electronic scale with an
201 accuracy of 0.1 kg (SECA 861, SECA, Hamburg, Germany) was used to measure weight.
202 The body mass index (BMI) was calculated by dividing body weight (kg) by height
203 squared (m^2), and participants were classified according to their age and sex as having
204 underweight, normal weight, overweight, or obesity, using the cut-off points suggested
205 by Cole et *al*. (38). Body fat percentage was calculated from skinfold thickness
206 measurements using the Slaughter's equation (39). Fat mass index (FMI) was calculated
207 by dividing fat mass (kg) by height squared (m^2), this index adjusts for body size similarly
208 to the method used for BMI. Fat-free mass index (FFMI) was calculated by dividing lean
209 mass (kg) to height (m^2). Waist circumference (WC) measurements were performed three
210 consecutive times with a non-elastic tape (SECA 200, SECA, Hamburg, Germany) to the
211 nearest 0.1 cm at the midpoint between the lower rib and the iliac crest (40). For BMI z-
212 score calculation, the reference values of Cole et *al*. were used (38). For WC, FMI and
213 FFMI z-score cut-off points were established according to the studied sample itself.

214

215 2.4 Sociodemographic characteristics

216 Demographic characteristics of the participants and information on age and sex were
217 collected using a general questionnaire. A modified version of the Family Affluence Scale

(FAS) was used in this study, a valid indicator to measure the socio-economic status and material circumstances of adolescents (41). A score of 0-2 reflects low family wealth, 3-5 medium family wealth and 6-8 high family wealth, so participants were grouped into 3 categories: low, medium, or high socio-economic status. FAS has been included as a covariate in the analyses due to its potential influence on both eating behaviours and body composition in adolescents.

2.5 Physical Activity

Physical activity was included as a covariate in the analyses due to its relevance across all stages of life (42) and its potential influence on body composition (43, 44), particularly during adolescence. The GT1M monitor (ActiGraph©, Pensacola, FL, USA) was used to assess adolescents' physical activity levels. The process for using this device and data collection has been previously described (45). After downloading the data, they were expressed as mean physical activity in counts per minute. At least 3 days of recording with a minimum of 8 or more hours of recording per day were necessary for the adolescent to be included in the analysis. Moderate-vigorous physical activity (MVPA) variable was defined as time in minutes in which PA was >2000 counts/min (45).

2.6 Statistical Analysis

To check for normality of continuous variables the Shapiro-Wilk test has been performed. Since not all variables followed a normal distribution, sex-specific descriptive characteristics are shown as a median and interquartile range for the continuous variables; the Mann-Whitney U-test was used for between-group comparisons. Moreover, Pearson's Chi-square test was performed to establish sex comparisons on categorical variables, which are shown as absolute and relative frequencies.

Then, multiple linear regression models were conducted to examine the association between EWI-C subscales (independent variables) and body composition indicators (dependent variables). All models were adjusted for age, socio-economic status (FAS), physical activity (MVPA) and city of origin as confounders. Analysis was performed in the whole sample and stratified by sex. Normality of residuals of the main regression models were examined via Q-Q plots and tests of normality.

Furthermore, according to EWI-C answers, the sample was grouped into three response categories ("Totally disagree", "Disagree", and "Agree") for each subscale. This transformation was performed using the Visual Binning function in SPSS, which automatically calculates percentiles to create balanced groups based on the distribution of responses within each subscale. This step was necessary to ensure sufficient sample sizes in each group, particularly where extreme response options were underrepresented, and to improve the statistical power of the ANCOVA analysis. Subsequently, analysis of covariance (ANCOVA) models was applied to examine differences in adiposity indicators (BMI, FMI, WC, FFMI), across these response categories. All models were adjusted for age, socio-economic status (FAS), moderate-to-vigorous physical activity (MVPA), and city of origin. Post hoc pairwise comparisons were performed using Bonferroni adjustment to identify specific differences between the three response categories within each subscale.

SPSS STATISTICS v.26 (IBM Corp. Released 2017) and R studio statistical software have been used to perform all statistical analysis. The value $p < 0.05$ was established as indicative of significant findings.

3. RESULTS

Table 2 shows the main characteristics of the HELENA participants included in the present study. The residuals showed an approximately normal distribution with no major deviations, supporting the validity of the reported findings (Annex I).

For the EWI subscales, Table 3 shows significant differences between sexes for all subscales except in “Food cue responsiveness”. Males had a significant higher score compared to females in the subscales named “well-being nutrition”, “obesity perception” and “parental pressure” subscales. In contrast, the remaining EWI subscales showed females having significantly higher scores than males ($p \leq 0.001$). Annex II show correlations between EWI subscales for females and males separately ($p < 0.05$).

Table 2. General characteristics of the sample.

	TOTAL	MALES	FEMALES	*P*
Sex	2059 (100%)	920 (44.7%)	1139 (55.3%)	
Age (years)	14.67 (1.92)	14.75 (2.08)	14.67 (1.92)	.803
Centre				.507
Athens (Greece)	188 (9.1%)	84 (9.1%)	104 (9.1%)	
Dortmund (Germany)	228 (11.1%)	130 (14.1%)	98 (8.6%)	
Gent (Belgium)	252 (12.2%)	120 (13.0%)	132 (11.6%)	
Heraklion (Crete)	63 (3.1%)	12 (1.3%)	51 (4.5 %)	
Lille (France)	192 (9.3%)	79 (8.6%)	113 (9.9%)	
Pecs (Hungary)	263 (12.8%)	116 (12.6%)	147 (12.9%)	
Rome (Italy)	164 (8.0%)	65 (7.1%)	99 (8.7%)	
Stockholm (Sweden)	202 (9.8%)	74 (8.0%)	128 (11.2%)	
Vienna (Austria)	172 (8.4%)	77 (8.4%)	95 (8.3%)	
Zaragoza (Spain)	335 (16.3%)	163 (17.7%)	172 (15.1%)	
Weight (kg)	56.50 (14.50)	60.30 (16.68)	54.50 (12.60)	**<.001**
Height (cm)	165.10 (12.70)	170.50 (13.18)	162.20 (9.60)	**<.001**
Waist (cm)	70.00 (9.50)	71.73 (10.09)	68.43 (9.90)	**<.001**
BMI categories				.731
Underweight	90 (4.4%)	41 (4.5%)	49 (4.3%)	
Normal weight	1657 (80.5%)	733(79.7%)	924 (81.1%)	
Overweight	241 (11.7%)	110 (12%)	131 (11.5%)	
Obesity	71 (3.4%)	36 (3.9%)	35 (3.1%)	
BMI z score	-.066 (1.21)	-.033 (1.11)	-.083 (1.22)	.118
FMI z score	-.283 (1.06)	-.356 (0.96)	-.220 (1.13)	.588
WC z score	-.180 (1.18)	-.087 (1.16)	-.280 (1.22)	**<.001**
MVPA (mins)	54.36 (29.67)	64.13 (32.74)	48.78 (24.51)	**<.001**
FAS				**.002**
Low	262 (12.7%)	90 (10.5%)	172 (15.1%)	
Medium	1147 (55.7%)	527 (57.3%)	620 (54.5%)	
High	650 (31.5%)	303 (32.9%)	347 (30.5%)	

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Table 3. Median scores on EWI-C subscales in the total sample and by sex.

EWI subscales	TOTAL	MALES	FEMALES	*P*
1- Hunger level and susceptibility to food cues	2.00 (.75)	1.87 (.88)	2.00 (.75)	.056
2- Importance and impact of eating on sense of well-being	2.43 (.86)	2.57 (.71)	2.43 (.86)	**<.001**
3- Eating as a means of coping with emotional stress	1.50 (.88)	1.37 (.63)	1.62 (1.00)	**<.001**
4- Concerns about eating and weight	1.62 (1.25)	1.37 (.88)	2.00 (1.25)	**<.001**
5- Dietary restraint	1.71 (1.14)	1.42 (.86)	2.00 (1.14)	**<.001**
6- Attitude toward healthful nutrition	2.50 (.75)	2.50 (1.00)	2.75 (.75)	**<.001**
7- Attitude toward the obese	2.40 (1.00)	2.40 (1.00)	2.20 (1.20)	**.008**
8- Pressures to eat from parents	2.40 (1.00)	2.41 (1.00)	2.39 (1.00)	**<.001**
9- Fear of weight gain	2.00 (1.67)	1.33 (1.00)	2.33 (1.67)	**<.001**
10- Figure dissatisfaction	1.80 (1.40)	1.40 (1.00)	2.40 (1.40)	**<.001**

The relationships between EWI subscales and adiposity indicators for males and females are shown in Figure 2. Findings are statistically significant showing a negative association between "Food cue responsiveness", "Well-being nutrition" and "Parental pressure" subscales and the three adiposity indicators in both males and females. However, "Obesity perception" only presented a significant negative association with WC, in males. Positive associations were observed between the rest of EWI-C subscales and adiposity indicators in both sexes. In contrast to the analysis in the total sample (Annex III), the association between "Emotional eating" and waist circumference was statistically significant only in males (β = 0.224, 95% CI: 0.095,0.354).

Notably, subscales related to weight concerns showed stronger associations with adiposity indicators in males; for instance, each additional point on the "Weight concerns" subscale was associated with a β coefficient of 0.974 (95% CI: 0.891, 1.057) in BMI.

Conversely, higher scores on the "Parental pressure" subscale were associated with lower BMI values (β =-0.305, 95% CI: -0.402, -0.028). Overall, the strength of associations between EWI-C subscales and adiposity indicators tended to be higher in males than in females.

Table 4 presents adjusted mean values of adiposity indicators across grouped responses to the EWI-C subscales, stratified by sex. These comparisons were conducted using ANCOVA models adjusted for age, socio-economic status (FAS), physical activity (MVPA), and city of origin. These results confirm previous findings of the strong association of EWI scales related to body and weight concerns with higher adiposity indicators, especially in males. In general, higher agreement on these behaviours in both sexes are associated to higher body fat. It is noteworthy that in the results of response groupings, many more females tend to be found in the "agree" category than males as, for example, in "Weight gain fear" where only 132 males agree (14.3%) and a total of 553 females (48.5%) ($p < 0.001$). Post hoc pairwise comparisons using Bonferroni adjustment indicated that, for most subscales, the "Agree" group differed significantly from the other two categories, particularly in scales related to weight and body concerns (all $p < 0.001$), while differences between "Totally disagree" and "Disagree" were less consistent. For the ANCOVA analyses, age showed consistent positive associations with BMI and WC across both sexes, while FAS was negatively associated with most body composition outcomes. Full beta coefficients and 95% confidence intervals are available in Supplementary Annex IV.

Table 4. Adjusted means of body composition indicators across EWI-C Subscale Response Categories. ANCOVA models, by sex.

		N (%)	BMI		FMI		WC		FFMI	
			Mean±SD	*p*	Mean±SD	*p*	Mean±SD	*p*	Mean±SD	*p*
Food cue responsiveness										
Male				**<.001**		**<.001**		**<.001**		.551
	Totally disagree	396 (43,0%)	21,57±3,71		4,89±3,42		74,56±9,17		15,55±3,35	
	Disagree	283 (30,8%)	21,06±3,49		4,31±3,15		73,91±8,62		15,41±3,29	
	Agree	241 (26,2%)	20,15±3,34		3,73±2,71		71,65±8,01		15,61±3,46	
Female				**.001**		**.001**		**.011**		.849
	Totally disagree	441 (38,7%)	21,25±3,40		5,80±2,41		70,076±8,00		16,85±3,34	
	Disagree	366 (32,1%)	21,49±3,66		5,97±2,79		70,65±8,107		16,74±3,16	
	Agree	332 (29,1%)	20,60±3,08		5,33±2,29		69,02±6,62		16,72±3,44	
Well-being nutrition										
Male				**<.001**		**<.001**		**<.001**		.522
	Totally disagree	229 (24,9%)	22,15±3,92		5,14±3,51		75,54±9,62		15,70±3,28	
	Disagree	308 (33,5%)	21,00±3,61		4,49±3,36		73,44±9,16		15,50±3,35	
	Agree	383 (41,6%)	20,41±3,19		3,90±2,74		72,56±7,71		15,44±3,43	
Female				**<.001**		**<.001**		**<.001**		.703
	Totally disagree	379 (33,3)	21,74±3,66		6,09±2,67		70,86±8,46		16,83±3,42	
	Disagree	403 (35,4%)	21,25±3,28		5,78±2,39		70,34±7,48		16,84±3,29	
	Agree	357 (31,3%)	20,38±3,15		5,25±2,42		68,54±6,81		16,65±3,22	
Emotional eating										
Male				**.004**		**.001**		**.002**		.721
	Totally disagree	453 (49,2%)	20,77±3,29		4,13±2,87		72,84±8,09		15,52±3,27	
	Disagree	299 (32,5%)	21,02±3,70		4,43±3,33		73,54±8,95		15,50±3,53	
	Agree	168 (18,3%)	21,80±4,04		5,11±3,65		75,75±9,90		1,56±3,36	
Female				.082		**.023**		.076		.380
	Totally disagree	341 (29,9%)	20,92±3,32		5,55±2,40		69,51±7,59		16,76±3,32	
	Disagree	370 (32,5%)	20,92±3,13		5,52±2,84		69,36±7,56		16,94±3,37	
	Agree	428 (37,6%)	21,49±3,70		6,03±2,77		70,81±7,80		16,64±3,26	
Weight concerns										
Male				**<.001**		**<.001**		**<.001**		.083
	Totally disagree	450 (48,9%)	19,34±2,30		2,95±1,48		69,97±5,54		15,23±3,20	
	Disagree	310 (33,7%)	21,54±3,09		4,70±2,79		74,62±8,48		15,91±3,35	
	Agree	160 (17,4%)	24,85±4,21		7,95±4,34		81,82±10,57		15,60±3,36	
Female				**<.001**		**<.001**		**<.001**		.348
	Totally disagree	273 (24,0%)	18,46±1,91		3,92±1,18		64,82±4,52		16,55±3,32	
	Disagree	400 (35,1%)	20,99±2,71		5,53±2,03		69,16±6,33		16,87±3,46	
	Agree	466 (40,9%)	22,99±3,52		6,94±2,78		73,63±8,27		16,84±3,18	

Dietary restraint							
Male			**<.001**	**<.001**	**<.001**		.775
	Totally disagree	473 (51,4%)	19,81±2,71	3,28±1,98	71,04±6,51	15,32±3,22	
	Disagree	252 (27,4%)	21,44±3,61	4,74±3,20	74,50±9,11	15,60±3,40	
	Agree	195 (21,2%)	23,50±4,04	6,72±4,13	78,64±10,58	15,92±3,61	
Female			**<.001**	**<.001**	**<.001**		.138
	Totally disagree	322 (28,3%)	19,49±3,00	4,71±2,23	67,04±6,52	16,60±3,43	
	Disagree	270 (23,7%)	20,83±3,03	5,46±2,27	69,73±7,09	16,61±3,42	
	Agree	547 (48,0%)	22,26±3,40	6,44±2,57	71,77±8,05	16,96±3,28	
Healthy nutrition							
Male			**.004**	**.001**	**.008**		.813
	Totally disagree	381 (41,4%)	20,62±3,30	3,91±2,71	72,75±8,27	15,32±3,24	
	Disagree	273 (29,7%)	21,33±3,90	4,80±3,41	74,32±9,32	15,70±3,50	
	Agree	266 (28,9%)	21,34±3,61	4,71±3,51	74,07±8,85	15,65±3,40	
Female			**.001**	**.001**	**.001**		.328
	Totally disagree	333 (29,2%)	20,59±3,50	5,32±2,62	68,70±7,55	16,61±3,28	
	Disagree	405 (35,6%)	21,21±3,46	5,81±2,51	70,18±7,64	16,98±3,32	
	Agree	401 (35,2%)	21,52±3,24	5,96±2,41	70,76±7,72	16,70±3,33	
Obesity perception							
Male			.395	.241	.185		.273
	Totally disagree	339 (36,8%)	21,18±3,86	4,60±3,43	74,22±9,55	15,32±3,39	
	Disagree	266 (28,9%)	20,80±3,28	4,14±2,79	73,42±8,05	15,48±3,30	
	Agree	315 (34,2%)	21,09±3,53	4,43±3,25	73,07±8,48	15,77±3,36	
Female			.880	.951	.281		.181
	Totally disagree	481 (42,2%)	21,03±3,64	5,70±2,62	70,25±8,07	16,76±3,32	
	Disagree	310 (27,2%)	21,16±3,28	5,67±2,45	70,12±7,27	16,59±3,31	
	Agree	348 (30,6%)	21,27±3,21	5,79±2,44	69,37±7,46	16,96±3,30	
Parental pressure							
Male			**<.001**	**<.001**	**<.001**		.586
	Totally disagree	307 (33,4%)	21,81±3,60	4,85±3,35	75,34±8,68	15,27±3,39	
	Disagree	320 (34,8%)	21,05±3,76	4,47±3,33	73,51±9,37	15,65±3,22	
	Agree	293 (31,8%)	20,22±3,19	3,87±2,78	71,87±7,84	15,65±3,48	
Female			**<.001**	**<.001**	**<.001**		.300
	Totally disagree	444 (39,0%)	21,83±3,51	5,99±2,58	71,16±8,23	16,80±3,35	
	Disagree	395 (34,7%)	21,07±3,44	5,79±2,61	69,96±7,37	16,90±3,35	
	Agree	300 (26,3%)	20,21±3,00	5,22±2,22	68,14±6,85	16,58±3,03	
Weight gain fear							
Male			**<.001**	**<.001**	**<.001**		.578
	Totally disagree	379 (41,2%)	19,76±2,80	3,30±2,09	70,71±6,72	15,62±3,26	
	Disagree	409 (44,5%)	21,52±3,70	4,74±3,36	74,49±9,00	15,43±3,45	
	Agree	132 (14,3%)	23,25±3,86	6,52±3,92	79,12±10,04	15,52±3,39	
Female			**<.001**	**<.001**	**<.001**		.158
	Totally disagree	169 (14,8%)	19,03±3,22	4,32±2,22	65,89±6,63	16,78±3,10	
	Disagree	417 (36,6%)	20,51±3,04	5,37±2,31	69,09±6,77	16,56±3,42	
	Agree	553 (48,6%)	22,25±3,32	6,41±2,53	71,84±8,03	16,94±3,29	

Figure dissatisfaction							
Male				**<.001**	**<.001**	**<.001**	.491
	Totally disagree	519 (56,4%)	19,59±2,36	3,12±1,61	70,40±5,92	15,42±3,25	
	Disagree	293 (31,8%)	21,91±3,45	5,05±3,03	75,36±8,93	15,76±3,47	
	Agree	108 (11,7%)	25,61±4,22	8,86±4,55	84,21±10,14	15,37±3,59	
Female				**<.001**	**<.001**	**<.001**	.850
	Totally disagree	275 (24,1%)	18,75±2,14	4,15±1,41	65,27±5,11	16,76±3,34	
	Disagree	377 (33,1%)	20,66±3,07	5,44±2,36	68,98±6,39	16,87±3,31	
	Agree	487 (42,8%)	22,85±3,33	6,82±2,52	73,34±8,19	16,71±3,31	

4. DISCUSSION

The present study provides additional evidence on the association between eating-related psychological and attitudinal constructs and adiposity indicators in European adolescents: Behaviours related to weight concerns, dietary restraint, emotional eating, fear of weight gain, healthy nutrition, and figure dissatisfaction were strongly positively associated with higher BMI, FMI and WC.

Our findings revealed significant sex differences in eating-related psychological and attitudinal constructs, with females scoring higher. Scores on the "Emotional eating," "Weight concerns," "Weight gain fear," and "Healthy nutrition" subscales align with existing literature, showing that females are more concerned about these behaviours (46, 47), which have been associated with a likelihood of developing eating disorders (48). Females also scored higher on the “Dietary restraint” and “Figure dissatisfaction” subscales, reflecting concerns about weight and body image (49, 50). Other study show that while adolescents are generally dissatisfied with their body image, males prefer a larger size, while females prefer a slimmer one (51).

Males scored higher on the “Well-being nutrition”, “Obesity perception”, and “Parental pressure” subscales. This first of these subscales, similar to the “Enjoyment of food' subscale” (13), suggests that males are less concerned about food intake. This finding aligns with a previous study reporting higher scores in boys (52), although other research in children has found the opposite pattern, with girls scoring higher (13, 53). In the same

334 way, “obesity perception” scoring higher in males, aligns with research showing males
335 tend to express stronger weight stigma (54). It is important to note that several items in
336 this subscale are framed in gendered and appearance-focused terms, often targeting
337 women (e.g., ‘A woman only looks good when she is slim’), which may reflect and
338 reinforce societal biases, which could influence how participants—particularly males—
339 respond to these items (55). Regarding the “Parental pressure” subscale, studies have
340 found similar results, where males tend to receive more parental pressure than females
341 (56). Higher body weight may be more socially accepted in males than females, as shown
342 above and supported by other studies (57); parents may encourage overeating in males
343 while preventing significant weight gain in females (58).
344 In the EWI validation study, sex differences mirrored our findings, with females scoring
345 higher on “Weight concerns,” “Dietary restraint,” “Weight gain fear,” and “Figure
346 dissatisfaction,” and lower on “Food cue responsiveness,” “Well-being nutrition,”
347 “Obesity perception,” and “Parental pressure.” There was no significance in the
348 “Emotional eating” subscale, where females scored higher in our study (17). This
349 difference could be due to the diverse cultures and countries included in our sample (59).
350 The observed sex differences may reflect how behavioural subscales are perceived and
351 expressed differently by males and females. Males might be more likely to openly display
352 behaviours such as high food cues responsiveness or low dietary restraint (60), which are
353 directly linked to body composition, thereby strengthening the statistical associations in
354 their group. However, previous research suggests that males are less likely to
355 acknowledge behaviours such as emotional eating (61), possibly due to social stigma or
356 gender norms, and may only report such behaviours when adiposity is more evident (62).
357 In contrast, females tend to express greater concern about weight and body image, even
358 in without elevated adiposity (61). These gendered patterns of perception and reporting

may influence both the strength and visibility of associations between eating-related psychological and attitudinal constructs and adiposity indicators in each group (63).

The association between eating-related psychological and attitudinal constructs and adiposity indicators varied by subscale. Although fat-free mass index was included as an adiposity indicator in our models, results were not shown in detail due to the lack of statistically significant associations. Previous studies have also reported weak or inconsistent associations between fat-free mass and eating behaviours in adolescents (64), suggesting that FFM may be more influenced by other aspects such as physical activity and developmental factors than by behavioural traits (65).

Our findings reveal that both "Food cue responsiveness" and "Well-being nutrition" subscales showed a negative relationship with the three adiposity indictors (BMI, FMI, WC). This contrasts with previous studies, which either reported no significant associations with similar behaviour subscales as "food responsiveness" in CEBQ (66), or found positive associations between food responsiveness and obesity indicators in children, as shown in the meta-analysis by Kininmonth et *al*. (67). Another study showed that food approach traits, like enjoyment of food and hunger, were positively linked to growth rates in weight, BMI, and body fat percentage (68).

The results from the "Emotional eating" subscale suggest that adolescents may eat in response to emotional states rather than for pleasure. This may be explained by psychological factors like anxiety, linked to emotional eating and higher rates of overweight and obesity (21). In this subscale, as in others like "weight concerns" or "figure dissatisfaction", betas were higher in males, while females were more likely to "agree" with the subscale. This indicates that although emotional eating is more prevalent among females, its association with adiposity indicators is stronger in males, possibly reflecting a more pronounced impact when present (62). A recent study align with our

findings on the association of this subscale and body fat in sex-segmented young people (69).

A strong positive relationship was found between subscales related to concerns about weight, body image, and eating ("Weight concerns", Weight gain fear", "Dietary restraint", "Healthy nutrition", "Figure dissatisfaction"), and adiposity indicators, with "Weight concerns" and "Dietary restraint" showing the highest beta scores. These findings align with previous studies where BMI was significantly correlated with restrictive eating, body dissatisfaction, and worry about gaining weight (49, 70-72). Adolescents with concerns about weight or body image may engage in dietary restraint. Although some literature distinguishes between flexible and rigid cognitive control of eating behaviour—each potentially associated with either positive or detrimental effects (73)—it remains uncertain whether these distinctions apply directly to dietary restraint or have consistent implications for body composition.

"Parental pressure" was negatively associated with body composition, with higher pressure linked to lower excess fat in children. Previous research found that children's BMI predicted parental feeding practices such as pressure to eat and restriction, but not the reverse (74). This is consistent with other study that conclude that parental concern tends to vary according to children weight status (56). A systematic review found mostly non-significant associations between parental pressure to eat and weight outcomes in children and adolescents. However, high-quality studies suggested that such pressure to eat may lead to lower weight outcomes over time (75), possibly due to changes in children's eating behaviour in response to parental control.

The associations between eating-related psychological and attitudinal constructs and body composition may be bidirectional or unidirectional, as in this cross-sectional study, both are measured simultaneously, making the direction of causality unclear.

Additionally, other factors not accounted for, may influence this relationship (76). In some subscales, apparent inconsistences may arise, such as higher fear of weight gain correlating with greater body fat. This could reflect either a fear of gaining additional weight or that such fear has contributed to a problematic relationship with food (77), leading to excess weight. Moreover, it is established that individuals with higher body fat are at greater risk for eating disorders (78), which could potentially explain these results. Finally, individuals with overweight or obesity may feel uncomfortable endorsing attitudes perceived as pro-eating when responding to questionnaires, which could also influence the results.

Excess adiposity status has a multifactorial origin (79) and does not depend only on one variable such as eating behaviour, even if this includes several dimensions. Therefore, it was essential to adjust for factors such as socio-economic status and physical activity, where eating behaviour-adiposity association was stronger. Similar findings were observed in another study that accounted for socio-demographic factors in the relationship between stress, eating behaviours, physical activity, and adolescent overweight/obesity (70). Prior research, suggests that associations between eating behaviours and body composition vary based on factors such as gender, age, socio-economic status, physical activity, and social context (80).

4.5 Strengths and limitations.

Strengths of this study include a large sample size, a well-defined methodology, and its focus on eating-related psychological and attitudinal constructs and body composition in adolescents, an area with limited research compared to children. This study further contributes by examining sex differences and adjusting for additional influencing variables. The use of the EWI questionnaire, previously analysed only once and never in

relation to body composition, adds unique value to the research (23). A limitation of this study is the use of a self-reported questionnaire, which may introduce biases due to the complex developmental stage of adolescence. While the questionnaire was originally validated in English and German, subsequently translated, and culturally adapted to other languages, it was not revalidated in each translated version, which may have introduced minor inconsistencies. Additionally, results were adjusted for age and sex but not tanner stages to avoid reducing the sample size. Lastly, due to the cross-sectional design, long-term effects on the tracking of eating-related psychological and attitudinal constructs could not be assessed.

5. CONCLUSIONS

The present findings suggest a direct association between eating-related psychological and attitudinal constructs and body adiposity indicators in adolescents. Positive associations were found for subscales like "Emotional eating," "Weight concerns," "Dietary restraint," "Healthy nutrition," "Weight gain fear," and "Figure dissatisfaction," while negative associations were observed for "Food cue responsiveness," "Well-being nutrition," and "Parental pressure." Associations were stronger in males, and notable sex differences in responses may reflect contextual and perceptual factors, highlighting the need to critically evaluate how such measures are designed and interpreted. This can help improve eating behaviour guidelines and develop interventions to prevent fat accumulation during this critical age. Given the social pressures and physiological changes adolescents face, it is crucial to promote health while addressing concerns about food, weight, and body dissatisfaction. Further studies, particularly longitudinal research, are needed to confirm these associations in adolescents and track them from early childhood.

6. REFERENCES

1. WHO. Obesity and overweight World Health Organization2021 [Available from: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight.
2. Llewellyn A, Simmonds M, Owen CG, Woolacott N. Childhood obesity as a predictor of morbidity in adulthood: a systematic review and meta-analysis. Obes Rev. 2016;17(1):56-67.
3. Agustina R, Meilianawati, Fenny, Atmarita, Suparmi, Susiloretni K, et al. Psychosocial, Eating Behavior, and Lifestyle Factors Influencing Overweight and Obesity in Adolescents. Food and nutrition bulletin. 2021;42(1_suppl):S72-S91.
4. Qorbani M, Khashayar P, Rastad H, Ejtahed H, Shahrestanaki E, Seif E, et al. Association of dietary behaviors, biochemical, and lifestyle factors with metabolic phenotypes of obesity in children and adolescents. Diabetology & metabolic syndrome. 2020;12(1).
5. Jimeno-Martínez A, Maneschy, I., Rupérez, A. I., & Moreno, L. A. Factores determinantes del comportamiento alimentario y su impacto sobre la ingesta y la obesidad en niños. *Journal of Behavior and Feeding*. 2021;1(1):60-71.
6. Russell A, Jansen E, Burnett AJ, Lee J, Russell CG. Children's eating behaviours and related constructs: conceptual and theoretical foundations and their implications. International Journal of Behavioral Nutrition and Physical Activity. 2023;20(1):1-16.
7. Grimm ER, & Steinle, N. I. Genetics of Eating Behavior: Established and Emerging Concepts. Nutrition reviews. 2011;69(1):52-60.
8. Maneschy I, Jimeno-Martínez, A., Miguel-Berges, M. L., Rupérez, A. I., Ortega-Ramiréz, A. D., Masip, G., & Moreno, L. A. Eating Behaviours and Dietary Intake in Children and Adolescents: A Systematic Review. Current nutrition reports. 2024;13(3).
9. F. GRP. Motivations Associated with Food Choices and Eating Practices. Foods. 2021;10(4):834.
10. Herle M, Smith, A. D., Kininmonth, A., & Llewellyn, C. The Role of Eating Behaviours in Genetic Susceptibility to Obesity. Current Obesity Reports. 2020;9(4):512-21.
11. Norris SA FE, Black MM, Dong Y, Fall C, Lampl M, Liese AD, Naguib M, Prentice A, Rochat T, Stephensen CB, Tinago CB, Ward KA, Wrottesley SV, Patton GC. Nutrition in adolescent growth and development. Lancet (London, England). 2022;399(10320).
12. van Strien T, Oosterveld P. The children's DEBQ for assessment of restrained, emotional, and external eating in 7- to 12-year-old children. The International journal of eating disorders. 2008;41(1):72-81.
13. Wardle J, Guthrie C, Sanderson S, Rapoport L. Development of the Children's Eating Behaviour Questionnaire. Journal of child psychology and psychiatry, and allied disciplines. 2001;42(7):963-70.
14. Jimeno-Martínez A, Maneschy, I., Rupérez, A. I., & Moreno, L. A. Factores determinantes del comportamiento alimentario y suimpacto sobre la ingesta y la obesidad en niños. Journal of Behavior and Feeding. 2021;1:60-71.
15. Yabsley JL, Gunnell, K. E., Bryant, E. J., Drapeau, V., Thivel, D., Adamo, K. B., & Chaput, J. P. Validation of a child version of the Three-Factor Eating Questionnaire in a Canadian sample: a psychometric tool for the evaluation of eating behaviour. Public Health Nutrition. 2019;22(3):431-43.
16. Warkentin S, Costa, A., & Oliveira, A. Validity of the Adult Eating Behavior Questionnaire and Its Relationship with Parent-Reported Eating Behaviors among Adolescents in Portugal. Nutrients. 2022;14(6):1301.
17. Diehl J. [Attitude to eating and body weight by 11- to 16-year-old adolescents]. Schweizerische medizinische Wochenschrift. 1999;129(5):162-75.
18. Liu KSN, Chen, J. Y., Ng, M. Y. C., Yeung, M. H. Y., Bedford, L. E., & Lam, C. L. K. How Does the Family Influence Adolescent Eating Habits in Terms of Knowledge, Attitudes and Practices? A Global Systematic Review of Qualitative Studies. Nutrients. 2021;13(11):3717.

19. Bodega P, de Cos-Gandoy, A., Fernández-Alvira, J. M., Fernández-Jiménez, R., Moreno, L. A., & Santos-Beneit, G. Body image and dietary habits in adolescents: a systematic review. Nutrition reviews. 2023;82(1):104-1027.
20. Izydorczyk B, Sitnik-Warchulska, K., Wajda, Z., Lizińczyk, S., & Ściegienny, A. Bonding With Parents, Body Image, and Sociocultural Attitudes Toward Appearance as Predictors of Eating Disorders Among Young Girls. Frontiers in psychiatry. 2021;12:590542.
21. Dakanalis A, Mentzelou M, Papadopoulou S, Papandreou D, Spanoudaki M, Vasios G, et al. The Association of Emotional Eating with Overweight/Obesity, Depression, Anxiety/Stress, and Dietary Patterns: A Review of the Current Clinical Evidence. Nutrients. 2023;15(5):1173.
22. Ramírez-Contreras C F-CA, Izquierdo-Pulido M, Zerón-Rugerio MF. A higher dietary restraint is associated with higher BMI: a cross-sectional study in college students. Physiology & behavior. 2021;240.
23. Maneschy I, Moreno L, Ruperez A, Jimeno A, Miguel-Berges M, Widhalm K, et al. Eating Behavior Associated with Food Intake in European Adolescents Participating in the HELENA Study. Nutrients. 2022;14(15):3033.
24. Flieh SM, Miguel-Berges, M. L., González-Gil, E. M., Gottrand, F., Censi, L., Widhalm, K., Manios, Y., Kafatos, A., Molnár, D., Dallongeville, J., Stehle, P., Gonzalez-Gross, M., Marcos, A., De Henauw, S., Molina-Hidalgo, C., Huybrechts, I., & Moreno, L. A. The Association between Portion Sizes from High-Energy-Dense Foods and Body Composition in European Adolescents: The HELENA Study. Nutrients. 2021;13(3):954.
25. Garawi F, Devries K, Thorogood N, Uauy R. Global differences between women and men in the prevalence of obesity: is there an association with gender inequality? European journal of clinical nutrition. 2014;68(10):1101-6.
26. Keller K, Kling S, Fuch sB, Pearce A, Reigh N, Masterson T, et al. A Biopsychosocial Model of Sex Differences in Children's Eating Behaviors. Nutrients. 2019;11(3):682.
27. Silva Freitas R, Brandão T, Cardoso da Silveira J, Souza OJ, Longo-Silva G, de Menezes R. Commensality and eating patterns in adolescents: An analysis from structural equation modeling. Appetite. 2022;178.
28. Kininmonth A, Smith A, Carnell S, Steinsbekk S, Fildes A, Llewellyn C. The association between childhood adiposity and appetite assessed using the Child Eating Behavior Questionnaire and Baby Eating Behavior Questionnaire: A systematic review and meta-analysis. Obesity reviews : an official journal of the International Association for the Study of Obesity. 2021;22(5).
29. Desbouys L MC, De Henauw S, Castetbon K. Socio-economic and cultural disparities in diet among adolescents and young adults: a systematic review. Public Health Nutrition. 2019;23(5):843-60.
30. Bridger Staatz C KY, Lacey RE, Blodgett JM, George A, Arnot M, Walker E, Hardy R. Socioeconomic position and body composition in childhood in high- and middle-income countries: a systematic review and narrative synthesis. International journal of obesity (2005). 2021;45(11).
31. Hahn JS FE, Harrison A, Lewis G, Solmi F. Family Socioeconomic Position and Eating Disorder Symptoms Across Adolescence. JAMA Network Open. 2025;8(8).
32. Jiménez-Pavón D F-VA, Alexy U, Pedrero R, Cuenca-García M, Polito A, Vanhelst J, Manios Y, Kafatos A, Molnar D, Sjöström M, Moreno LA, Group. HS. Association of objectively measured physical activity with body components in European adolescents. BMC Public Health. 2013;13:667.
33. Martinez-Avila W, Sanchez-Delgado G, Acosta F, Jurado-Fasoli L, Oustric P, Labayen I, et al. Eating Behavior, Physical Activity and Exercise Training: A Randomized Controlled Trial in Young Healthy Adults. Nutrients. 2020;12(12).
34. Moreno L, Gottrand F, Huybrechts I, Ruiz J, González-Gross M, DeHenauw S. Nutrition and lifestyle in european adolescents: the HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) study. Advances in nutrition (Bethesda, Md). 2014;5(5):615S-23S.
35. Béghin L, Castera M, Manios Y, Gilbert C, Kersting M, De Henauw S, et al. Quality assurance of ethical issues and regulatory aspects relating to good clinical practices in the

HELENA Cross-Sectional Study. International journal of obesity (2005). 2008;32 Suppl 5:S12-8.
36. González-Gross M, de Henauw S, Gottrand F, Gilbert C, Moreno L. Manual of operation : the HELENA study: Prensas en la Universidad de Zaragoza: Zaragoza, Spain, 2013.; 2023 [Available from: https://indaga.ual.es/discovery/fulldisplay/alma991001488129704991/34CBUA_UAL:VU1.
37. Nagy E, Vicente-Rodriguez, G., Manios, Y., Béghin, L., Iliescu, C., Censi, L., Dietrich, S., Ortega, F. B., De Vriendt, T., Plada, M., Moreno, L. A., Molnar, D., & HELENA Study Group. Harmonization process and reliability assessment of anthropometric measurements in a multicenter study in adolescents. International journal of obesity (2005). 2008;32 Suppl 5:S58–S65.
38. Cole T, Lobstein T. Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. Pediatric obesity. 2012;7(4):284-94.
39. Slaughter M, Lohman T, Boileau R, Horswill C, Stillman R, Van Loan M, et al. Skinfold equations for estimation of body fatness in children and youth. Human biology. 1988;60(5):709-23.
40. Nagy E, Vicente-Rodriguez G, Manios Y, Béghin L, Iliescu C, Censi L, et al. Harmonization process and reliability assessment of anthropometric measurements in a multicenter study in adolescents. International journal of obesity (2005). 2008;32 Suppl 5:58-68.
41. Currie C, Molcho M, Boyce W, Holstein B, Torsheim T, Richter M. Researching health inequalities in adolescents: the development of the Health Behaviour in School-Aged Children (HBSC) family affluence scale. Social science & medicine (1982). 2008;66(6):1429-36.
42. Ruegsegger GN BF. Health Benefits of Exercise. Cold Spring Harbor Perspectives in Medicine. 2018;8(7).
43. Wu T Y-HJ, Vernooij MW, Rodriguez-Ayllon M, Jaddoe VWV, Raat H, Klein S, Oei EHG. Physical activity, screen time and body composition in 13-year-old adolescents: The Generation R Study. Pediatric obesity. 2023;18(11):13076.
44. Mateo-Orcajada A G-GN, Abenza-Cano L, Vaquero-Cristóbal R. Differences in Physical Fitness and Body Composition Between Active and Sedentary Adolescents: A Systematic Review and Meta-Analysis. Journal of youth and adolescence. 2022;51(2).
45. Ruiz JR, Ortega, F. B., Martínez-Gómez, D., Labayen, I., Moreno, L. A., De Bourdeaudhuij, I., Manios, Y., Gonzalez-Gross, M., Mauro, B., Molnar, D., Widhalm, K., Marcos, A., Beghin, L., Castillo, M. J., Sjöström, M., & HELENA Study Group. Objectively measured physical activity and sedentary time in European adolescents: the HELENA study. American journal of epidemiology. 2011;174(2):173–84.
46. Bryant E, Thivel D, Chaput J, Drapeau V, Blundell J, King N. Development and validation of the Child Three-Factor Eating Questionnaire (CTFEQr17). Public health nutrition. 2018;21(14):2558-67.
47. Richards M, Casper R, Larson R. Weight and eating concerns among pre- and young adolescent boys and girls. Journal of adolescent health care : official publication of the Society for Adolescent Medicine. 1990;11(3):203-9.
48. Silva W, Santana M, Maroco J, Maloa B, Campos J. Body weight concerns: Cross-national study and identification of factors related to eating disorders. PloS one. 2017;12(7):e0180125.
49. Jáuregui-Lobera I, Iglesias Conde A, Sánchez Rodríguez J, Arispon Cid J, Andrades Ramírez C, Herrero Martín G, et al. Self-perception of weight and physical fitness, body image perception, control weight behaviors and eating behaviors in adolescents. Nutricion hospitalaria. 2018;35(5):1115-23.
50. Vieira B, Brandão M, Warkentin S, Henriques A, Abelha F, Lucas R. Body image dissatisfaction and experimental pressure pain sensitivity in a cohort of 13-year-old adolescents. Journal of psychosomatic research. 2022;158:110912.
51. Liyanage G, Karunainathan T, Jeyarajah L, Thevatheepan P, Thavendra M, Seneviwickrama M. Body image dissatisfaction and its determinants in urban Sri Lankan adolescents. The Ceylon medical journal. 2021;66(4):185-90.

52. dos Passos DR, Gigante, D. P., Maciel, F. V., and Matijasevich, A. Comportamento alimentar infantil: comparação entre crianças sem e com excesso de peso em uma escola do município de Pelotas, RS. Revista Paulista de Pediatria. 2015;33:42-9.
53. Jimeno-Martínez A, Maneschy I, Moreno L, Bueno-Lozano G, De Miguel-Etayo P, Flores-Rojas K, et al. Reliability and Validation of the Child Eating Behavior Questionnaire in 3- to 6-Year-Old Spanish Children. Frontiers in psychology. 2022;13(4):705912.
54. Ciloglu H, Yilmaz M. Attitudes and Self-Perception of 10- to 14-Year-Old Students Toward Obese Children. The Journal of school nursing : the official publication of the National Association of School Nurses. 2022;38(3):279-28.
55. Springmann ML SJ, Kiegelmann M. A qualitative study of gendered psychosocial processes in eating disorder development. The International journal of eating disorders. 2022;55(7).
56. Loth K, MacLehose R, Fulkerson J, Crow S, Neumark-Sztainer D. Food-related parenting practices and adolescent weight status: a population-based study. Pediatrics. 2013;131(5):e1443-50.
57. Presnell K, Bearman S, Stice E. Risk factors for body dissatisfaction in adolescent boys and girls: a prospective study. The International journal of eating disorders. 2004;36(4):389-401.
58. Brann L, Skinner J. More controlling child-feeding practices are found among parents of boys with an average body mass index compared with parents of boys with a high body mass index. Journal of the American Dietetic Association. 2005;105(9).
59. Enriquez JP A-GJ. Social and cultural influences on food choices: A review. Critical reviews in food science and nutrition. 2022;62(13).
60. Evans C TJ, Banks J, Austin J, Antonio J. Beyond Sex Differences: Body Composition and Dietary Behaviors. Muscles (Basel, Switzerland). 2025;4(3).
61. Capuano EI RA, Scazzocchio B, Zanchi G, Lombardo C, Silenzi A, Ortona E, Varì R. Gender differences in eating disorders. Frontiers in Nutrition. 2025;12:1583672.
62. Braden A AE, Koball AM. Emotional Eating and Obesity: An Update and New Insights. Current obesity reports. 2025;14(1).
63. Feraco A, Armani, A., Amoah, I., Guseva, E., Camajani, E., Gorini, S., Strollo, R., Padua, E., Caprio, M., & Lombardo, M. Assessing gender differences in food preferences and physical activity: a population-based survey. Frontiers in Nutrition. 2024;11:1348456.
64. Štefanová E, Bakalár, P., & Baška, T. Eating-Disordered Behavior in Adolescents: Associations with Body Image, Body Composition and Physical Activity. International Journal of Environmental Research and Public Health. 2020;17(18):6665.
65. Hopkins M BK, Gibbons C, Halford JCG, Blundell J, Stubbs J, Finlayson G. The Control of Food Intake in Humans. 2022.
66. Panichsillaphakit E, Chongpison, Y., Saengpanit, P., Kwanbunbumpen, T., Uaariyapanichkul, J., Chomtho, S., Pancharoen, C., & Visuthranukul, C. Children's Eating Behavior Questionnaire Correlated with Body Compositions of Thai Children and Adolescents with Obesity: A Pilot Study. Journal of Nutrition and Metabolism. 2021:Article 6496134.
67. Kininmonth A, Smith, A., Carnell, S., Steinsbekk, S., Fildes, A., & Llewellyn, C. The association between childhood adiposity and appetite assessed using the Child Eating Behavior Questionnaire and Baby Eating Behavior Questionnaire: A systematic review and meta-analysis. Obesity reviews : an official journal of the International Association for the Study of Obesity. 2021;22(5):e13169.
68. Olwi D, Day F, Cheng T, Olga L, Petry C, Hughes I, et al. Associations of appetitive traits with growth velocities from infancy to childhood. Scientific reports. 2023;13(1):16056.
69. Evans C, Tartar, J., Banks, J., Austin, J., & Antonio, J. Beyond Sex Differences: Body Composition and Dietary Behaviors. Muscles. 2025;4(3):38.
70. Roy S, Jahan K, Alam N, Rois R, Ferdaus A, Israt S, et al. Perceived stress, eating behavior, and overweight and obesity among urban adolescents. Journal of health, population, and nutrition. 2021;40(1):54.
71. Dos Santos R, Forte G, Mundstock E, Amaral M, da Silveira C, Amantéa F, et al. Body composition parameters can better predict body size dissatisfaction than body mass index in children and adolescents. Eating and weight disorders : EWD. 2020;25(5):1197-203.

72. Choudhary S BA, Tung S, Kaur G. The Association of Eating Behaviours, and Self-Concept, With Weight Status of Indian Adolescents. Pediatric obesity. 2025;20(10).
73. Meule A. Interactive effects between flexible and rigid control of eating behavior on body weight: a moderated serial multiple mediation model. Health Psychology Report. 2017;5(4):314-22.
74. Liszewska N, Scholz U, Radtke T, Horodyska K, Luszczynska A. Bi-directional associations between parental feeding practices and children's body mass in parent-child dyads. Appetite. 2018;129:192-7.
75. Beckers D, Karssen L, JM V, Burk W, Larsen J. Food parenting practices and children's weight outcomes: A systematic review of prospective studies. Appetite. 2021;158:105010.
76. Sohail R, Hasan H, Saqan R, Barakji A, Khan A, Sadiq F, et al. The Influence of the Home Food Environment on the Eating Behaviors, Family Meals, and Academic Achievement of Adolescents in Schools in the UAE. International Journal of Environmental Research and Public Health. 2024;21(9):1187.
77. Marentes-Castillo M CI, Tomás I, González-Acevedo O, Álvarez O. Fear of Fat, Processes of Change, and Weight-Related Behaviors in Mexican and Spanish Adolescents. Children (Basel, Switzerland). 2024;11(8).
78. Veses A, Martínez-Gómez D, Gómez-Martínez S, Vicente-Rodriguez G, Castillo R, Ortega F, et al. Physical fitness, overweight and the risk of eating disorders in adolescents. The AVENA and AFINOS studies. Pediatric obesity. 2014;9(1):1-9.
79. Thomas-Eapen N. Childhood Obesity. Primary care. 2021;48(3):505-15.
80. Kowalkowska J, Poínhos R. Eating Behaviour among University Students: Relationships with Age, Socioeconomic Status, Physical Activity, Body Mass Index, Waist-to-Height Ratio and Social Desirability. Nutrients. 2021;13(10):3622.

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8. AUTHORS CONTRIBUTIONS

All authors contributed significantly to the development of this work, as described below. AJM conceived the present work, performed the analyses, and wrote the manuscript; MSC. assisted with data analysis and revised the manuscript; IM, AIR, and LM provided detailed revisions and corrections to the manuscript. LM additionally was the coordinator and designed the study. All other authors (KW, AK, CMH, MGG, SGM, EN, SDH, DM, RR, LB, MK, CB, YM, AG, GA) read and critically reviewed the manuscript, and were responsible for obtaining the data in their respective countries.

9. STATEMENTS AND DECLARATIONS

9.1 Conflict of interest:

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

9.2 Ethical approval:

The Research Ethics Committees of each involved city approved the study. The research has been performed in accordance with the Declaration of Helsinki and has been approved by each of the following ethics committee:

- Athens and Heraklion (Greece): HELENA study protocol was approved by the Ministry of Education, Research and Religious Affairs (protocol number 79162)
- Dortmund (Germany): HELENA study protocol was approved by the University Klinik Bonn (protocol number 91209-07)
- Ghent (Belgium): HELENA study protocol was approved by the University of Ghent (protocol number 007034)
- Lille (France): HELENA study protocol was approved by the Ethics Committee for the Protection of Persons Participating in Biomedical Research (number CP06/12)
- Pecs (Hungary): HELENA study protocol was approved by Regional Research Ethics Committee of the Medical Center, Pécs
- Rome (Italy): HELENA study protocol was approved by the Ethics Committee of the University of Naples Federico II - Ethics Committee for Biomedical Activities - in the session of 11 May 2006 (document signed by the president Prof. Claudio Buccelli – protocol number C.E. n 95/06)
- Stockholm (Sweden): HELENA study protocol was approved by the Regional Ethics Committee -EPN (protocol number 2007/2-17)
- Vienna (Austria): HELENA study protocol was approved by the University of Vienna (protocol number 535/2005)
- Zaragoza (Spain): HELENA study protocol was approved by the Ethics Committee of the government of Aragon - department of health and consumption -- in the session of 17 Feb 2006 (document signed by the executive Secretary María Gonzales Plinjos - protocol number 06/01).

9.3 Funding Statement:

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10. FIGURES AND TABLES LEGENDS

Figure 1. Flow chart of the sample selection process.

Abbreviations: FAS, family affluence scale; BMI, Body mass index; FMI, fat mass index; WC, waist circumference; MVPA, moderate vigorous physical activity.

Table 2. General characteristics of the sample.

The data are shown as median and interquartile range for continuous variables with a non-normal distribution and N (%) for categorical variables. P value significance in Mann-Whitney U test for numerical variable or the Chi-square test for categorical variables. Significant differences by sex ($p < 0.05$) are shown in bold font. BMI: Body Mass Index, FMI: Fat Mass Index, WC: Waist Circumference, MVPA: Moderate-Vigorous Physical Activity, FAS: Family Affluence Scale.

Table 3. Median scores on eating behaviours subscales in the total sample and by sex.

The data are shown as median and interquartile range as continuous variables with a non-normal distribution. P value significance in Mann-Whitney U test for numerical variable. Significant differences by sex ($p < 0.05$) are shown in bold font.

Figure 2. Forest plot of the association of EWI-C subscales and BMI, FMI, WC.

Multiple linear regression on the adjusted model of the behavioural eating subscales (EWI-C) and adiposity indicators adjusted for covariates: age, FAS, MVPA and centre. The analysis was carried out separately on male (N=920) and female (N=1139) participants. (1) Food cue responsiveness: Hunger level and susceptibility to food cues; (2) Well-being nutrition: Importance and impact of eating on sense of well-being nutrition; (3) Emotional eating: Eating as a means of coping with emotional stress; (4) Weight concerns: Concerns about eating and weight; (5) Dietary restraint: Dietary restraint; (6) Healthy nutrition : Attitude toward healthful nutrition;

774 (7) Obesity perception: Attitude toward the obese; (8) Parental pressure: Pressures to eat from parents; (9) Weight gain fear: Fear of
775 weight gain; (10) Figure dissatisfaction: Figure dissatisfaction.

776 **Table 4. Adjusted means of body composition indicators across EWI-C Subscale Response**
777 **Categories. ANCOVA models, by sex.**

778 Grouped answers of EWI-C by sex. The percentage indicated is the percentage of each sex in each response group out of the total.
779 The analysis was carried separately on male (N=920) and female (N=1139) participants. Analysis was adjusted for covariates: age,
780 FAS, MVPA and centre. (1) Food cue responsiveness: Hunger level and susceptibility to food cues; (2) Well-being nutrition:
781 Importance and impact of eating on sense of well-being; (3) Emotional eating: Eating as a means of coping with emotional stress; (4)
782 Weight concerns: Concerns about eating and weight; (5) Dietary restraint: Dietary restraint; (6) Healthy nutrition : Attitude toward
783 healthful nutrition; (7) Obesity perception: Attitude toward the obese; (8) Parental pressure: Pressures to eat from parents; (9) Weight
784 gain fear: Fear of weight gain; (10) Figure dissatisfaction: Figure dissatisfaction. Significant differences ($p < 0.05$) are shown in bold
785 font.