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The Association between Disordered Eating Behavior and Body Image Biological Maturation and Levels of Adipocytokines in Preadolescent Girls: The Healthy Growth Study

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Abstract: During puberty, rapid, complex hormonal, physical and cognitive changes occur that affect body image and eating behavior. The aim of this cross-sectional study, a secondary analysis of data from the Greek Healthy Growth Study, was to explore associations of disordered eating behaviors and body image in 1206 10–12-year-old girls during pubertal maturation, with serum leptin and adiponectin levels, according to body mass index (BMI). Eating behavior and disordered eating were assessed with the Dutch Eating Behavior Questionnaire (DEBQ) and the Children Eating Attitudes Test Questionnaire (ChEAT), respectively. Associations of components of DEBQ and ChEAT with maturation according to Tanner Stage (TS) and levels of leptin and adiponectin were explored by univariate and multivariate regression analysis. Adiponectin levels in girls at TS 1 were positively associated with the "social pressure to eat" score of ChEAT. Leptin levels in girls at TS 4 were positively correlated with the "restraint eating" score of DEBQ, and the "dieting", "body image" and "food awareness" scores of ChEAT. After adjustment for TS and BMI, only "body image" and leptin remained significant. Further research may shed light on how these hormonal changes affect eating behaviors at various pubertal stages, contributing to "TS-specific" preventive strategies for eating disorders in girls.

Keywords: Tanner Stage; body image; eating disorder; adiponectin; leptin; puberty

1. Introduction

Adolescence is an important developmental period that signals the transition from childhood to adulthood [1]. For adolescent girls, the striking body and social changes taking place during puberty and early adulthood strongly influence their body image. Developmental (e.g., pubertal timing), psychological (e.g., self-esteem), and sociocultural (e.g., culturally defined and transmitted messages regarding attractiveness) factors are involved in the development and maintenance of body image disturbance and related issues in adolescents [2]. Body image is a multidimensional construct reflecting the way one perceives oneself [3]. An increasing trend of preoccupation with body image is observed in young children of both sexes at puberty [4], and relevant research has documented negative thoughts about their body figure in children even before they reach puberty [5,6].

Body dissatisfaction in preadolescent girls has been associated with dieting and excessive exercise, and with low self-esteem [7]. Studies have revealed that even before the age of six years, some girls express a desire to be thinner [8], with a negative impact on their attitude towards food and their eating behavior, with effects such as food restriction and refusal to eat their meals with other family members as these girls are growing up and entering puberty [9]. Such phenomena play a catalytic role in the determination of body image later in life and mainly in adolescence and young adulthood [10].

Research findings regarding the role of age in the body image of adolescents are inconsistent. Some research suggests that as children grow up, their concerns about body weight and shape tend to increase [7], becoming intense in adolescence [11], while body self-appreciation and resilience against negative appearance decrease with age [12]. Other researchers suggest a more positive trend in appearance esteem as adolescents move from early adolescence to emerging adulthood. One study [13] demonstrated that a decline in the self- esteem of early adolescents related to appearance was followed by an upward trend in late adolescence, and another [14] showed that late adolescents applied more protective body image strategies (e.g., ignoring negative appearance information, critically filtering media ideals, and deprioritizing the pursuit of having an ideal body), resulting in higher body satisfaction.

The rapid, complex hormonal changes that take place in puberty, in combination with physical and cognitive development [15], require a considerable degree of adaptation by the growing individuals. Children entering or going through puberty are becoming more autonomous, but they also become highly susceptible to developing various behavioral disturbances, and in particular eating disorders [16,17]. In female pre-adolescents, a relationship between body image concerns, low self-esteem and disordered eating attitudes and behaviors has been identified, prompting the need for appropriate intervention [18]. This relationship has also been found in and adolescents [19–21].

Some researchers note that disordered eating is more common among girls and boys who experience the early onset of puberty, suggesting that both biological and psychosocial mechanisms may act as potential triggers [22]). The biological maturation of females during puberty is followed by a significant increase in the levels of adipose tissue [23], which is often associated with an increase in body dissatisfaction [24]. Two adipokines that are linked with fat metabolism, adiponectin and leptin, are secreted by the white adipose tissue, and their serum levels usually vary at different stages of biological maturation [25]. Leptin appears to play a significant role in the onset and progression of puberty [26]. In a recent review, leptin and adiponectin are presented as key players in the onset of puberty through their effects on the hypothalamic-pituitary-gonadal axis. It is suggested that the initiation of puberty, apart from genetic predisposition, is catalytically determined by body fat accumulation and the level of adipokines, while extreme values have been reported in the levels of adipokines in eating disorders [27].

Recognizing that the body works as a whole, and that hormonal changes during puberty have a bidirectional relationship with body composition and behavior, we aimed to investigate disordered eating behavior and body image in girls in relation to their biological maturation, and to explore their association with of leptin and adiponectin levels. We hypothesize that a confirmation of the association among such biological measures, physical changes and disordered eating attitudes will facilitate timely, relevant action for the prevention or early treatment of eating disorders. The need of associating physical changes with eating attitudes, body image and eating disorders is high, as the screening for the last is usually through self-reported questionnaires, which are inherently biased by the person's feelings at the time they fill them out [28,29].

2. Results

Of the 1206 girls in the study sample aged 10–12 years (mean age 11.26 $\pm$ 0.6 years), 270 girls already had menses. The distribution according to TS was: TS1 261 (22%), TS2 469 (38%), TS3 314 (26%), TS5 39 (3%).

Table 1 presents the age, anthropometric data and levels of leptin and adiponectin of the girls in the study sample, according to their TS. The age of the girls was significantly lower in those in TS 1and 2 (10.6 ± 0.6, 11.1 ± 0.7, $p = 0.01$) than in the other stages, but no age differences were observed between TS 3, 4 and 5.

Table 1. Anthropometric data and adipokine levels according to Tanner Stage (TS) of maturation in 10–11-year-old girls (N = 1206).

	TS1 (Mean ± SD)	TS2 (Mean ± SD)	TS3 (Mean ± SD)	TS4 (Mean ± SD)	TS5 (Mean ± SD)	*p*-Value
N = 1206	261	469	314	132	30	
Age (years)	10.6 ± 0.6 ^{a,b,c,d}	11.1 ± 0.7 ^{a,e,f,g}	11.4 ± 0.6 ^{b,e}	11.5 ± 0.7 ^{c,f}	11.7 ± 0.6 ^{d,g}	0.001 $^{+}$
Weight (kg)	37.6 ± 8.8 ^{a,b,c,d}	43.9 ± 9.4 ^{a,e,f,g}	49 ± 10.4 ^{b,e,h,i}	52.1 ± 10.2 ^{c,f,h}	55.7 ± 8.8 ^{d,g,i}	0.001 $^{+}$
Height (cm)	142.6 ± 7.3 ^{a,b,c,d}	148.3 ± 6.9 ^{a,e,f,g}	152.8 ± 6.8 ^{b,e,h,i}	155 ± 7.1 ^{c,f,h}	156.6 ± 5.7 ^{d,g,i}	0.001 $^{+}$
BMI	18.4 ± 3.3 ^{a,b,c,d}	19.9 ± 3.6 ^{a,e,f,g}	20.9 ± 3.6 ^{b,e}	21.6 ± 3.4 ^{c,f}	22.7 ± 3.3 ^{d,g}	0.001 $^{+}$
Leptin (μg/mL)	8.9 ± 7.5 ^{a,b,c}	11.4 ± 9.5 ^{a,d}	14.1 ± 10.7 ^{b,d}	14 ± 10.3 ^{c}	14.2 ± 8.2	0.001 $^{+}$
Adiponectin *(μg/mL)	7.8 ± 3.4 ^{a,b}	7.1 ± 3.1 ^{a}	7.2 ± 3.3	6.8 ± 2.7	5.6 ± 2.01 ^{b}	0.002 $^{++}$

SD = standard deviation; BMI = Body Mass Index, * Variable was log-transformed, $^{+}$ Derived from Kruskal-Wallis Test, $^{++}$ Derived from One-way ANOVA; Differences annotated with the same letter (a to i) are statistically significant after Bonferroni correction.

Body weight and height increased with age and showed significant differences between TS, with the exception of TS 4 and 5 (body weight 52.1 ± 10.2 kg v 55.7 ± 8.8 kg, $p = 0.01$). BMI was significantly lower in TS 1 and 2 (18.4 ± 3.3, 19.9 ± 3.6, $p = 0.01$) than in all the other TS, but no significant differences in BMI were detected between TS 3, 4 and 5.

The level of leptin was significantly lower in girls in TS 1 than in all the other TS, and lower in TS 2 than in TS 4 (11.4 ± 9.5 units, 14 ± 10.3 units, $p = 0.01$). Conversely, the level of adiponectin was significantly higher in TS 1 than in TS 2 and 5 (7.8 ± 3.4 μg/mL, 7.1 ± 3.1 μg/mL, 5.6 ± 2.01 μg/mL, $p = 0.01$).

Table 2 shows the differences in the mean scores of the girls on the individual components of the DEBQ and ChEAT questionnaires, according to the TS. As far as their eating behavior is concerned, the "emotional eating" and "external eating" scores on the DEBQ were similar in all the TS categories, but "restraint eating" showed a significantly higher score in TS1 than in TS 3 and 4 (24.66 ± 9, 27.22 ± 9.15, 29.09 ± 9.05, $p = 0.01$). On the ChEAT scales, the scores for "dieting", "food preoccupation" and "food awareness" showed no significant difference across the TS range. The score for "body image" was significantly higher in TS 2, 3, and 4 than in TS1 (10.2 ± 5.06, $p = 0.01$), while that for "social pressure to eat" was significantly higher in TS 1 than in TS 3, 4 and 5 (5.47 ± 3.05, 4.68 ± 2.93, 4.43 ± 2.92, 4 ± 2.75, $p = 0.01$).

Table 2. Mean scores on components of Dutch Eating Behavior Questionnaire (DEBQ) and Children's Eating Attitudes Test (ChEAT) according to Tanner Stage (TS) of maturation in 10–11-year-old girls (N = 1206).

Components of Eating Questionnaires	TS 1 (Mean ± SD)	TS 2 (Mean ± SD)	TS 3 (Mean ± SD)	TS 4 (Mean ± SD)	TS 5 (Mean ± SD)	*p*-Value $^{++}$
DEBQ						
Emotional eating score	22.86 ± 11.58	22.88 ± 9.64	23.51 ± 9.73	21.92 ± 9.12	20.48 ± 6.54	0.38
External eating score	24.81 ± 6.74	24.51 ± 9.14	24.45 ± 6.41	23.95 ± 6.68	23.04 ± 5.93	0.43
Restraint eating score	24.66 ± 9 ^{a,b}	26.56 ± 9.83	27.22 ± 9.15 ^{a}	29.09 ± 9.05 ^{b}	29.1 ± 8.83	<0.01
ChEAT						
Total dieting score	6.73 ± 3.71	7.08 ± 3.73	7.27 ± 3.83	7.42 ± 3.46	7.8 ± 3.81	0.11
Total body image score	10.2 ± 5.06 ^{a,b,c}	11.54 ± 4.77 ^{a}	12.07 ± 4.87 ^{b}	12.75 ± 4.52 ^{c}	12 ± 4.74	<0.01
Total food preoccupation score	6.71 ± 3.41	6.61 ± 3.23	6.67 ± 3.53	6.61 ± 3.12	6.1 ± 3.1	0.91
Total food awareness	9.18 ± 3.75	9.04 ± 3.8	8.93 ± 3.61	9.45 ± 3.51	8.31 ± 3.19	0.51
Total social pressure to eat score	5.47 ± 3.05 ^{a,b,c}	5 ± 3.14	4.68 ± 2.93 ^{a}	4.43 ± 2.92 ^{b}	4 ± 2.75 ^{c}	<0.01

SD = standard deviation, Differences annotated with the same letter are statistically significant after Bonferroni correction, $^{++}$ Derived from Kruskal-Wallis Test; Differences annotated with the same letter (a to c) are statistically significant after Bonferroni correction.

The crude associations between the scores on the various components of the DEBQ and ChEAT with the levels of adiponectin and leptin are presented in Table 3. Regarding adiponectin, a positive association was observed between adiponectin level and the score on the ChEAT "social pressure to eat" component ($p < 0.001$). Leptin levels showed correlation with a greater number of components, specifically positive association with the "restraint eating" score on DEBQ, and the ChEAT components "dieting", "body image" and "food awareness" ($p < 0.001$). A negative association was demonstrated between leptin level and the DEBQ "external eating" score and the ChEAT "social pressure to eat" score ($p < 0.001$). Correction of these associations for TS and BMI resulted in loss of the significant crude associations, with the exception of the positive association observed between the ChEAT "body image" score leptin level ($p = 0.024$) (Table 4).

Table 3. Crude [b] association between scores on the components of the Dutch Eating Behavior Questionnaire (DEBQ) and the Children's Eating Attitudes Test (ChEAT) and the serum levels of adipokines in 10–12-year-old girls (N = 1206).

Components of Eating Questionnaires	ADIPONECTIN [a] (μg/mL)		LEPTIN [a] (μg/mL)	
	β	*p*-Value	β	*p*-Value
DEBQ components				
Emotional eating score [a]	0.04	0.33	−0.03	0.63
External eating score [a]	0.08	0.12	−0.34	<0.01
Restraint eating score [a]	−0.06	0.14	0.84	<0.01
ChEAT components				
Total dieting score [a]	−0.04	0.13	0.52	<0.01
Total body image score [a]	-0.03	0.20	0.60	<0.01
Total food preoccupation score [a]	0.02	0.52	0.07	0.21
Total food awareness [a]	−0.02	0.58	0.25	<0.01
Total social pressure to eat score [a]	0.08	<0.01	−0.39	<0.01

β: unstandardized beta coefficient, [a] Variable was log-transformed, [b] Crude associations include one dependent variable and one independent variable without adjustment for any confounder.

Table 4. Adjusted association [b] between scores on the Dutch Eating Behavior Questionnaire (DEBQ) and Children's Eating Attitudes Test (ChEAT) and serum levels of adiponectin and leptin in 10–11-year-old girls (N = 1206).

	ADIPONECTIN [a] (mg/mL)		LEPTIN [a] (mg/mL)	
	β	*p*-Value	β	*p*-Value
DEBQ components				
Emotional eating score [a]	0.01	0.60	0.02	0.38
External eating score [a]	0.02	0.51	−0.01	0.90
Restraint eating score [a]	0.05	0.15	0.02	0.29
ChEAT components				
Total dieting score [a]	0.04	0.19	0.01	0.55
Total body image score [a]	0.06	0.06	0.05	0.02
Total food preoccupation score [a]	0.02	0.42	0.01	0.65
Total food awareness [a]	0.02	0.50	−0.01	0.81
Total social pressure to eat score [a]	0.04	0.21	0.03	0.11

β: unstandardized beta coefficient, [a] Variable was log-transformed, [b] Adjusted for age, BMI.

3. Discussion

This study examined the possible associations between distorted eating behaviors, as assessed by the DEBQ and ChEAT questionnaires, with the serum levels of adiponectin and leptin in 10–12-year-old girls at different TS of maturation. We found that the girls in this study had increased restraint eating behaviors, dieting, and awareness about body image and food, at higher TS, when leptin was higher.

The girls in this study expressed various disordered eating behaviors at different TS of maturation, according to their scores on the DEBQ and ChEAT questionnaires. Specifically, the scores of the "external eating" and "restraint eating" DEBQ components, and the score of the "social pressure to eat" ChEAT component were higher in girls at earlier TS. These findings are in agreement with previous research that reveals a significant effect on the eating behavior of young girls of beauty standards formed by sociocultural factors, including parents, peers and the media [30]. A proportion as high as 40–50% of children from western countries express a dissatisfaction with their body image that affects their eating attitudes before they have even reached puberty [31]. Concerns about body image in childhood have been associated with many psychological health issues, including lower self-esteem [32]. Some studies describe early-adolescent girls as being the most vulnerable to the "thin-ideal" internalization and as having the most severely disturbed eating behaviors [33].

It is possible that girls use restraint from food as a measure to balance the pressure they feel from the external environment. In the study of Tatangelo and Ricciardelli (2013), body ideals for girls in pre-adolescence appeared to be strongly affected by peers and the media, pushing them towards wanting to have a slimmer body, and therefore to the use of weight reduction strategies [34]. At this stage of development, however, girls experience an increase in appetite [35], which is linked to high levels of adiponectin, among other hormones.

In this study, the girls showed a tendency to suppress their hunger as the high external pressure eating attitude scores increased. The augmentation of adiponectin, produced by the white adipose tissue in pre-adolescence, stimulates the appetite in anticipation of the forthcoming growth spurt. As suggested by Barbe and colleagues (2019), adiponectin receptors might be present in two gonadotropins essential for the process of gametogenesis, namely follicle stimulating hormone (FSH) and luteinizing hormone (LH) [36]. The body demands an adequate food supply for the energy required for the rapid changes from childhood to adulthood. Some children at this stage, however, might start denying food due to external pressures urging them to be thin. In anorexia nervosa, where food intake is minimal, the serum level of adiponectin is noticeably raised, although the body fat levels are extremely low [37]. In this context, the adipose tissue in the bone marrow becomes activated during caloric restriction and contributes to the raised circulating adiponectin [38] in an effort to stimulate the appetite and to increase food intake.

Relevant educational efforts aiming to prevent such ideation developing in young girls should focus on the adult "influencers", finding ways to discourage them from delivering misleading messages to growing children and ways to reduce the pressure on them regarding their body image and eating habits. These adult influencers in these early developmental stages (TS1, 2) could be parents and teachers [39], while for the later stages they might be famous athletes and social influencers [40]. This study also showed that the more mature girls with higher TS had higher scores on the body image scale. During critical developmental periods, in this case adolescence, when various changes in physical, hormonal, and cognitive development are experienced, anxiety about physical appearance often increases [41], especially among girls [42]. The changes in body shape and composition associated with higher adipose tissue levels have been reported as additional factors in the development of negative body image [43].

In the study population, the serum levels of leptin, which also has a hunger suppressive effect, and is involved in the long-term regulation of energy balance and body weight [44], increased with the increase in TS. The amount of total body fat alters the serum

levels of leptin [45], but increased leptin levels have also been found to be correlated with obesity and loss of eating control in young children and adolescents [45].

We found that a raised leptin level at a higher TS was associated with an increase in restraint eating behaviors, dieting, and awareness about body image and food. As Farooqi and colleagues showed, leptin can decrease ratings in hunger in the fasting state, but also postprandial satiety [46], which provides girls with the efficacy to control their food intake. Physical dissatisfaction is recognized in children long before they reach puberty, and the urge to enhance a positive body image in young children is apparent, and intervention at this stage can help to avert the onset of more serious psychological and physical ramifications later in life [47].

Leptin, apart from suppressing hunger and controlling appetite, mediates metabolic information to the hypothalamo-pituitary-gonadal axis on agouti neurons, affecting mechanisms that give rise to abnormal sexual maturation and fertility attributable to malnourishment, and to leptin resistant obesity [48]. In view of food denial, dieting, and anxiety about food choices and body image that evidently increased at later TS, efforts should be made to provide better social influencers during adolescence. Models must be developed that will provide healthy body ideals and combine balanced dietary habits with adequate but not extreme physical activity and that will alleviate anxiety about elusive body standards.

Considering the human body as a whole and the balance between the metabolic changes (adiponectin-leptin relationship), growth (sexual maturation) and the concerns of young girls related to their maturing bodies, appropriate measures should be adopted to forestall the introduction of abnormal eating behaviors, according to the different developmental stages and the phenotypes of distorted eating behaviors. These efforts should start before the onset of puberty.

It is important to identify the triggers for the different age groups that exacerbate abnormal eating behaviors, and to take appropriate prophylactic measures at the critical time. The hormonal profile will possibly be a good indicator for these specific strategies, as in the early TS stages the body image concerns of girls appear to be related to the influence of their family [49] and other adults in the external environment, such as teachers [50] and coaches [51]. Teachers and coaches should be appropriately educated in terms of nutrition and psychological strategies in relation to body image, and families should be well-informed, with access to support when needed. In this way they will be able to encourage the prepubertal girl to become self-confident and to appreciate herself by focusing on her positive features and cultivating skills for being happy and adapting to new circumstances. In the later pubertal stages, children and adolescents are more influenced by their friends/peers, and by actors, singers, athletes and other role models [52]. The media play an exaggerated role in the communication to young people of beauty standards and body image esthetics [5]. The media could instead aid in building positive appraisal and self-acceptance in young girls. The media can also serve as the route to promote messages about healthy eating behavior and physical activity at this particular age cohort [53].

This study had certain strengths and limitations. It was part of a large-scale epidemiological study, HGA, involving a representative sample of children in Greece and covering urban, semi-urban and rural areas. The data from the associations presented regarding disordered eating behaviors in girls at this age range can therefore be generalized and can provide the basis for the design of measures for prevention and/or intervention. Although the data were not very recent, due to the priorities of HGA, we do not believe that the time frame affected the validity of the study. The data analysis for the present study was confined to girls. Body image concerns are also observed in pre-adolescent and adolescent boys, but they will be the subject of a later analysis. The adjustment for certain possible confounders probably resulted in higher accuracy of the results, but the cross-sectional design of the study does not allow the establishment of the causality of distorted eating behaviors in girls at different TS. As DEBQ and ChEAT are self-reported questionnaires, the data are qualitative, and as such are subject to self-reporting bias and indicate perceptions rather than behavior.

4. Materials and Methods

4.1. Population Sample

The Greek Healthy Growth Study (HGS) was a large-scale cross-sectional epidemiological study initiated in May 2007 and completed in June 2009. The initial findings of the study have already been published [54–58]. Approval to conduct the study was provided by the Greek Ministry of National Education and the Ethical Committee of Harokopio University of Athens (16/19.12.2006) and supported with a research grant from the Friesland Foods Hellas and facilitated by the EU-funded HOPE project 'Health promotion through Obesity Prevention across Europe (the Commission of the European Communities, SP5A-CT-2006-044128)' [59].

The study population was a representative sample of 9–13-year-old schoolchildren living in the four counties in the study, which are scattered throughout Greece, covering the northern (i.e., Thessaloniki), central (i.e., Attica), western (i.e., Aitoloakarnania), and southern (i.e., Iraklio-Crete) parts of the country (indicating potential representativeness at a national level). The sampling of schools participating in the HGS was random, multistage, and stratified by parental educational level and the total population of students attending schools within the municipalities of these counties. A detailed letter explaining the aims of the study and a consent form for conducting full measurements was provided to all parents or guardians ("parents" hereinafter) with a child in these schools. Parents who responded positively were asked to sign the consent form and provide their contact details. Data from children and their parents were collected by face-to-face interviews and clinical assessments conducted at school sites. Of the 4145 children who were eligible to participate, 2656 were enrolled in the study (64.1% response) after the parents granted consent on behalf of the children. Detailed methodology has been published elsewhere [60]. Of these 2656 children, a subsample of 1206 girls for whom a full dataset existed on both the independent and dependent variables was used for analysis for the purposes of the present study.

4.2. Data Collection

As part of this study, specific questionnaires were administered, physical examination and anthropometric measurements were made, and blood tests were conducted, all within the specifications of the HGS.

4.3. Measures

4.3.1. Questionnaires

Two standardized questionnaires were administered in order to assess eating behavior (emotional, external, restrained eating) and eating behavior disorders, respectively:

Eating behavior was assessed using the Greek version of the Dutch Eating Behavior Questionnaire (DEBQ) [61] for children aged 7–12 years. This questionnaire consists of 13 questions on "emotional eating", referring to eating behavior affected by emotions; 10 questions on "external eating", referring to eating behavior affected by external stimuli; and 10 questions on "restrained eating", referring to eating behavior influenced by personal restrictions. The Cronbach alpha ranged from 0.73 to 0.82 [62].

The Children Eating Attitudes Test (ChEAT) [63] is a validated questionnaire that was used to assess the level of disordered eating behavior. This is a self-reported 14-item questionnaire with a score range between 0–78 points, with the higher scores indicating greater severity for each of the following components: total ChEAT score, dieting score, body image, food preoccupation, food awareness, and social pressure to eat [63].

4.3.2. Physical Examination and Anthropometry

The participants were weighed (while wearing light clothes) to the nearest 10 g using a Seca digital scale (Seca Alpha, Model 770, Hamburg, Germany). Height was measured to the nearest 0.1 cm using a commercial stadiometer (Leicester Height Measure, Invicta Plastics, Oadby, UK) with the participant standing barefoot, with the shoulders in a relaxed position, the arms hanging freely and the head in the Frankfort horizontal plane. Body mass

index (BMI) was calculated using Quetelet's equation: weight (kg)/height (m^2). Using the International Obesity Task Force (IOTF) cut-off points, the children were categorized as "underweight", "normal weight", "overweight" or "obese" [64].

The study population was sub-grouped according to the level of biological maturation. One trained female pediatrician in each prefecture determined the biological maturation of each participant according to a sexual maturity rating system based on Tanner's classification scheme. The five Tanner Stages (TS) correspond to: (1) prepubertal, (2) beginning pubertal, (3) midpubertal, (4) advanced pubertal, (5) postpubertal [16].

4.3.3. Biochemical Indices

After a 12-h overnight fast, an early morning venous blood sample was drawn from each participant for biochemical tests as described in detail elsewhere [61].

The serum leptin level was measured by a human leptin ELISA, Clinical Range kit (BioVendor Research and Diagnostic products, Karasek, Czech Republic) and was reported in ng/mL. The serum adiponectin level was measured by a Human Adiponectin/Acrp30 Duo Set ELISA kit (R&D Systems, Minneapolis, MN, USA) and reported in μg/mL.

4.4. Statistical Analysis

Normality of the distribution of all continuous variables was evaluated using the Kolmogorov-Smirnov test. Other parameters examining the normality of the examined variables were tested, including skewness, kurtosis, and outliers, showing the same results as the normality test. Non-normally distributed variables were log-transformed. Continuous variables are presented as mean ± standard deviation (SD).

Analysis of Variance (ANOVA) was used to compare the anthropometric data, levels of adiponektin, DEBQ and ChEAT scores between girls at different TS. The Bonferonni correction was applied where necessary for all post-hoc comparisons, and the non-parametric Kruskall-Wallis test was used when needed.

The levels of leptin and adiponectin and the scores of the different components of DEBQ and ChEAT were non-normally distributed, and after the log-transformation they remained non-normally distributed. Comparisons of categorical variables between TS were examined with the chi-square test in addition to the two-sample Z-test for pair-wise comparisons. Linear regression analysis was performed to test the associations of DEBQ and ChEAT and the levels of leptin and adiponectin. Univariate and multivariate linear regression analysis was performed to test for the association between the components of DEBQ and ChEAT with TS. Statistical analysis was conducted using the Statistical Package for Social Sciences (SPSS, version 21.0, Armonk, NY: IBM Corp.). All analyses were two-tailed and the level of statistical significance was set at $p < 0.05$.

5. Conclusions

This study linked certain components of the ChEAT and DEBQ scales with the normally expected differences of the serum levels of leptin and adiponectin related to the changes in body composition of young girls in different pubertal stages. After adjusting for potential confounders, including TS and BMI, only body image retained a statistically significant relationship. It was apparent that various concerns regarding body image triggered distorted eating behaviors in these girls. These findings should be taken into consideration from a public health perspective when decisions are made regarding measures for the prevention of eating disorders in young girls. Specific measures should be elaborated at different developmental and educational levels, and societal initiatives including in-school interventions (aided by specialized school personnel, such as school nurses, who are able to recognize the developmental stages), should play a key role in interventions.

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