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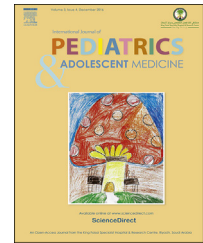


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Original Research Article

# Regional differences in the prevalence of underweight, overweight and obesity among 13-year-old adolescents in Greece



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## KEYWORDS

Central obesity;  
Abdominal obesity;  
Waist circumference;  
Weight status;  
Adolescence;  
Obesity surveillance

**Abstract** *Background and objectives:* To assess regional differences in the weight status and abdominal obesity among 13-year-old Greek adolescents.

*Design and setting:* Cross-sectional, nationwide study in Greece.

*Patients and methods:* A representative sample of 4833 13-year-old adolescents (50.7% boys) was recruited throughout the nine regional districts of Greece from 2010 to 2012. Basic anthropometry measurements (weight, height, and waist circumference) were obtained. Abdominal obesity and weight status were assessed according to the International Obesity Task Force criteria.

*Results:* The majority of the sample had a healthy body weight (60.3%), 4.1% were underweight, 27.2% were overweight, and 8.5% were obese. For boys, the highest prevalence of underweight was recorded in Epirus, normal body weight on the Ionian Islands, overweight in Central Greece and Macedonia, and obesity on the Ionian Islands. Among girls, the highest underweight prevalence was on the Ionian Islands, normal body weight in Macedonia, overweight in Central Greece and Macedonia, and obesity in Crete. Abdominal obesity affected 12.9% of the sample, with the greatest prevalence among Cretan boys and Thracian girls. Additionally, residing on the Greek islands was associated with a higher prevalence of central adiposity.

*Abbreviations:* BMI, Body Mass Index; CBC, Cannot Be Calculated; CI, Confidence Interval; COB, Central Obesity; IOTF, International Obesity Task Force; NR, Not Reported; OB, Obesity; PR, Prevalence Ratio; UW, Underweight.

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**Conclusion:** Greek 13-year-old adolescents who are subjected to geographical changes exhibit high obesity and abdominal obesity rates. This study provides evidence to design regionally tailored interventions that aim to tackle and prevent the disease among the nine regional districts in Greece.

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## 1. Introduction

Early adolescence consists of a period of major metabolic, psychological, and physiological adjustments. This naturally occurring, radical metabolic transition along with the increased risky behavior and reduced physical activity levels that are both associated with adolescence act synergically to multiply the prevalence of overweight during this period of life [1,2].

According to the STRIP intervention, children who are overweight at the age of 13 years had actually begun to gain more weight than their normal body weight peers by the age of two years old [3]. Many youngsters are affected by multiple components of metabolic syndrome [4], and it has been estimated that approximately 10% of overweight 13-year-old adolescents fulfill the syndrome's diagnostic criteria [5]. More than half of 13-year-old overweight boys and nearly 2/3 of girls develop into obese adults [6], whereas many suffer from body dissatisfaction [7]. Overweight, early adolescent girls have also reported a negative health-related quality of life [8].

Despite the multiple national and European Union (EU) funds spent on studying obesity during the last few decades, nutritional surveillance remains inadequate in Greece, a country with a high obesity rate [9]. According to a nutrition policy meeting that took place under the wing of the Greek Ministry of Health in July 2015, the national database urgently needs to be updated with data concerning certain age groups and specific geographical regions of the country. National data collections appear limited in the capital and in major cities, and the age distribution of obesity prevalence studies is scattered [10]. Hence, childhood and adolescent obesity are among the national health priorities, according to the Ministry of Health's agenda.

Thus, the aim of the present study was to present the national and regional prevalences of underweight, overweight, and obesity among 13-year-old adolescents in Greece.

## 2. Patients and methods

A nationally representative sample of 4833 13-year-old Greek adolescents (50.7% boys) was derived as a nested cohort from the ADONUT study [10]. The sample was selected through proportionate stratified random sampling. The recruitment took place in the participants' schools. Participation in the study was voluntary, after approval was granted by the children's parents/guardians. The Directorate of Secondary Education, the Greek Ministry of Education and the Alexander Technological Educational

Institute's Research Committee approved the study. All data have been handled in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) for data involving humans.

## 3. Anthropometry

Trained dieticians retrieved anthropometric indices during the morning hours. Anthropometry involved measurement of body weight to the nearest 0.1 kg and height to the nearest 0.1 cm using SECA 874 portable digital scales and SECA 214 portable stadiometers (SECA, Hamburg, Germany), respectively. Body mass index (BMI) was calculated as body weight divided by squared height ( $\text{kg}/\text{m}^2$ ). Adolescents were categorized by BMI according to the International Obesity Task Force (IOTF) weight-status cutoffs [11,12]. In brief, underweight boys were those with a  $\text{BMI} < 15.84 \text{ kg}/\text{m}^2$ , overweight boys were those with a  $21.91 \leq \text{BMI} < 26.84 \text{ kg}/\text{m}^2$ , and obese boys were those with a  $\text{BMI} \geq 26.84 \text{ kg}/\text{m}^2$ . Among 13-year-old girls, underweight was defined as a  $\text{BMI} < 16.26 \text{ kg}/\text{m}^2$ , overweight as  $22.58 \leq \text{BMI} < 27.76 \text{ kg}/\text{m}^2$ , and obese as  $\text{BMI} \geq 27.76 \text{ kg}/\text{m}^2$ . The IOTF classification was selected for this study to provide similar overall obesity results to the WHO growth charts [13]; moreover, it is more frequently used in adolescent research [14], and it allows for better comparability with other published studies [10,15]. Waist circumference was measured according to a standardized method [16], using a common inelastic tape to the nearest 0.5 cm. Abdominal obesity was diagnosed according to the criteria set by the International Diabetes Federation for European–American children [17].

## 4. Statistics

The 21st version of the Statistical Package for Social Sciences (SPSS Inc., Hong Kong) was used for data analyses. Comparisons between categorical values were conducted with chi-square tests and prevalence ratios (PR), which are suitable for cross-sectional studies [18]. A  $P$  value  $\leq .05$  was considered significant. A geographical map was created with GIMP 2.8.2 software for OS X, and the bubble chart was designed with Microsoft® Excel® for Mac 2011.

## 5. Results

In the total sample of 13-year-old adolescents, 4.1% were categorized as underweight, the majority (60.3%) were categorized as having a normal body weight. The prevalences of overweight and obesity were 27.2% and 8.5%,

respectively. Abdominal obesity affected 12.9% of the total sample, coinciding with simple obesity in approximately half of the cases (6.2%).

The regional epicenters of each body weight status category according to sex are presented in Table 1. Overall, in terms of prevalence, 3.1% of boys were underweight, 57.0% were considered normal body weight, and the remaining (39.9%) were either overweight or obese. In the nine geographical regions, underweight among boys were most prevalent in Epirus (7.9%) with two-fold and three-fold larger PRs than those of Central Greece and Macedonia (PR = 2.77, 95%CI:1.22–6.25,  $P \leq .011$  and PR = 3.42, 95%CI:1.72–6.79,  $P \leq .001$ , respectively). The largest prevalence of normal body weight was recorded among boy residents of the Ionian Islands (66.7%). The highest prevalences of overweight among adolescent boys were in Central Greece (33.5%) and Thrace (40.0%). The highest prevalence of obese boys was recorded among islanders (Ionian Islands 16.7%; Aegean Islands 14.4%; Crete 13.2%). Among girls, the vast majority exhibited normal body weight (63.2%), 5.3% were underweight, 25.1% were overweight, and 6.6% were obese. In the Ionian Islands, 22.0% of the girls were underweight; this prevalence was significantly higher than that of Thrace ( $P \leq .022$ ), Epirus ( $P \leq .013$ ), Thessaly ( $P \leq .042$ ), Central Greece ( $P \leq .048$ ), and Macedonia ( $P \leq .008$ ). Girls who resided in Macedonia had the greatest prevalence of healthy body weight, with a greater PR than that of Peloponnese (PR = 1.27, 95%CI:1.02–1.59,  $P \leq .046$ ) and Crete (PR = 1.65, 95%CI:1.14–2.37,  $P \leq .027$ ). Half of the girls from Thrace were overweight (50%). Obesity highly prevalent among Cretan girls (8.7%) as well as girls from Central Greece (7.1%).

Differences between 13-year-old boys and girls regarding abdominal obesity are presented in Table 2. In the total sample, abdominal obesity was diagnosed in 13.9% of the boys and 11.5% of the girls. Abdominal obesity coincided with simple obesity in 7.8% of boys, whereas it occurred in 4.5% of girls. Boys from Crete and Thessaly had the highest ratio of abdominal obesity (23.7% and 20.6%, respectively). Peloponnesian boys were the least affected by central obesity (9.8%); they had a lower PR than inhabitants of the Aegean Islands (PR = 0.49, 95%CI:0.26–0.92,  $P \leq .022$ ), Crete (PR = 0.42, 95%CI:0.19–0.92,  $P \leq .030$ ), and Thessaly (PR = 0.48, 95%CI:0.26–0.89,  $P \leq .014$ ). Girls from Thrace exhibited the highest prevalence of abdominal obesity (27.3%), whereas girls from the Ionian Islands (0.0%) and Peloponnese exhibited the lowest (3.6%). Compared with girls from Crete, Peloponnesian girls had a lower PR of abdominal obesity (PR = 0.21, 95%CI:0.06–0.76,  $P \leq .011$ ), and the remaining six regions demonstrated a greater PR of central obesity (Aegean: PR = 1.17, 95%CI:1.07–1.27,  $P \leq .001$ ; Thrace: PR = 1.33, 95%CI:1.02–1.72,  $P \leq .001$ ; Epirus: PR = 1.15, 95%CI:1.05–1.26,  $P \leq .002$ ; Thessaly: PR = 1.21, 95%CI:1.12–1.31,  $P \leq .001$ ; Central Greece: PR = 1.07, 95%CI:1.02–1.12,  $P \leq .04$ ; Macedonia: PR = 1.08, 95%CI:1.04–1.12,  $P \leq .016$ ).

After stratification of the participants who resided on the islands (the Aegean and Ionian Islands, as well as Crete), they exhibited greater prevalences of abdominal obesity (PR = 1.52, 95%CI:1.21–1.90,  $P \leq .001$ ) and concurrent simple and abdominal obesity (PR = 1.59, 95%

CI:1.13–2.23,  $P \leq .008$ ) than the mainland residents. With regards to sex, boys who lived on the islands had a higher proportion of abdominal obesity than those who lived in mainland Greece (PR = 1.56, 95%CI:1.17–2.09,  $P \leq .004$ ). This finding did not extend to girls. Girls residing on the islands demonstrated a greater prevalence of underweight (PR = 1.76, 95%CI:1.03–3.00,  $P \leq .039$ ).

Fig. 1 represents a bubble chart map of the pooled prevalence of overweight and obesity between boys (blue) and girls (red) who resided in different geographical regions within Greece. The size of each bubble represents the pooled prevalence of overweight and obesity. The highest pooled prevalence was observed among girls in Thrace (50.0%) and Aegean boys (44.5%). The lowest prevalence was observed in girls who inhabited the Ionian Islands (22.2%) and boys from Epirus (26.9%).

## 6. Discussion

Our study indicates that among 13-year-old Greek adolescents, 4.1% were underweight, the vast majority (60.3%) had a healthy body weight, 27.2% were overweight, and the remaining 8.5% were obese. Body weight status varied widely among participants with prominent regional influences. In the girls, the highest prevalence of both overweight and obesity was recorded in Thrace (50.0%), followed closely by that in Crete (47.8%). The majority of overweight boys resided in the Aegean Islands (44.5%) and in Central Greece (44%). Abdominal obesity ranged from as low as 6.7% in the peninsula of Peloponnese and the Ionian Islands to as high as 21.9% in Thrace.

The prevalence of abdominal obesity was 12.9% in our sample (13.9% for boys and 11.5% for girls). Although the pooled prevalence does not appear to be alarmingly high, after considering the regional distribution, central obesity affected a large proportion of 13-year-old adolescents in Crete (21.3%), Thessaly (20.5%), and the Aegean Islands (18.9%). During adolescence, visceral adiposity is associated with decreased bone and muscle density [19], insulin resistance, metabolic syndrome [20], and elevated resting heart rate (in boys) [21]. Furthermore, waist circumference has been shown to increase with age among adolescent boys and girls [10,22,23]. Although 12.9% of the adolescents exhibited central adiposity, concurrent abdominal and simple obesity was present in only half of those cases (6.2%), with the remaining 6.7% of participants exhibiting excess waist circumference without being classified as obese according to the BMI age- and gender-specific cut-offs. According to the International Diabetes Federation [24], these two types of obesity tend to coexist, but this was not the case in our study or in previous studies on adolescents [10,23]. This finding indicates that adolescent obesity diagnosis and therapy should be based not only on the BMI classification but on other factors as well, such as visceral adiposity, which is often neglected when BMI falls within the "normal" range.

The findings showed that residing on the Greek islands was associated with a greater prevalence of obesity than residing in the mainland in the total sample ( $P \leq .001$ ) as well as in boys ( $P \leq .004$ ). As observed in Table 1, the highest obesity trends were reported in islanders of both

**Table 1** Prevalence of each category of body weight among 13-year-old boys and girls according to geographical region of residence.

Geographical district	Boys												Girls														
	N	Underweight			Normal body weight			Overweight			Obese			N	Underweight			Normal body weight			Overweight			Obese			
		n	%	CI	n	%	CI	n	%	CI	n	%	CI		n	%	CI	n	%	CI	n	%	CI	n	%	CI	
Epirus	126	10	7.9	3.2	82	65.1	56.6–73.5	24	19.0	12.1	10	7.9	3.2	112	4	3.6 <sup>§</sup>	0.1	69	61.6	52.5	32	28.6 <sup>¶</sup>	20.1	7	6.3	1.7	
				–12.7						–26.0			–12.7				–7.1			–70.8			–37.1			–10.8	
Thessaly	209	11	5.3 <sup>‡</sup>	2.2	117	56.0	49.2–62.8	60	28.7 <sup>†</sup>	22.5	21	10.0	15.1	200	11	5.5 <sup>§</sup>	2.3	127	63.5	26.8	54	27.0 <sup>¶</sup>	20.8	8	4.0	1.2	
				–8.3						–34.9			–26.1				–8.7			–70.2			–33.2			–6.7	
Thrace	10	0	0.0	–	6	60.0	23.1–96.9	4	40.0	30.6	0	0.0	–	22	0	0.0 <sup>§</sup>	–	11	50.0	27.3	11	50.0	27.3	0	0.0	–	
										–76.9										–72.3							
Ionian Islands	6	0	0.0	–	4	66.7	12.5–120.9	1	16.7	–26.2	1	16.7	–26.2	9	2	22.2	–11.7	5	55.6	15.0	2	22.2	–11.7	0	0.0	–	
										–59.5			–59.5				–56.1			–96.1			–56.1				
Crete	38	0	0.0	–	22	57.9	41.4–74.3	11	28.9	13.8	5	13.2	1.9	23	2	8.7	–3.8	10	43.5 <sup>‡</sup>	21.56	9	39.1	17.6	2	8.7	–3.8	
										–44.1			–24.4				–21.2			–65.4			–60.7			–21.2	
Macedonia	1378	32	2.3 <sup>†</sup>	1.5	801	58.1	55.5–60.7	396	28.7 <sup>†</sup>	26.3	149	10.8	9.2	1324	56	4.2 <sup>§§</sup>	3.1	869	65.6	63.1	317	23.9 <sup>¶¶</sup>	21.6	82	6.2	4.9	
				–3.1						–31.1			–12.5				–5.3			–68.2			–26.2			–7.5	
Aegean Islands	153	4	2.6	0.1	81	52.9 <sup>†</sup>	44.9–60.9	46	30.1 <sup>†</sup>	22.7	22	14.4	8.8	133	10	7.5	3.0	81	60.9	52.5	32	24.1 <sup>¶</sup>	16.7	10	7.5	3.0	
				–5.2						–37.4			–20.0				–12.1			–69.3			–31.4			–12.1	
Peloponnese	112	6	5.4	1.1	62	55.4	46.0–64.7	33	29.5	20.9	11	9.8	4.2	112	9	8.0	2.9	63	56.3 <sup>‡</sup>	46.9	35	31.3	22.5	5	4.5	0.6	
				–9.6						–38.0			–15.4				–13.2			–65.6			–40.0			–8.4	
Central Greece	418	12	2.9 <sup>†</sup>	1.3	222	53.1 <sup>†</sup>	48.3–57.9	140	33.5 <sup>††</sup>	28.9	44	10.5	7.6	448	27	6.0 <sup>§</sup>	3.8	282	62.9	58.5	107	23.9 <sup>¶¶</sup>	19.9	32	7.1	4.8	
				–4.5						–38.0			–13.5				–8.2			–67.4			–27.9			–9.5	
Total	2450	75	3.1	2.4	1397	57.0	55.1–59.0	715	29.2	27.4	263	10.7	9.5	2383	127	5.3	4.4	1506	63.2	61.3	599	25.1	23.4	157	6.6	5.6	
				–3.7						–31.0			–12.0				–6.2			–65.1			–26.9			–7.6	

<sup>†</sup>Significantly different compared to Epirus ( $†P \leq .05$ ,  $††P \leq .01$ ).

<sup>‡</sup>Significantly different compared to Macedonia ( $‡P \leq .05$ ).

<sup>§</sup>Significantly different compared to the Ionian islands ( $§P \leq .05$ ,  $§§P \leq .01$ ).

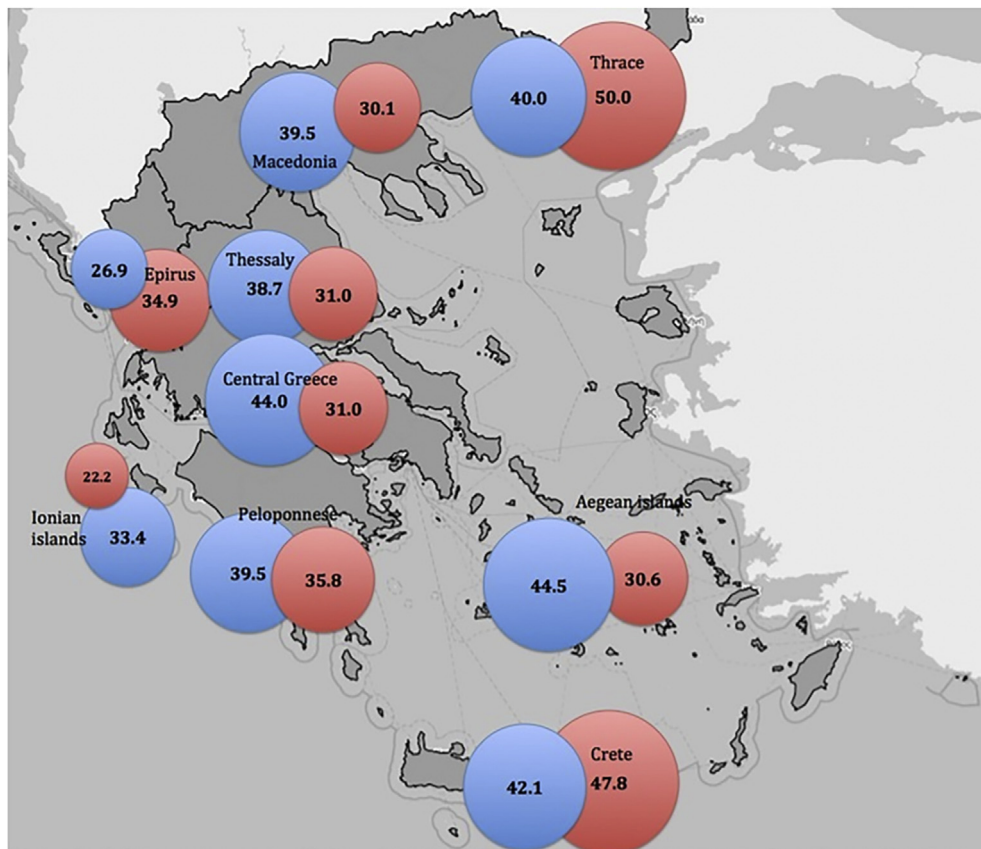
<sup>¶</sup>Significantly different compared to Thrace ( $¶P \leq .05$ ,  $¶¶P \leq .01$ ).

CI: Confidence interval.

**Table 2** Prevalence of abdominal obesity among 13-year-old boys and girls according to geographical region of residence.

County	Boys							Girls						
	COB				OB & COB			COB				OB & COB		
	N	n	%	95%CI	n	%	95%CI	N	n	%	95%CI	n	%	95%CI
Epirus	126	15	11.9	6.2–17.6	8	6.3	2.0–10.7	112	18	16.1 <sup>††</sup>	9.2–23.0	7	6.3	1.7–10.8
Thessaly	209	43	20.6 <sup>†††</sup>	15.1–26.1	15	7.2	3.7–10.7	200	41	20.5 <sup>†††††</sup>	14.9–26.1	7	3.5	0.9–6.1
Thrace	10	1	10.0	–12.6–32.6	0	0.0	–	22	6	27.3 <sup>††††</sup>	7.1–47.5	0	0.0	–
Ionian Islands	6	1	16.7	–26.2–59.5	1	16.7	–26.2–59.5	9	0	0.0	–	0	0.0	–
Crete	38	9	23.7 <sup>†‡</sup>	9.5–37.9	5	13.2	19.0–24.4	23	4	17.4 <sup>†</sup>	0.6–34.2	2	8.7	–3.8–21.2
Macedonia	1378	163	11.8	10.1–13.5	103	7.5	6.1–8.9	1324	142	10.7 <sup>†††</sup>	9.1–12.4	60	4.5	3.4–5.7
Aegean Islands	153	31	20.3 <sup>†‡</sup>	13.8–26.7	16	10.5	5.6–15.4	133	23	17.3 <sup>†††</sup>	10.8–23.8	10	7.5 <sup>†</sup>	3.0–12.1
Peloponnese	112	11	9.8	4.2–15.4	7	6.3	1.7–10.8	112	4	3.6	0.1–7.1	2	1.8	–0.7–4.3
Central Greece	418	67	16.0 <sup>†</sup>	12.5–19.6	36	8.6	5.9–11.3	448	43	9.6 <sup>†</sup>	6.9–12.3	20	4.5	2.5–6.4
Greece	2450	341	13.9	12.6–15.3	191	7.8	6.7–8.9	2383	275	11.5	10.3–12.8	108	4.5	3.7–5.4

Significantly different compared to <sup>†</sup>Epirus ( $P \leq .05$ ,  $^{††}P \leq .01$ ), <sup>‡</sup>Macedonia ( $^{‡}P \leq .05$ ,  $^{†††}P \leq .001$ ), <sup>††††</sup>Thrace ( $^{††††}P \leq .05$ ,  $^{†††††}P \leq .01$ ), <sup>†††††</sup>Peloponnese ( $^{†††††}P \leq .05$ ,  $^{††††††}P \leq .01$ ,  $^{†††††††}P \leq .001$ ), and <sup>†††††††</sup>Central Greece ( $^{†††††††}P \leq .05$ ,  $^{††††††††}P \leq .01$ ,  $^{†††††††††}P \leq .001$ ).  
 CI: Confidence interval; COB: Central obesity; OB&COB: Concurrent simple and central obesity.



**Figure 1** Map of Greece with bubble charts that present the pooled prevalence of overweight, including obesity, according to sex and regional district. The bubble size reflects the prevalence.

sexes. This is in agreement with a Puerto-Rican study that noted that young island inhabitants (10–19 years old) were obese in a greater proportion than those who lived on the US mainland [25]. A recent systematic review [14] showed a greater prevalence of obesity among Cretan adolescents than that among adolescents from the islands of Sicily and

Sardinia in Italy and from the Balearic and Grand Canary Islands in Spain. Whatever the cause behind the increased simple and abdominal obesity found among Greek adolescents living on the islands, this finding requires validation from further research and immediate intervention. A recent study compared Greek children aged 10–12 years

old who lived in urban and rural areas and noted a higher prevalence of obesity among rural residents despite their higher physical activity level [26]. As noted in previous studies [23], it is possible that the limited opportunities for sports participation, the lack of variety in physical activity offered, the fewer venues, and the lesser time spent traveling on foot due to shorter traveling distance might be more prominent on the islands than in the mainland, inducing a further increase in overweight. Given the

relatively small sample of islanders, this finding should be interpreted cautiously and, as already stated, validated by further research.

A review of published studies that assessed the weight status of 13-year-old adolescents in Europe, all of which used the IOTF criteria, is presented in Table 3 [27–52]. With regards to underweight, girls were mostly affected. Ten years ago, Tzotzas and associates [35] stressed a similar prevalence of underweight in the country among 13-

**Table 3** Weight status data of 13-year-old adolescents in Europe according to the IOTF [11,12] criteria.

Country	Data collection		Boys			Girls			Total		
	Year	Area	N	UW	OW + OB	N	UW	OW + OB	N	UW	OW + OB
				%	%		%	%		%	%
Bulgaria [27]	2012–4	Smolian	62	12.9	22.6	49	8.2	16.3	111	10.8	19.8
Bulgaria [28]	1995–2000	Sofia	101	12.9	20.8	99	15.2	15.2	200	14.0	18.0
Croatia [29]	2001–2	National <sup>c</sup>	778	14.3	14.3	619	17.0	16.6	1397	15.5	15.3
Cyprus [30]	1999–2000	National	95	–	28.4	101	–	17.8	196	–	22.9
Cyprus [31]	2005–6	National	NR	–	31.7	NR	–	13.5	NR	–	CBC
Czech Republic [32]	2001	National	1693	–	15.7	1578	–	11.7	3271	–	13.8
FYROM [33]	2012	National	22	4.1	34.6	35	6.9	28.0	57	5.5	30.5
Greece [34]	NR	National <sup>a</sup>	NR	–	26.8	NR	–	10.2	1313	–	CBC
Greece [35]	2003	National <sup>b</sup>	2400	–	39.0	2809	–	24.1	5209	–	31.0
Greece [36]	NR	Thessaloniki, urban & rural	42	–	26.2	48	–	22.9	90	–	24.4
Ireland [37]	2001–2	National	206	–	20.0	152	–	32.0	358	–	25.1
Ireland [38]	2007	Ko Kildare	3	–	33.3	–	–	–	–	–	–
Italy [39]	2002	National	740	–	24.5	802	–	14.1	1542	–	19.1
Italy [40]	NR	Sicily	192	6.8	30.2	206	10.2	11.7	398	8.5	20.6
Italy [41]	2004	Tuscany	NR	6.5	22.0	NR	11.4	11.5	1185	9.8	16.8
Italy [41]	2006	Tuscany	NR	6.5	22.8	NR	9.6	12.8	1086	8.0	18.0
Lithuania [42]	2000	Vilnius	NR	–	4.8	NR	–	5.0	NR	–	CBC
Lithuania [42]	2002	various cities	NR	–	8.7	NR	–	5.7	NR	–	CBC
Lithuania [29]	2001–2	National <sup>c</sup>	954	9.4	10.1	981	10.8	10.7	1935	10.1	10.4
Netherlands [43]	2003	National	NR	–	14.8	NR	–	17.2	10,568	–	CBC
Netherlands [44]	2008–9	National	NR	–	13.6	NR	–	14.1	NR	–	CBC
Norway [45]	2003–6	Bergen	238	–	15.9	217	–	10.1	455	–	9.9
Poland [46]	2005	Podlaskie, Kujawsko-Pomorskie, Malopolskie, Lubuskie, Pomorskie	818	–	17.0	900	–	15.2	1718	–	16.1
Portugal [47]	2008	mainland Portugal	1357	–	26.7	1364	–	25.6	2721	–	26.1
Serbia [48]	NR	Belgrade	898	–	24.3	894	–	18.0	1792	–	21.2
Slovenia [49]	2006	National	–	–	–	8814	–	20.3	–	–	–
Spain [50]	2000–2	Granada, Madrid, Murcia, Santander, Saragossa <sup>d</sup>	184	2.7	26.1	183	2.7	30.4	367	2.7	28.3
Spain [51]	2000–2	Granada, Madrid, Murcia, Santander, Saragossa <sup>d</sup>	NR	–	35.0	NR	–	32.0	NR	–	CBC
Turkey [52]	2001	Edirne	104	11.5	13.5	99	11	14.0	203	11.3	13.8

NR: Not reported; CBC: Cannot be calculated; UW: Underweight; OW: Overweight; OB: Obese.

<sup>a</sup> Age of participants 13.5 ± 0.3 years old.

<sup>b</sup> Age of participants 13–15 years old.

<sup>c</sup> Self-reported weight and height.

<sup>d</sup> Different samples of the same study.

to 15-year-olds, while in Spain, Artero and colleagues [50] reported half of the underweight prevalence compared to the herein, among 13-year olds. Girls from Bulgaria exhibited a two-fold [27] or even a three-fold [28] higher prevalence than that recorded in Greece. Girls from the FYROM [33] showed a high prevalence of underweight (6.9%), whereas in Italy the prevalence ranged from 9.6 to 11.4% [39,40]. In boys, underweight did not seem to be a major issue because the prevalence was low (3.1%), similar to that reported for boys from the FYROM [33] and Spain [50] and lower than that reported for 13-year-olds from Bulgaria [27] and Croatia [29]. Being underweight in adolescence is associated with low socio-economic status [53], weight status misperception [54], and weight control practices mediated by their family or the media [23,55]. The extent to which these factors influence our sample is unknown although we speculate that there is a remaining effect of the economic crisis in Greece from 2009 to this day.

Compared with previous Greek national studies [34,35] that were carried out within a decade before ours, our study showed a huge increment in the pooled overweight and obesity prevalence of boys from 26.8% before the year 2003 to 39.0% during 2003, which seems to level off in our study (39.9%). Among girls, the prevalence of pooled overweight and obesity demonstrates a steady increase over the years, starting from 10.2% before the year 2003, climbing to 24.1% during 2003, and reaching 31.7% in the present study. The progression of adolescent obesity rates in Greece has been a subject of conflict in literature; Wabitsch et al [56] proposed an unexpected plateau, and Ahluwalia [57] suggested that among adolescents from 25 countries, only Greek adolescents demonstrated increasing rates of pooled overweight and obesity from 2002 to 2010.

Akin prevalences of pooled overweight and obesity among boys (39.9%) have been reported by studies conducted in the FYROM (34.6%) [33], Spain (35.0%) [50]. Additionally, studies from the FYROM [33], Poland [46], and Spain [50] have reported a similar pooled overweight and obesity prevalence among girls to that reported in this study. The similarities in the obesity prevalence among adolescents from Greece, Spain, and the FYROM could be explained by the gradient phenomenon of overweight on the European continent [58]. Recent research has shown that the economic crisis has influenced the diet and, subsequently, the health status of Southern Europeans who have appeared to abandon their traditional diet and adopt a cheaper, more obesogenic diet [59–61]. Thus, the acute impact of the recession could explain the rising trends in adolescent obesity; however, it mostly seems to affect 13-year-old girls whose pooled overweight rate has spiked to 31.7% in the present study from 24.1% during the year 2003 [35], while the rate for boys has shown a minor increase (39.9% vs. 39.0%) in the same period.

Overall, 13-year-old Greeks seem to be the most affected by the obesity epidemic throughout the European continent, with a recorded obesity prevalence of 8.9% and a distressing pooled overweight and obesity prevalence of 35.7%. The majority of European studies on 13-year-old adolescents have stressed a pooled prevalence of overweight and obesity that has not exceeded 20%. Childhood

obesity has been associated with increased morbidity and mortality during adulthood, regardless of adult BMI [62]. In Greece, a country with a traditionally cardioprotective diet, early adolescents have been shown to exhibit high obesity rates, to adopt a sedentary lifestyle, and to have a low adherence to the Mediterranean diet [63,64]. These results, which are consistent with those in the literature, demand instant action to promote a healthy adolescent and adult population.

As previously stated, despite the funding that is spent on childhood obesity research in Greece, the country still lacks an intervention strategy, solutions, and adequate surveillance. At 13 years old, Greek adolescents are attending their 2nd year of secondary school, graduating after a total of six years of compulsory education, approaching adulthood at age 18, and are possibly pursuing a university degree. The detection of overweight during early adolescence could prove effective if structured interventions are incorporated while adolescents are still within the 6-year compulsory educational system. The literature states that successful interventions involving diet and physical activity can be implemented in both 13-year-old boys [65] and girls [66]. An ideal intervention model could include screening during the first and second years of secondary education with yearly follow-ups and school-managed interventions throughout the 6-year system to reduce the prevalence of overweight among 18-year-olds; at that age, a structured intervention is not be feasible as the compulsory education will have ended.

This study has strengths and limitations. To our knowledge, this is the first Greek study that aimed to depict regional district influences on body weight among 13-year-old adolescents. Furthermore, we used a nationally representative sample that was selected through proportionate stratified random sampling, thus eliminating selection bias. Some regions are represented by a relatively small sample or unequal sex distribution that might alter the strength of the represented associations; however, the selected sample reflects the population distribution of the specific region. The associations provided by this study, although significant, are as strong in causality as the cross-sectional nature of the study allows.

In conclusion, 13-year-old Greek adolescents exhibited high simple and abdominal obesity rates that were subjected to geographical distribution influences. The present study provides enough evidence to design regionally tailored interventions that aim to tackle and prevent the disease among the nine Greek regional districts.

## Conflict of interest

The authors have no conflict of interest to report.

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## Ethical clearance

The study was approved by the Directorate of Secondary Education, the Greek Ministry of Education, and the Ethical Committee of the Alexander Technological Educational Institute. All data were handled in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans.

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