



Childhood overweight and obesity in Europe: Changes from 2007 to 2017

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Summary

The Childhood Obesity Surveillance Initiative (COSI) routinely measures height and weight of primary school children aged 6–9 years and calculates overweight and obesity prevalence within the World Health Organization (WHO) European Region using a standard methodology. This study examines the trends in the prevalence of overweight and obesity from the first round of COSI carried out in 2007/2008 to the latest of 2015/2017 in 11 European countries in which data were collected for at least three rounds. In total 303,155 children were measured. In general, the prevalence of overweight and obesity among boys and girls decreased in countries with high prevalence (Southern Europe) and remained stable or slightly increased in Northern European and Eastern European countries included in the analysis. Among boys,

the highest decrease in overweight (including obesity) was observed in Portugal (from 40.5% in 2007/2008 to 28.4 in 2015/2017) and in Greece for obesity (from 30.5% in 2009/2010 to 21.7% in 2015/2017). Lithuania recorded the strongest increase in the proportion of boys with overweight (from 24.8% to 28.5%) and obesity (from 9.4% to 12.2%). The trends were similar for boys and girls in most countries. Several countries in Europe have successfully implemented policies and interventions to counteract the increase of overweight and obesity, but there is still much to be done.

KEYWORDS

children, obesity, overweight, prevalence, temporal trend

1 | INTRODUCTION

Analyses of data from around the world show that the prevalence of obesity and overweight in children and adolescents have risen, although they have stabilized or have started to decrease in some European countries in recent years.^{1,2} The predictions for the future are not encouraging, with some estimates suggesting that 254 million children aged 5–19 years will be with obesity by 2030.³

Increased globalization and urbanization may influence this trend, with many children and adolescents who are growing up in environments that encourage weight gain and obesity. For example, young people are exposed to ultraprocessed, energy-dense, nutrient-poor foods, which are cheap and readily available.^{4,5} Moreover, the opportunities for practicing physical activity may have declined in the last decades, especially active transport,^{6,7} although a recent pooled analysis of 298 school-based surveys from 146 countries showed a small reduction of insufficient physical activity among adolescents boys but no changes among girls.⁸ In the meantime, exposure to sedentary behavior (television, electronic devices, etc.) has increased.^{7,9} The changes in food type and availability, the excessive portions, and the decline in active transportation may have resulted in energy imbalance.¹⁰

Several studies have used national health surveys, multicenter studies, or have pooled population-based studies from different countries to estimate children and adult trends in height, weight, Body Mass Index (BMI), and prevalence of overweight and obesity worldwide and in specific areas.^{1,2,11–15} Some studies have evaluated the temporal changes by age, sex, socioeconomic status, or other characteristics.^{1,2,11–17} However, the studies were often conducted using different methods and targeted different populations.

To monitor changes in overweight and obesity in primary school children using a standard methodology, the WHO Regional Office for Europe in 2007 established the Childhood Obesity Surveillance Initiative (COSI).^{18,19} COSI routinely measures height and weight of primary school children aged 6–9 years and calculates overweight and obesity prevalence, in order to monitor progress addressing childhood overweight and enabling intercountry comparisons within the WHO European Region.

The aim of this study is to examine the trends in the prevalence of overweight and obesity among primary school children (aged

6–9 years) from the first round of COSI carried out in 2007–2008 to the fourth round in 2015–2017, stratified by country, age, and sex.

2 | METHODS

The first round of COSI data collection took place in 2007–2008, the second in 2009–2010, the third in 2012–2013, and the fourth in 2015–17. The number of countries that collected data has increased over time, ranging from 12 countries in the first round, 14 countries in the second round, 19 in the third round, and 36 in the fourth round.

Thirteen countries have participated in both the fourth round of COSI and at least two other earlier rounds: nine countries participated in all four rounds (Czechia, Ireland, Italy, Latvia, Lithuania, Malta, Norway, Portugal, and Slovenia) and four countries in three rounds (Greece, North Macedonia and Spain in 2009/2010, 2012/2013, and 2015/2017 editions and Bulgaria in 2007/2008, 2012/2013, and 2015/2017 editions).

For this analysis, the following inclusion criteria were applied: (i) children belonging to age groups that were targeted by the country of residence in at least three rounds of data collection and (ii) children with informed consent and complete information on age, sex, weight, and height. Data collected in Malta and North Macedonia were excluded because these countries changed the targeted age group between rounds.

2.1 | Study population, sampling design and data collection procedures

According to the COSI protocol, countries could choose one or more of the following age groups: 6.0–6.9, 7.0–7.9, 8.0–8.9, or 9.0–9.9 years. Age groups included in the analysis by country and rounds are reported in Table 1. Four countries collected data in more than one age group (Greece, Italy, Slovenia, and Spain).

A nationally representative sample was selected in all countries. All countries adopted a cluster sampling design and maintained the same sampling design throughout all rounds of data collection (Table 1). Five countries employed a sentinel site approach, that is, the schools that were selected in the first round constituted the sample also for the

TABLE 1 Study characteristics, proportion of children invited to participate who were measured and number of children included in the analysis by country and round of data collection. COSI/WHO Europe rounds 1–4 (2007/2008, 2009/2010, 2012/2013, and 2015/2017)

Countries	Sampling design	Sentinel approach ^a	Proportion of children invited to participate who were measured (and who had complete information on age, sex, weight, and height)				Targeted age groups included in the analysis				Number of children included in the analysis ^b			
			R1	R2	R3	R4	R1	R2	R3	R4	R1	R2	R3	R4
Southern Europe														
Greece	Cluster sampling design—SUs: primary schools	No	-	76.5 (76.5)	78.1 (78.1)	63.5 (63.0)	7	-	2541	2721	1898			
Italy	Stratified cluster sampling design—SUs: third grades of the primary school	No	90.4 (90.4)	91.0 (89.9)	90.0 (89.9)	90.2 (90.1)	8	5131	25,965	29,001	29,633			
Portugal	Two-stage stratified cluster sampling design—PSUs: primary schools; SSUs: first and second grades	Yes	81.6 (81.6)	79.1 (79.1)	79.9 (79.8)	92.1 (92.1)	7	1813	1807	2644	3325			
Slovenia	Two-stage cluster sampling design—PSUs: primary schools; SSUs: first, second, and third grades	No	87.4 (87.4)	82.2 (82.2)	95.8 (95.8)	96.7 (96.7)	6	3263	3622	5504	6115			
Spain	Two-stage stratified cluster sampling design—PSUs: primary schools; SSUs: first to fourth grades	No	-	59.4 (59.4)	n.a.	73.1 (73.1)	7	-	2201	1814	2815			
Northern Europe														
Ireland	Two-stage stratified cluster sampling design—PSUs: primary schools; SSUs: first and fourth grades	Yes	72.3 (72.3)	64.0 (63.9)	58.6 (58.5)	56.6 (56.6)	7	2383	1000	1012	882			
Latvia	Stratified cluster sampling design—SUs: primary schools	NO	78.9 (78.9)	82.1 (82.1)	85.8 (85.8)	80.4 (80.4)	7	3248	2833	3480	2737			
Lithuania	n.a.	Yes	84.2 (84.0)	81.5 (81.5)	71.2 (71.0)	70.8 (70.7)	7	3305	3435	2584	2540			
Norway	Two-stage stratified cluster sampling design—PSUs: counties; SSUs: primary schools	Yes	87.9 (87.9)	87.3 (87.0)	86.1 (85.9)	83.2 (83.1)	8	2834	2621	2873	2734			

(Continues)

TABLE 1 (Continued)

Countries	Sampling design	Sentinel approach ^a	Proportion of children invited to participate who were measured (and who had complete information on age, sex, weight, and height)				Targeted age groups included in the analysis	Number of children included in the analysis ^b			
			R1	R2	R3	R4		R1	R2	R3	R4
Eastern Europe											
Bulgaria	Two-stage stratified cluster sampling design—PSUs; primary schools; SSUs; first grades ^c	Yes	78.7 (78.5)	-	85.5 (85.5)	83.7 (83.7)	7	2501	-	3347	3386
Czechia	Stratified cluster sampling design—SUs; pediatric clinics	No	99.2 (99.1)	94.0 (94.1)	95.0 (94.9)	n.a.	7	913	1269	1452	1002

Abbreviations: COSI, Childhood Obesity Surveillance Initiative; “-” no data collection; n.a., not available; PSUs, primary sampling units; R1, Round 1 (2007/2008); R2, Round 2 (2009/2010); R3, Round 3 (2012/2013); R4, Round 4 (2015/2017); SSUs, secondary sampling units; SUs, sampling units.

^aSentinel approach: The same schools are selected and participate in multiple rounds of data collection. Portugal adopted a sentinel approach in the first three rounds of data collection but selected a new sample of school in the fourth round.

^bChildren with informed consent and complete information on age, gender, weight, and height. Children with biologically implausible (or extreme) values were excluded from the analysis (i.e., BMI/A values below -5 or above $+5$ Z-scores relative to the 2007 WHO growth reference median).

^cIn round 4, Bulgaria adopted a three-stage stratified cluster sampling design with primary schools as PSUs, first grades as SSUs and 7-year-old students as tertiary sampling units.

following rounds (Bulgaria, Ireland, Lithuania, Norway, and Portugal [for the first three rounds and a new sample for the fourth round]), while six countries selected a new sample of schools (or pediatricians, in Czechia) at each round (Greece, Italy, Latvia, Spain, and Slovenia).

Children were measured by examiners who were trained in measuring weight and height using the WHO standardized techniques.¹⁹

More details about data collection procedures are provided elsewhere.^{19–22}

2.2 | Data elaboration

All country datasets were reviewed for inconsistencies and completeness in a standard manner at the WHO Regional Office before they were aggregated for the intercountry comparisons.

Children's weight status was based on BMI (weight/height²), and the 2007 WHO recommended cutoffs were used to compute BMI-for-age (BMI/A) Z-scores and to estimate the prevalence of overweight and obesity.²³ According to WHO definitions, overweight and obesity are defined as a BMI-for-age value $> +1$ Z-score and $> +2$ Z-scores, respectively. The estimates of prevalence of overweight include children with obesity. Children with biologically implausible (or extreme) values were excluded, that is, those with BMI/A values below -5 or above $+5$ Z-scores relative to the 2007 WHO growth reference median (less than 0.5% of children).

2.3 | Statistical analysis

The estimates of prevalence of overweight and obesity among boys and girls, along with their 95% confidence intervals (95% CI), were calculated by age group, round of data collection, and country. Data are shown according to the geographic area, based on the United Nations “Standard Country or Area Codes for Statistical Use”²⁴: Southern Europe (Greece, Italy, Portugal, Slovenia, and Spain), Northern Europe (Ireland, Latvia, Lithuania, and Norway), and Eastern Europe (Bulgaria and Czechia).

To investigate the linear time trend in the prevalence of overweight and obesity, multivariate country-specific logistic regression models for having overweight/obesity (compared to not having) were estimated including a linear term for time. The significance of the trend was assessed using an adjusted Wald F test with $\alpha = 0.05$. Separate models were used to test linear trends in prevalence for each targeted age group.

The absolute change in prevalence estimates at the maximum time lapse (e.g., the time between the fourth round and the first round), along with its 95% CIs, was also estimated for each country, sex, and targeted age group.

All statistical analyses considered boys and girls separately. Prevalence estimates were presented as percentages.

Sampling weights to adjust for the sampling design, oversampling, and nonresponse were available only for the fourth round of data collection. For this reason, the analysis was performed unweighted, and therefore, despite the fact that data come from nationally representative samples, the generalization of the results to the children

from which the samples were drawn should be interpreted with caution. The standard errors and 95% CIs were estimated allowing for the cluster sample design.

All statistical analyses were performed using Stata version 15.1 (StataCorp LLC, College Station, TX, USA).

3 | RESULTS

3.1 | Study population

Eleven of the countries which collected data in the latest round of COSI (2015/2017) were included in this study because they also had data for at least two previous rounds and targeted always the same age groups. In total 303,155 children were measured between 2007 and 2017 in these countries and were included in the analysis: 18,504 aged 6 years, 94,309 aged 7 years, 133,628 aged 8 years, and 56,714 aged 9 years (Table 1). The participation proportion (proportion of children invited to participate who were measured) was higher than 70% in all countries, except Greece in the fourth round, Ireland in the second, third, and fourth rounds and Spain in the second round.

3.2 | Trends of overweight and obesity in boys

In general, the prevalence of overweight (including obesity) among boys decreased in Southern European countries included in the analysis, showing a linear declining trend, and remained stable or slightly increased in Northern and Eastern European countries over time (Figure 1).

The highest reduction was observed in Portugal where the proportion of 7-year-old boys having overweight decreased from 40.5% in 2007/2008 to 28.4% in 2015/2017—down 12.1 percentage points; 95% CI: 8.2%–16.1% (Table 2). A decrement of more than 10 percentage points was estimated also among Greek 9-year-old boys for whom the overweight prevalence was equal to 57.2% in 2009/2010. Italy and Spain also had high values of overweight prevalence at the beginning of the investigated period (above 44%) and registered a decrease of around 5 percentage points. In Slovenia, where childhood overweight was less widespread than in the other Southern Europe countries included in the study, an important reduction of the proportion of boys having overweight was recorded as well. For example, the percentage of 7-year-old boys having overweight decreased from 32.5% in 2007/2008 to 24.5% in 2015/2017—down 8.0 percentage points; 95% CI: 5.9%–10.2%. On the other hand, overweight prevalence increased among 7-year-old boys in Lithuania from 24.8% in 2007/2008 to 28.5%—up 3.7 percentage points; 95% CI: 0.1; 7.2; while it was stable in the other Northern and Eastern European countries.

Likewise, obesity prevalence showed a declining linear trend in all Southern European countries (Figure 1). As shown in Table 2, Greece and Italy, where the obesity prevalence value was the highest at the beginning (above 23%), recorded a reduction between 3.5 percentage points (95% CI: 0.2%; 7.0%) and 8.8 (95% CI: 5.1%; 12.4%). Also, in

Portugal and Slovenia, the proportion of boys having obesity noticeably decreased—from 15.6% to 10.6% among Slovenian 7-year-old boys. A tendency to increase was observed among 7-year-old boys from Lithuania and Bulgaria for whom the 2007/2008 prevalence values (9.4% and 12.8%, respectively) went up of more than 2 percentage points. Similarly to overweight, the other countries of Northern and Eastern Europe showed a stable pattern.

The prevalence of overweight and obesity among boys stratified by age, round of data collection, and country, along with 95% CI, is reported in Table S1.

3.3 | Trends of overweight and obesity in girls

Similarly to boys, assessing the prevalence of overweight for girls (Figure 2) revealed predominantly decreasing trends in all Southern European countries.

In this area, the strongest reduction was found in Greece (down around 8 percentage points) which was also the country with the highest starting values of overweight prevalence (44.8% and 50.0% among girls aged 7 and 9 years, respectively, in 2009/2010). Italy and Portugal also experienced an important decrease in the proportion of girls having obesity, which was above 35% in 2007/2008 and went down 4–6 percentage points in 10 years (Table 3). An important decreasing linear trend in overweight proportion also emerged among girls from Ireland—from 31.1% in 2007/2008 to 21.2% in 2015/2017—whereas stable or slightly rising proportion was recorded in all other Northern European countries and Eastern European countries included in the analysis.

Obesity prevalence proportions mirrored those of overweight, with decreasing obesity prevalence over time in Southern European countries. As shown in Table 3, the strongest declines were found in Greece and Italy: The proportion of 9-year-old girls having obesity decreased from 20.8% to 11.9% in Greece (down 8.9 percentage points; 95% CI: 5.7; 12.0) and from 15.8% to 11.8% in Italy (down 4.0; 95% CI: 1.8; 6.2). While the prevalence of obesity showed a decreasing linear trend also in Slovenia and Portugal, it was stable in Spain. A noticeable declining trend emerged also among 7-year-old girls in Ireland, with the obesity prevalence decreasing from 9.7% to 5.5% in 10 years (down 4.2, 95% CI: 1.4; 7.0). A stable pattern was observed in the other Northern and Eastern European countries but in Latvia where the proportion of girls aged 7 years having obesity slightly increased from 4.6% to 6.4% (up 1.8; 95% CI: 0.2; 3.5). The prevalence of overweight and obesity among girls stratified by age, round of data collection, and country, along with 95% CI, is reported in Table S2.

4 | DISCUSSION

The first and most important result of our study is the general tendency for the prevalence of overweight and obesity in Europe to be stable or to decline. In particular, the countries included in the study with a higher initial prevalence of overall overweight or obesity had

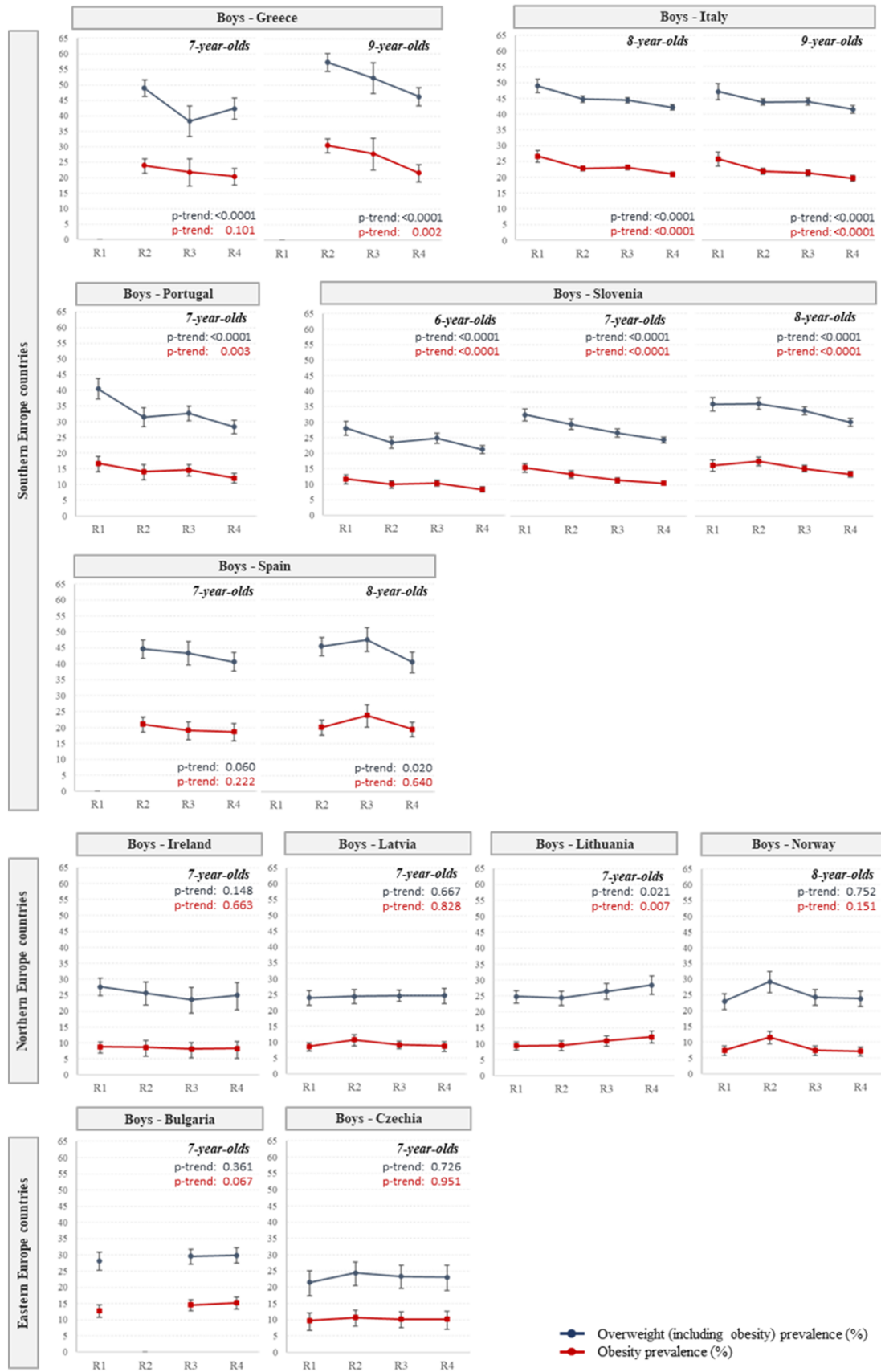


FIGURE 1 Country-specific prevalence (%) of overweight (including obesity) and obesity—WHO definition—and 95% CI among boys by round of data collection and age group. Childhood Obesity Surveillance Initiative (COSI)/WHO Europe rounds 1–4 (2007/2008, 2009/2010, 2012/2013, and 2015/2017). P-trend: *p*-value for the adjusted Wald *F* test used to assess the linear time trends

TABLE 2 Absolute change between COSI round 4 (2015/2017) and COSI round 1 (2007/2008)^a in country-specific prevalence of overweight (including obesity) and obesity—WHO definition—among boys stratified by age group

Country—age group		Overweight (including obesity)		Obesity	
		Prevalence (%) R1 ^a and 95% CI	Absolute change in prevalence (%) and 95% CI R4 versus R1 ^a	Prevalence (%) R1 ^a and 95% CI	Absolute change in prevalence (%) and 95% CI R4 versus R1 ^a
Southern Europe					
Greece	7	48.9 [46.2–51.6]	−6.6 [−10.9; −2.3]	23.9 [21.6–26.2]	−3.5 [−7.0; +0.2]
	9	57.2 [54.3–60.0]	−10.9 [−15.0; −6.8]	30.5 [28.2–32.9]	−8.8 [−12.4; −5.1]
Italy	8	49.0 [46.9–51.1]	−6.9 [−9.2; −4.6]	26.6 [24.8–28.5]	−5.6 [−7.6; −3.6]
	9	47.1 [44.6–49.7]	−5.6 [−8.4; −2.9]	25.7 [23.6–28.0]	−6.0 [−8.4; −3.6]
Portugal	7	40.5 [37.3–43.8]	−12.1 [−16.1; −8.2]	16.7 [14.4–19.3]	−4.6 [−7.5; −1.7]
Slovenia	6	28.0 [25.8–30.4]	−6.8 [−9.5; −4.2]	11.7 [10.2–13.3]	−3.4 [−5.1; −1.6]
	7	32.5 [30.7–34.4]	−8.0 [−10.2; −5.9]	15.6 [14.3–17.1]	−5.0 [−6.5; −3.4]
	8	35.9 [33.7–38.2]	−5.7 [−8.3; −3.1]	16.4 [14.7–18.2]	−2.9 [−4.8; −0.8]
Spain	7	44.5 [41.6–47.5]	−3.9 [−8.1; +0.2]	21.0 [18.7–23.5]	−2.3 [−5.9; +1.3]
	8	45.3 [42.4–48.3]	−4.8 [−9.2; −0.5]	20.0 [17.8–22.5]	−0.5 [−3.9; +2.8]
Northern Europe					
Ireland	7	27.6 [24.9–30.4]	−2.7 [−7.7; +2.4]	8.7 [7.2–10.6]	−0.5 [−3.6; +2.6]
Latvia	7	24.0 [21.8–26.4]	+0.7 [−2.7; +4.0]	8.6 [7.4–10.0]	+0.2 [−1.9; +2.2]
Lithuania	7	24.8 [22.9–26.8]	+3.7 [+0.1; +7.2]	9.4 [8.1–10.7]	+2.8 [0.5; +5.1]
Norway	8	23.0 [20.6–25.6]	+0.9 [−2.6; +4.4]	7.5 [6.1–9.1]	−0.3 [−2.3; +1.7]
Eastern Europe					
Bulgaria	7	28.1 [25.4–31.0]	+1.7 [−2.0; +5.3]	12.8 [11–14.8]	+2.4 [−0.2; +5.1]
Czechia	7	21.4 [17.8–25.6]	+1.7 [−3.8; +7.1]	9.7 [7.3–12.7]	+0.4 [−3.4; +4.2]

Abbreviations: COSI, Childhood Obesity Surveillance Initiative; R1, Round 1 (2007/2008); R4, Round 4 (2015/2017).

^aGreece and Spain did not collect data in COSI round 1 (2007/2008), so “R1” refers to COSI round 2 (2009/2010) which was the first data collection in these two countries.

decreased over time (i.e., Southern European countries), while countries with lower initial prevalence proportions (Northern European and Eastern European countries) had either stable trends or a slight increase in the prevalence proportions of children with obesity and overweight. These differences by subregion of Europe are consistent with previous research which compared the first two rounds of COSI, from 2007 to 2010²⁵ and other studies.^{1,2,26} However, despite the encouraging decrease, the Southern European countries continue to have a higher prevalence of childhood overweight and obesity relative to other countries,²² and declines are not as steep as experts would like them to be. These differences in trends may be due to cultural differences, including a mistaken perception of the effects of overweight and obesity on health and differences in children's exposure to risk factors within the food and physical activity environments. In Southern Europe, studies have shown a progressive shifting away from traditional healthy dietary patterns, such as the Mediterranean diet, especially among the younger generations, over the last decades.^{27–30} The levels of physical activity in children living in the Mediterranean countries are also lower than in those living in other parts of Europe.^{31,32} The causes of obesity are complex, and it is beyond the scope of this paper to speculate why individual countries may have seen specific trends. However, it is important to identify that a number of known policy options exist for preventing and

controlling childhood obesity. These actions include the following: implementing comprehensive programs to promote the intake of healthy foods and reduce the intake of unhealthy foods and sugar-sweetened beverages (including implementation of a sugary drinks tax); implementing comprehensive programs that promote physical activity and reduce sedentary behaviors in children and adolescents; strengthening guidance for Noncommunicable diseases (NCDs) prevention with current guidance for preconception and antenatal care to reduce the risk of childhood obesity; providing guidance and support for healthy diet, sleep, and physical activity in early childhood (including promotion of breastfeeding); implementing comprehensive programs that promote healthy school environments, health, and nutrition literacy and physical activity among school-age children and adolescents; and providing family-based multicomponent services on lifestyle weight management for children and young people who are with obesity.³³ Obesity prevention policies are likely to be synergistic, and a comprehensive approach is needed.

In our study, the trends in overweight and obesity are similar for boys and girls in most countries. In a meta-analysis of 103 studies that included 477,620 children aged 2 to 13 years in 28 European countries, the trends of the prevalence of overweight and obesity from 1999 to 2016 showed higher prevalence among girls in most countries and only a small, sex difference in trends.²⁶

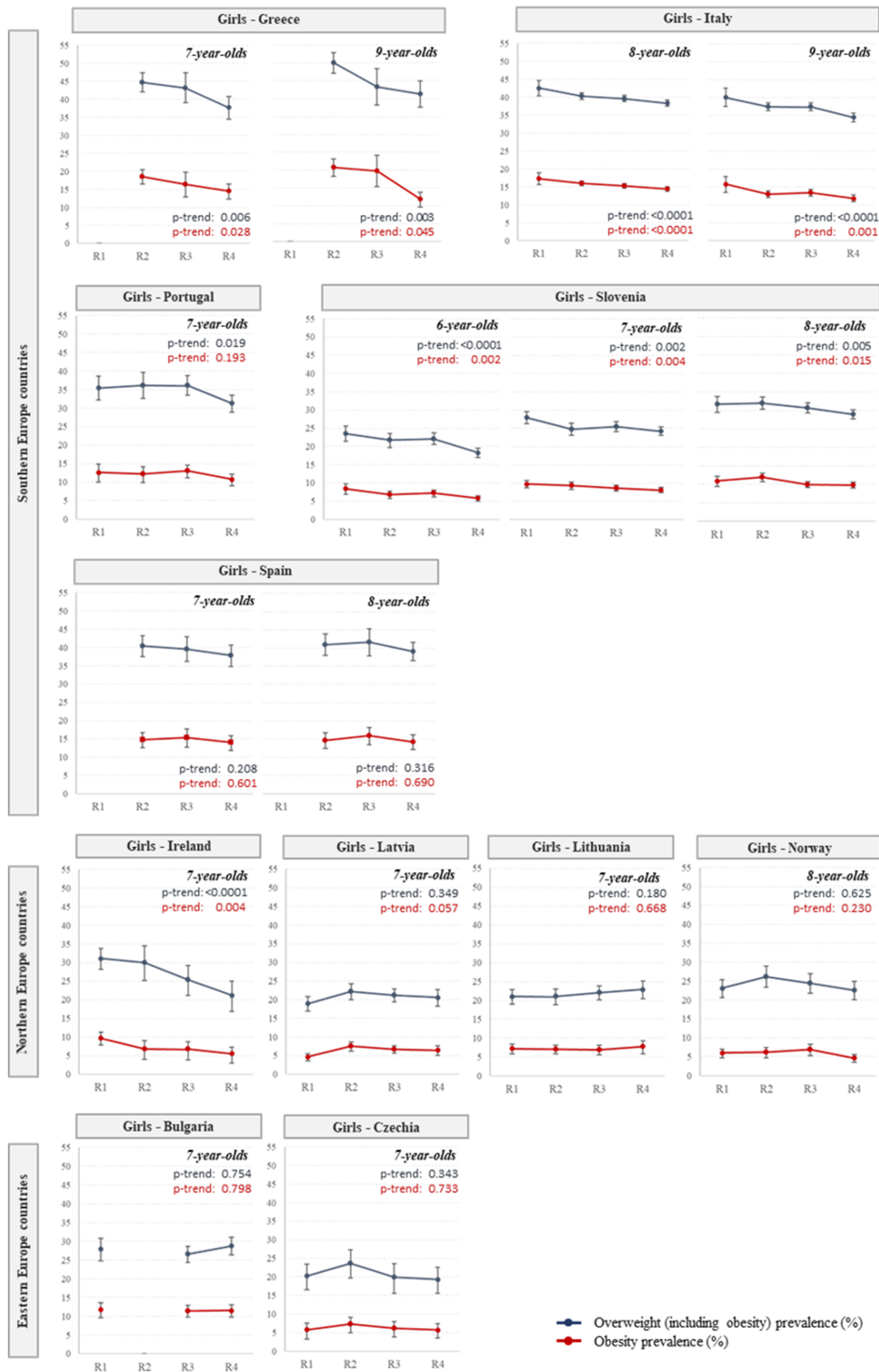


FIGURE 2 Country-specific prevalence (%) of overweight (including obesity) and obesity—WHO definition—and 95% CI among girls by round of data collection and age group. Childhood Obesity Surveillance Initiative (COSI)/WHO Europe rounds 1–4 (2007/2008, 2009/2010, 2012/2013, and 2015/2017). P-trend: *p*-value for the adjusted Wald *F* test used to assess the linear time trends

TABLE 3 Absolute change between COSI round 4 (2015/2017) and COSI round 1 (2007/2008)^a in country-specific prevalence of overweight (including obesity) and obesity—WHO definition—among girls stratified by age group

Country—age group		Overweight (including obesity)		Obesity	
		Prevalence (%) R1 ^a and 95% CI	Absolute change in prevalence (%) and 95% CI R4 versus R1 ^a	Prevalence R1 ^a	Prevalence (%) R1 ^a and 95% CI
Southern Europe					
Greece	7	44.8 [42.1–47.4]	−7.1 [−11.1; −2.9]	18.6 [16.6–20.7]	−4.0 [−6.9; −1.1]
	9	50.0 [47.1–52.9]	−8.7 [−13.3; −4.0]	20.8 [18.5–23.3]	−8.9 [−12.0; −5.7]
Italy	8	42.5 [40.4–44.8]	−4.1 [−6.5; −1.8]	17.3 [15.8–19.0]	−2.8 [−4.6; −1.2]
	9	40.1 [37.3–42.9]	−5.6 [−8.6; −2.6]	15.8 [13.9–17.9]	−4.0 [−6.2; −1.8]
Portugal	7	35.5 [32.3–38.8]	−4.2 [−8.2; −0.2]	12.6 [10.4–15.2]	−1.9 [−4.7; +1.0]
Slovenia	6	23.6 [21.5–25.8]	−5.3 [−7.7; −2.8]	8.4 [7.1–9.9]	−2.6 [−4.2; −1.0]
	7	28.0 [26.3–29.7]	−3.7 [−5.8; −1.7]	9.8 [8.8–10.8]	−1.7 [−2.9; −0.4]
	8	31.7 [29.6–33.9]	−2.7 [−5.2; −0.2]	10.9 [9.6–12.4]	−1.1 [−2.7; +0.5]
Spain	7	40.4 [37.6–43.3]	−2.6 [−6.8; +1.5]	14.7 [12.7–16.9]	−0.7 [−3.6; +2.2]
	8	41.0 [38.0–44.0]	−1.9 [−5.8; +2.0]	14.7 [12.7–17.0]	−0.5 [−3.4; +2.4]
Northern Europe					
Ireland	7	31.1 [28.4–33.9]	−9.9 [−14.7; −4.9]	9.7 [8.1–11.6]	−4.2 [−7.0; −1.4]
Latvia	7	18.9 [17.0–21.0]	+1.7 [−1.3; +4.6]	4.6 [3.7–5.7]	+1.8 [+0.2; +3.5]
Lithuania	7	21.0 [19.2–23.0]	+1.9 [−1.2; +4.8]	7.2 [6.1–8.6]	+0.6 [−1.6; +2.7]
Norway	8	23.1 [20.9–25.5]	−0.4 [−3.8; +2.9]	6.0 [5.0–7.3]	−1.3 [−2.8; +0.2]
Eastern Europe					
Bulgaria	7	27.9 [25.0–31.0]	+0.9 [−3.0; +4.7]	11.8 [10.0–13.9]	−0.3 [−2.9; +2.3]
Czechia	7	20.2 [17.0–23.9]	−0.9 [−5.9; +4.0]	5.7 [4.0–8.3]	0.0 [−2.9; +2.8]

Abbreviations: COSI, Childhood Obesity Surveillance Initiative; R1, Round 1 (2007/2008); R4, Round 4 (2015/2017).

^aGreece and Spain did not collect data in COSI round 1 (2007/2008), so “R1” refers to COSI round 2 (2009/2010) which was the first data collection carried out in these two countries.

In this paper, we compared trends in different age groups in four countries (Greece, Italy, Slovenia, and Spain); trends in obesity and overweight tended to be similar among the different age groups (although the different age groups ranged by only 1 or 2 years).

COSI provides a unique large dataset of national representative samples of children aged 6–9 years old, with standardized weight and height measurements. Its repeated rounds, using a harmonized methodology, provide a uniquely valuable opportunity to accurately assess changes over time and to compare trends in childhood obesity across European countries. That said, it is important to acknowledge some limitations. For example, some countries included in this study had a participation proportion less than 60% in one or more rounds and did not achieve the requested minimum final sample size of 2800 children per age group.¹⁹ This may have led to lower representation of populations in these countries, especially among vulnerable families and children who were more likely to be with overweight or obesity. Finally, the analyses were performed unweighted because sampling weights to adjust for the applied sampling design, oversampling, and nonresponse proportion were available only in round four (2015/2017). The comparison of the weighted and unweighted results in round four did not show great differences in most countries, and six out of eleven countries included in the analysis had a sentinel approach which implied that the children measured at each round

were students at the same schools. Nevertheless, we cannot exclude the possibility that the reported changes in prevalence of overweight and obesity over time (especially when small in magnitude) could be related to changes in the sampled or participating children, rather than the changes in prevalence of childhood overweight and obesity. Future research will need to continue to collect data from children, in order to better examine the trends over time. For this reason, it is important that initiatives like COSI can be sustained in the future.

The current study design of COSI does not allow to longitudinal follow-up of participants (to examine trends in body weight over the life course within the same person). However, future research may explore the possibility of following participants over time.

5 | CONCLUSIONS

This study shows that over a 10-year period (2007/2008 to 2015–2017), several European countries have been able to halt childhood overweight and obesity. However, in spite of this decrease, prevalence of overweight and obesity remains high, and there continue to be important differences between countries and socioeconomic groups. If several countries of the WHO European Region have successfully implemented policies and interventions to counteract

overweight and obesity,³⁴ more efforts, bolder actions, and economic investments are needed to reach the targets indicated by the WHO Global Action Plan for the Prevention and Control of Non-communicable Diseases 2013–2025 in all children of all countries of the Region.³⁵ The COSI can help to monitor the situation and to provide evidence on the impact and effectiveness of interventions in reducing the prevalence of childhood obesity.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. The funders played no role in the design of the COSI protocol, the decision to write this paper or its content.

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ETHICS STATEMENT

The WHO COSI study protocol was approved by the International Ethical Guidelines for Biomedical Research Involving Human Subjects, and all procedures were also approved by local Ethics Committees in each country. Furthermore, the children's parents or guardians have given their informed consent. The COSI study follows the International Ethical Guidelines for Biomedical Research Involving Human Subjects. Local ethics approval was also granted.

AUTHOR CONTRIBUTIONS

M.B., A.S., J.W., and P.N. conceptualized and drafted the manuscript. S.C. contributed to draft the manuscript. M.B. conducted all analyses. J.B. made substantial contribution to the conception and drafts of both the manuscript and the COSI study protocol as well as interpretation of the results. I.R. was involved in critically reviewing the drafts of the manuscript. A.I.R., M.G.S., E.K.G., E.G-G, and K.I.K commented on the draft of the paper and contributed with data collection and data cleaning. G.S., A.P., M.K., M.H., N. P-F., I. P., C.K., and V.D. contributed with data collection and data cleaning. All authors contributed to and approved the paper.

DISCLAIMER

J.B., I.R., and J.W. are staff members of the World Health Organization, and M.B. and S.C. are consultants with WHO. The authors alone are responsible for the views expressed in this article, and they do not necessarily represent the decisions, policy, or views of the institutions with which they are affiliated.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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