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SUPPLEMENT ARTICLE

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Thinness, overweight, and obesity in 6- to 9-year-old children from 36 countries: The World Health Organization European Childhood Obesity Surveillance Initiative—COSI 2015–2017

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Abbreviations: BMI, body mass index; BMI/A, BMI-for-age; COSI, Childhood Obesity Surveillance Initiative; H/A, height-for-age; IOTF, International Obesity Task Force; NCDs, noncommunicable diseases; W/A, weight-for-age; WHO, World Health Organization.

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Summary

In 2015–2017, the fourth round of the World Health Organization (WHO) European Childhood Obesity Surveillance Initiative (COSI) was conducted in 36 countries. National representative samples of children aged 6–9 (203,323) were measured by trained staff, with similar equipment and using a standardized protocol. This paper assesses the children's body weight status and compares the burden of childhood overweight, obesity, and thinness in Northern, Eastern, and Southern Europe and Central Asia. The results show great geographic variability in height, weight, and body mass index. On average, the children of Northern Europe were the tallest, those of Southern Europe the heaviest, and the children living in Central Asia the lightest and the shortest. Overall, 28.7% of boys and 26.5% of girls were overweight (including obesity) and 2.5% and 1.9%, respectively, were thin according to the WHO definitions. The prevalence of obesity varied from 1.8% of boys and 1.1% of girls in Tajikistan to 21.5% and 19.2%, respectively, in Cyprus, and tended to be higher for boys than for girls. Levels of thinness, stunting, and underweight were relatively low, except in Eastern Europe (for thinness) and in Central Asia. Despite the efforts to halt it, unhealthy weight status is still an important problem in the WHO European Region.

KEYWORDS
malnutrition, obesity, prevention, thinness

1 | INTRODUCTION

Assessing weight status during infancy and childhood is important due to the effects that thinness, overweight, and obesity can have on child development, health, and well-being.[1–4] Weight status in childhood is the consequence of complex environmental and genetic factors.[5,6]

Childhood overweight and obesity has increased over the last few decades: globally in 2016, an estimated 124 million children and adolescents aged 5–19 were affected by obesity and 213 million were affected by overweight, whereas 190 million were thin or underweight, mainly in low income countries.[7]

In Europe, the high prevalence of overweight and obesity remain a serious public health problem, although they have recently plateaued in some countries.[7,8] For example, overweight and obesity remain high in Spain, although showing a decreasing trend from 1999 to 2016.[9] In Slovakia, overweight has increased by 3%, and the prevalence of obesity has doubled since 2001,[10] whereas in Italy, despite the observed reduction from 2008 to 2016, the overall levels of overweight and obesity remain among the highest in Europe.[11] There has been a large increase in the prevalence of obesity among children and adolescents in England since the mid-1990s, with wide inequalities, including between children from different ethnic groups.[12]

Fewer studies are available on thinness and underweight among children in Europe and other high-income countries, but nowadays, they are estimated to be generally less frequent than overweight and obesity.[7,8]

In order to have an accurate understanding of these trends at the country level, it is important to collect anthropometric data from children using a nationally representative sample. Since 2007, following the recommendations of the World Health Organization (WHO) European Ministerial Conference on Counteracting Obesity in Istanbul (November 15–17, 2006),[13] the WHO Regional Office for Europe established the WHO European Childhood Obesity Surveillance Initiative (COSI).[14] With prevention recognized as the most feasible option for curbing the epidemic, surveillance data are essential for the effective design, implementation, and evaluation of the policies and strategies for counteracting obesity.[15]

The main aim of COSI is to measure the prevalence of childhood overweight and obesity routinely throughout the WHO European Region. Because these measurements are collected from a nationally representative sample using a standard protocol, the same highly accurate and precise anthropometric instruments and trained personnel,[16–19] COSI enables public health officials to compare situations between countries, set national targets, track progress over time, and evaluate the effect of interventions.

COSI data collection is conducted every 3 years: the fourth round (2015–2017) included 36 countries covering different areas of the WHO European Region.

Based on data from the COSI 2015–2017 round, this paper aims to assess, for the first time, the weight status of primary school-aged children living in these 36 countries and to compare the burden of childhood overweight, obesity, and thinness in different areas of the WHO European Region—namely Northern, Eastern, and Southern Europe and Central Asia.

2 | METHODS

The fourth COSI data collection round was conducted in 35 countries in the 2015–2016 and 2016–2017 school years and, in Kyrgyzstan, at the beginning of 2018. This surveillance initiative was conducted for the first time in 17 countries (Austria, Croatia, Cyprus, Denmark, Estonia, Finland, France, Georgia, Kazakhstan, Kyrgyzstan, Montenegro, Poland, Russian Federation (only Moscow), Serbia, Slovakia, Tajikistan, and Turkmenistan), whereas the other 19 countries (Albania, Bulgaria, Czechia, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Malta, North Macedonia, Norway, Portugal, Romania, San Marino, Slovenia, Spain, Sweden, and Turkey) had participated in at least one of the three previous rounds.[20–24]

2.1 | Study population and sampling design

According to the protocol, countries can select one or more of the following four age groups: 6.0–6.9, 7.0–7.9, 8.0–8.9, or 9.0–9.9 years. In the fourth edition of COSI, 17 countries targeted only 7-year-olds, seven only 8-year-olds, two only 9-year-olds, and 10 countries targeted more than one age group (Table 1). In order to reach the minimum sample size suggested by the protocol (2800 children per age group) and have a complete coverage of the targeted age group, some countries selected more than one grade of the same primary school.

A nationally representative sample was selected in all countries except in Estonia, Malta, and San Marino where the entire population of interest was included and in Russia where data were collected only in Moscow. Most of the countries adopted a two-stage cluster sampling design with primary schools as the primary sampling units and classes as the secondary sampling units. In most of the countries that adopted a sampling approach, the number of children measured in each targeted age group was equal to or above the minimum sample size suggested by the protocol (2800 children per age group), whereas in 10 countries, it was considerably lower or slightly lower (Table 1). More details on the study design and sampling adopted in each country are provided elsewhere.[24]

2.2 | Data collection procedures and anthropometric measurements

Data were collected according to a common protocol devised in 2007 by the WHO Regional Office for Europe and Member States,[16] which was slightly amended for the second, third, and fourth COSI rounds.[17–19] The COSI protocol is in accordance with the international Ethical Guidelines for Biomedical Research Involving Human Subjects.[25] Local ethical committees also approved the study.

Parents were fully informed about all study procedures and their informed consent for the measurements and for data treatment (written in the local language) was obtained prior to the child's enrolment in the study. Depending on local legal circumstances, countries have the option of choosing passive or active informed consent. The children could also refuse to be measured.

During the data collection, children were measured by examiners who had been trained in measuring body weight and height using the WHO standardized techniques. Measurements were taken after having removed shoes and socks, as well as all heavy clothes (coats, sweaters, jackets, etc.) and items such as wallets, mobile phones, or key chains. Each child was weighed to the nearest 0.1 kg, and height was measured to the nearest 1 mm. Each country provided the average weights of the types of clothes worn during the measurements, which were used to adjust the observed body weight. Further information on data collection and measurements procedure are provided elsewhere.[24]

2.3 | 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. Only children whose age fell within the target age group(s) and with available data on sex, weight, height, and type of clothes worn during the measurements were included in the analysis.

The child's age (in years) was calculated using the formula: date of measurement minus date of birth (expressed in days)/365.25. Body mass index (BMI) was calculated using the formula: weight (kg) divided by height squared (m^2).

The classification of children's weight status was based on the 2007 WHO recommended growth reference for school-aged children and adolescents.[26,27] The WHO 2007 cut-offs were used to compute height-for-age (H/A), weight-for-age (W/A), and BMI-for-age (BMI/A) *Z*-scores and to estimate the prevalence of thinness, overweight, obesity, and severe obesity. According to the WHO growth reference, overweight, obesity, and severe obesity are defined as a BMI-for-age value > +1 *Z*-score, BMI-for-age value > + 2 *Z*-scores, and BMI-for-age value > +3 *Z*-scores, respectively, whereas thinness as a BMI-for-age value < −2 *Z*-score. The estimated prevalence of overweight includes children with obesity, and prevalence of obesity includes severe obesity.[26,28] Stunting and underweight were defined as the proportion of children with a H/A value below −2 *Z*-scores and W/A value below −2 *Z*-scores, respectively. Children with biologically implausible (or extreme) values were excluded from the analysis[26]: W/A values below −6 or above +5 *Z*-scores, H/A values below −6 or above +6 *Z*-scores, and BMI/A values below −5 or above +5 *Z*-scores relative to the 2007 WHO growth reference median. As International Obesity Task Force (IOTF) cut-off points[29] are widely used in the WHO European Region, prevalence rates were also calculated using these cut-offs.

Countries were grouped into six macroregions according to the United Nations "Standard Country or Area Codes for Statistical Use"[30]: Eastern Europe, Northern Europe, Southern Europe, Western Europe, Central Asia, and Western Asia as listed in Table 2. Pooled estimates were calculated only for those macroregions where at least

TABLE 1 Children's response proportion in COSI/WHO Europe—round 4 and number of children included in analysis, by country

Country	No. of children invited to participate	Proportion who participated in measurements (%)	No. of children who fell in the targeted age group(s) and included in the analysis[a] by age			
			6-year-olds	7-year-olds	8-year-olds	9-year-olds
Albania - ALB	7113	91.8	-	-	3381	-
Austria - AUT	5135	49.3	-	-	1475	-
Bulgaria - BUL	4090	83.7	-	3386	-	-
Croatia - CRO	7220	78.6	-	-	2724	-
Cyprus - CYP	1819	85.7	-	-	-	653
Czechia - CZH	n.a.	n.a.	-	1002	-	-
Denmark - DEN	3202	84.6	-	1882	-	-
Estonia - EST	14038	91.9	-	6281	6397	-
Finland - FIN	n.a.	n.a.	-	4536	4511	3914
France - FRA	7094	76.8	-	1966	2333	-
Georgia - GEO	4143	80.7	-	2814	-	-
Greece - GRE	6920	63.5	-	1898	-	1874
Hungary - HUN	5978	91.2	-	2638	-	-
Ireland - IRE	2704	56.6	-	882	-	-
Italy - ITA	50902	90.2	-	-	29633	14494
Kazakhstan - KAZ	6026	92.7	-	-	-	2910
Kyrgyzstan - KGZ	8773	91.6	-	3248	3318	-
Latvia - LVA	8143	80.4	-	2737	-	2613
Lithuania - LTU	5527	70.8	-	2540	-	-
Malta - MAT	4329	91.8	-	2784	-	-
Montenegro - MNE	4094	84.1	-	1683	-	-
North Macedonia - MKD	3824	94.0	-	2343	-	-
Norway - NOR	4030	83.2	-	-	2734	-
Poland - POL	3828	89.0	-	-	3338	-
Portugal - POR	7475	92.1	-	3325	-	-
Romania - ROM	9094	83.7	-	-	3510	-
Russia (Moscow) - RUS	3900	77.7	-	2162	-	-
San Marino - SMR	329	95.1	-	-	202	-
Serbia - SRB	5605	86.7	-	2347	-	-
Slovakia - SVK	n.a.	n.a.	-	2761	-	-
Slovenia - SVN	29187	96.7	6115	9661	9259	3050
Spain - SPA	14908	73.1	2635	2815	2789	2635
Sweden - SWE	n.a.	n.a.	3153	-	2683	-
Tajikistan - TJK	3502	94.7	-	2894	-	-
Turkey - TUR	14164	81.7	-	9281	-	-
Turkmenistan - TKM	4085	96.7	-	3124	-	-

Abbreviation: n.a., not available.

[a]All children belonging to target age groups (6- to 9-year-olds) with complete information on sex, whose weight and height were measured and whose BMI/A Z-scores were greater than −5 and less than 5.

TABLE 2 Prevalence values (%) and confidence intervals (CI) of thinness, overweight, obesity, and severe obesity—according to the WHO growth references—among 7- to 9-year-old boys and girls by macroregion and country* (COSI Round 4 ([2015–2017])

	Thinness % [95%CI]		Overweight (including obesity) % [95%CI]		Obesity (including severe obesity) % [95%CI]		Severe obesity % [95%CI]	
Macroregion/country	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Eastern Europe[**,a,b,c]	**3.8 [3.1–4.5]**	**3.1 [2.4–3.8]**	**29.7 [28.0–31.5]**	**26.5 [24.8–28.1]**	**14.0 [12.7–15.3]**	**9.6 [8.3–11.0]**	**3.9 [3.2–4.6]**	**1.5 [1.2–1.9]**
BUL[b,c,d]	3.2 [2.2–4.2]	3.0 [2.2–3.9]	30.2 [27.7–32.8]	28.6 [26.1–31.2]	15.7 [13.7–17.8]	11.4 [9.6–13.1]	5.1 [4.1–6.2]	2.2 [1.5–3.0]
CZH[d,e,f]	5.8 [3.4–8.1]	1.1 [0.2–2.0]	22.9 [18.7–27.1]	19.1 [15.7–22.6]	10.9 [7.5–14.3]	5.5 [3.6–7.4]	4.2 [2.4–6.1]	1.4 [0.4–2.4]
HUN[d,f,g]	3.8 [2.5–5.1]	2.3 [1.2–3.4]	28.0 [25.1–31.0]	27.8 [25.1–30.6]	14.1 [12.0–16.1]	11.2 [9.4–13]	5.0 [3.8–6.3]	2.6 [1.6–3.5]
POL[d,f]	1.8 [1.0–2.6]	1.8 [0.8–2.7]	31.7 [28.2–35.1]	28.8 [25.8–31.8]	14.3 [11.7–16.9]	10.5 [7.6–13.4]	2.9 [1.7–4.1]	1.2 [0.6–1.8]
RUS[**,a,d,f]	3.3 [1.8–4.7]	2.6 [1.4–3.7]	27.0 [23.7–30.3]	22.4 [19.3–25.5]	10.2 [7.7–12.7]	6.5 [4.9–8.1]	2.5 [1.5–3.5]	1.2 [0.5–1.9]
ROM[a,c]	6.7 [5.1–8.3]	7.3 [5.7–9.3]	30.6 [28.3–32.9]	25.8 [22.5–29.0]	15.0 [13.2–16.8]	8.8 [7.4–10.1]	4.4 [3.4–5.4]	1.3 [0.4–2.1]
SVK[h,i]	4.2 [1.9–6.5]	3.0 [1.9–4.0]	30.1 [27.6–32.7]	23.3 [21.2–25.4]	12.4 [10.2–14.6]	10.5 [7.4–13.5]	5.1 [3.8–6.3]	2.0 [1.1–3.0]
Northern Europe[b,c,e]	**1.3 [1.0–1.6]**	**0.7 [0.4–1.0]**	**25.5 [24.3–26.7]**	**23.7 [21.9–25.5]**	**9.2 [8.4–10.0]**	**6.5 [5.9–7.1]**	**2.0 [1.6–2.5]**	**0.8 [0.6–1.0]**
DEN	2.2 [1.3–3.1]	1.1 [0.4–1.7]	17.6 [15.5–19.7]	20.1 [16.7–23.5]	4.9 [3.4–6.3]	5.1 [3.3–6.9]	0.5 [0.1–0.8]	0.3 [0.0–0.8]
EST[b,c,h]	1.6 [1.4–1.7]	1.2 [1.3–0.1]	28.6 [28.0–29.3]	23.3 [22.7–23.9]	11.4 [11.0–11.9]	7.9 [7.4–8.2]	4.0 [3.7–4.3]	1.4 [1.2–1.5]
FIN[d,f,g]	1.3 [0.9–1.8]	0.5 [0.2–0.8]	28.3 [26.6–30.1]	26.7 [24.9–28.5]	11.5 [10.2–12.8]	9.0 [7.8–10.1]	2.9 [2.2–3.5]	1.6 [1.1–2.1]
IRE[a,d]	0.0	0.0	27.1 [22.4–31.9]	19.8 [15.3–24.2]	9.3 [5.9–12.7]	5.3 [3.1–7.5]	2.8 [0.8–4.8]	0.7 [0.0–1.6]
LTU[a,b,i]	1.8 [1.1–2.4]	2.1 [1.2–3.0]	28.5 [25.5–31.4]	22.9 [20.5–25.2]	12.2 [10.3–14.1]	7.8 [6.0–9.5]	3.7 [2.6–4.9]	1.2 [0.5–2.0]
LVA[a,d,f]	2.0 [1.0–2.9]	1.0 [0.5–1.6]	24.8 [22.4–27.2]	20.6 [18.4–22.8]	8.8 [7.3–10.4]	6.5 [5.2–7.7]	2.5 [1.6–3.4]	1.1 [0.6–1.7]
NOR[d]	1.8 [1.0–2.6]	1.0 [0.3–1.7]	24.0 [21.2–26.8]	22.4 [19.9–24.9]	7.2 [5.7–8.7]	4.7 [3.7–5.6]	1.0 [0.4–1.5]	0.3 [0.1–0.6]
SWE[f,j,k]	0.9 [0.7–1.1]	0.1 [0–0.3.0]	27.5 [23.5–31.4]	28.2 [25.9–30.6]	10.4 [7.8–13.1]	7.1 [5.3–9.0]	1.8 [1.1–2.6]	0.7 [0.2–1.2]
Southern Europe[a,b,c]	**1.1 [0.9–1.3]**	**1.3 [0.9–1.7]**	**39.7 [38.3–41.2]**	**37.1 [35.6–38.6]**	**18.6 [17.4–19.9]**	**14.2 [13.0–15.4]**	**5.4 [4.7–6.1]**	**2.2 [1.7–2.7]**
ALB[b,c,h]	2.8 [2.0–3.5]	3.5 [2.5–4.6]	23.2 [20.4–25.9]	16.5 [14.4–18.7]	10.7 [9.0–12.5]	5.3 [3.9–6.7]	2.5 [1.7–3.2]	0.7 [0.3–1.1]
CRO[b,h,i]	0.9 [0.4–1.4]	2.6 [1.8–3.4]	37.1 [34.5–39.7]	28.5 [26.2–30.9]	16.2 [14.0–18.3]	10.3 [8.7–11.8]	4.2 [3.1–5.3]	1.6 [0.9–2.2]
GRE[f,k]	0.9 [0.1–1.6]	0.3 [0.0–0.6]	42.0 [38.5–45.5]	37.8 [34.5–41.1]	20.1 [17.4–22.9]	14.3 [12.2–16.4]	5.7 [4.1–7.2]	2.5 [1.4–3.5]
ITA[b,c,h]	1.6 [1.3–1.9]	1.4 [1.2–1.6]	41.9 [40.8–43.1]	38.5 [37.4–39.6]	21.0 [20.1–21.8]	14.0 [13.3–14.8]	5.5 [5.1–6.0]	2.0 [1.7–2.3]
MAT[a,c,d]	1.1 [0.9–1.3]	0.8 [0.7–1.0]	37.0 [36.2–37.8]	34.6 [33.8–35.4]	18.0 [17.4–18.6]	14.9 [14.3–15.5]	7.4 [7.0–7.9]	3.7 [3.4–4.0]
MKD[d,l]	4.7 [3.0–6.4]	2.7 [1.6–3.7]	32.2 [28.8–35.5]	29.5 [26.2–32.9]	17.3 [14.4–20.3]	12.9 [10.0–15.7]	7.9 [5.3–10.5]	3.0 [1.9–4.1]
MNE[a,b,c]	0.8 [0.3–1.4]	1.0 [0.3–1.6]	37.4 [33.6–41.3]	28.8 [25.4–32.1]	18.9 [16.3–21.5]	8.7 [6.7–10.7]	4.8 [3.6–6.0]	0.9 [0.2–1.6]
POR[a,i]	0.8 [0.2–1.3]	1.1 [0.6–1.7]	29.0 [26.6–31.4]	32.4 [30.1–34.7]	12.0 [10.3–13.6]	10.7 [8.9–12.5]	4.0 [3.0–5.0]	1.6 [0.9–2.4]
SMR[d]	1.1 [0.6–1.7]	0.0	39.1 [36.4–41.8]	32.2 [29.9–34.4]	19.5 [17.3–21.7]	8.7 [7.3–10.0]	2.3 [1.5–3.1]	0.9 [0.4–1.3]
SPA[g]	0.3 [0.2–0.4]	1.0 [0.5–1.5]	42.2 [39.5–44.9]	40.4 [36.7–44.0]	18.7 [15.8–21.5]	16.8 [14.3–19.3]	5.8 [4.1–7.5]	2.8 [1.8–3.7]
SRB[j,k]	1.4 [0.7–2.1]	2.0 [0.7–3.2]	32.6 [29.5–35.7]	28.5 [25.1–31.9]	15.0 [12.7–17.3]	9.7 [7.7–11.7]	4.3 [2.9–5.7]	1.4 [0.7–2.1]
SVN[c,g,k]	2.8 [2.3–3.2]	1.8 [1.4–2.2]	24.3 [23.3–25.3]	24.5 [23.3–25.7]	10.5 [9.8–11.1]	8.4 [7.6–9.1]	3.2 [2.9–3.6]	1.5 [1.3–1.8]

TABLE 2 (Continued)

Macroregion/country	Thinness % [95%CI]		Overweight (including obesity) % [95%CI]		Obesity (including severe obesity) % [95%CI]		Severe obesity % [95%CI]	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Western Europe**								
AUT[a,b,f]	1.9 [0.7–3.1]	2.6 [1.2–4.0]	30.3 [26.3–34.3]	22.3 [17.9–26.8]	12.4 [9.4–15.4]	6.2 [4.0–8.3]	3.2 [1.5–4.8]	1.1 [0.3–1.9]
FRA[f,g]	3.9 [2.1–5.7]	1.4 [0.6–2.3]	24.6 [20.9–28.4]	23.4 [20.6–26.2]	8.9 [6.0–11.8]	6.2 [4.4–7.9]	2.0 [1.0–3.0]	0.7 [0.0–1.5]
Central Asia[f]	**4.0 [3.2–4.8]**	**3.4 [2.8–4.1]**	**12.9 [11.5–14.3]**	**12.2 [10.2–14.2]**	**3.5 [2.8–4.3]**	**3.2 [2.3–4.1]**	**0.8 [0.5–1.2]**	**0.4 [0.0–0.9]**
KAZ	3.8 [2.2–5.4]	3.1 [1.8–4.5]	17.5 [14.2–20.8]	19.8 [15.4–24.2]	4.8 [3.1–6.6]	6.2 [3.8–8.6]	1.0 [0.2–1.8]	0.9 [0.0–2.3]
KGZ[d,f]	3.0 [2.0–4.0]	2.6 [1.4–3.7]	10.9 [8.9–12.9]	8.8 [7.3–10.4]	3.5 [2.2–4.9]	1.6 [1.0–2.3]	1.2 [0.5–1.8]	0.2 [0.0–0.5]
TJK[l]	4.8 [3.1–6.5]	3.7 [2.6–4.9]	9.4 [7.3–11.5]	5.2 [3.9–6.4]	1.8 [0.9–2.6]	1.1 [0.5–1.6]	0.5 [0.0–1.0]	0.1 [0.0–0.2]
TKM[f]	4.1 [2.8–5.5]	4.4 [3.2–5.7]	11.5 [9.2–13.8]	11.4 [9.4–13.3]	3.6 [2.5–4.7]	2.3 [1.5–3.1]	0.8 [0.3–1.3]	0.3 [0.0–0.6]
Western Asia**								
CYP[f]	2.7 [0.9–4.5]	2.8 [1.1–4.5]	43.0 [37.5–48.4]	43.1 [38.1–48.1]	21.5 [16.7–26.3]	19.2 [13.9–24.5]	5.7 [3.8–7.6]	2.2 [0.6–3.8]
GEO[a,c,d]	2.0 [1.3–2.7]	1.3 [0.5–2.0]	26.1 [23.7–28.5]	22.2 [20.0–24.5]	10.3 [8.7–11.9]	7.2 [5.7–8.7]	3.9 [2.9–4.8]	1.3 [0.6–2.0]
TUR[b,c]	1.8 [1.3–2.3]	1.4 [1.0–1.8]	27.3 [25.5–29]	25.4 [23.7–27.0]	12.7 [11.4–14.1]	8.8 [7.7–9.9]	4.1 [3.4–4.8]	1.9 [1.3–2.5]
Pooled estimates[b,c,e,h]	**2.5 [2.2–2.8]**	**1.9 [1.6–2.1]**	**28.7 [27.8–29.6]**	**26.5 [25.6–27.3]**	**12.5 [11.9–13.2]**	**9.0 [8.5–9.6]**	**3.5 [3.2–3.9]**	**1.5 [1.3–1.7]**

*Figures refer to: i) 7-year-olds in Bulgaria, Czechia, Denmark, Estonia, Finland; Georgia, Greece, Hungary, Ireland, Kyrgyzstan, Latvia, Lithuania, Malta, Montenegro, North Macedonia, Portugal, Russian Federation – only Moscow, Serbia, Slovakia, Slovenia, Spain, Tajikistan, Turkey and Turkmenistan ii) 8-year-olds in Albania, Austria, Croatia, France, Italy, Norway, Poland, Romania, San Marino and Sweden and iii) 9-year-olds in Cyprus and Kazakhstan.

**Estimates for Western Europe and Western Asia were not calculated because only few countries belonging to these two macroregions participated in COSI. Data collected in Russia (only in Moscow) were not included in Eastern Europe estimates because they are not representative of the whole country.

[a]Statistically significant difference of proportions between boys and girls for overweight (based on WHO definition)—Pearson's chi-squared corrected using Rao–Scott method, p-value < 0.05.

[b]Statistically significant difference of proportions between boys and girls for obesity (based on WHO definition)—Pearson's chi-squared corrected using Rao–Scott method, p-value < 0.0001.

[c]Statistically significant difference of proportions between boys and girls for severe obesity (based on WHO definition)—Pearson's chi-squared corrected using Rao–Scott method, p-value < 0.0001.

[d]Statistically significant difference of proportions between boys and girls for obesity (based on WHO definition)—Pearson's chi-squared corrected using Rao–Scott method, p-value < 0.05.

[e]Statistically significant difference of proportions between boys and girls for thinness (based on WHO definition)—Pearson's chi-squared corrected using Rao–Scott method, p-value < 0.001.

[f]Statistically significant difference of proportions between boys and girls for severe obesity (based on WHO definition)—Pearson's chi-squared corrected using Rao–Scott method, p-value < 0.05.

[g]Statistically significant difference of proportions between boys and girls for thinness (based on WHO definition)—Pearson's chi-squared corrected using Rao–Scott method, p-value < 0.05.

[h]Statistically significant difference of proportions between boys and girls for overweight (based on WHO definition)—Pearson's chi-squared corrected using Rao–Scott method, p-value < 0.0001.

[i]Statistically significant difference of proportions between boys and girls for severe obesity (based on WHO definition)—Pearson's chi-squared corrected using Rao–Scott method, p-value < 0.001.

[j]Statistically significant difference of proportions between boys and girls for thinness (based on WHO definition)—Pearson's chi-squared corrected using Rao–Scott method, p-value < 0.0001.

[k]Statistically significant difference of proportions between boys and girls for obesity (based on WHO definition)—Pearson's chi-squared corrected using Rao–Scott method, p-value < 0.001.

[l]Statistically significant difference of proportions between boys and girls for overweight (based on WHO definition)—Pearson's chi-squared corrected using Rao–Scott method, p-value < 0.001.

50% of the countries participated in the fourth round of COSI (i.e., Eastern Europe, Northern Europe, Southern Europe, and Central Asia). Data collected in Moscow were not included in Eastern Europe estimates because they are not representative of the whole country.

2.4 | Statistical analysis

The prevalence of thinness, overweight (including obesity), obesity (including severe obesity), severe obesity, stunting, and underweight among girls and boys and 95% confidence intervals (95% CI) were estimated for countries and age groups separately. The macroregion prevalence values were calculated including only one target age group per country in order to balance the contribution of each country to the pooled estimates and to limit as far as possible the differences in children's age. For the pooled analysis, 7-year-olds were used if they were targeted, otherwise the nearest targeted age group was chosen. For those countries which collected data on more than one age group, the prevalence of overweight (including obesity) and obesity was also calculated for each age group.

Sampling weights to adjust for the sampling design, oversampling, and nonresponse were available for all countries that applied a sampling approach except for Lithuania. These weights were used in all analyses to infer the results from the sample to the population. For Lithuania, the analysis was unweighted. All analyses took account of the complex survey nature of data (i.e., multiple stages, cluster, and stratification). In the pooled analysis, an adjusting factor was applied to the sampling weights to take account of differences in the population size of the countries involved. The adjusting factor was based on the number of children belonging to the targeted age group according to Eurostat figures or national official statistics for 2016.[24]

Pearson's chi-squared test corrected using the Rao–Scott method was used to determine differences in the distributions by child's sex. A *p*-value of 0.05 was used to define statistical significance. All statistical analyses were performed using the statistical software package Stata version 15·1.

3 | RESULTS

3.1 | Study population

Over a quarter of a million schoolchildren from 36 different European countries were invited to participate in the fourth round of the COSI study, with the number invited varying very widely from 329 in San Marino and 1819 in Cyprus to 29,187 in Slovenia and 50,902 in Italy (Table 1). Most of the parents authorized the measurement of their children, and the children agreed to participate. The response proportion was more than 70% in 28 countries, varying from 49.3% in Austria to 96.7% in Slovenia and Turkmenistan. This information was not available for five countries. Less than 0.5% of children were excluded because of implausible *Z*-score values. A total of 203,323 children fell in the targeted age groups and were included in the analysis. The target age groups were a single year (e.g., children age 6.0–6.9, 7.0–7.9, 8.0–8.9, or 9.0–9.9), and the analysis included a total of 11,903 children aged 6 years from only three countries, 80,990 children aged 7 from 25 countries, 78,287 children aged 8 from 15 countries, and 32,143 children aged 9 from eight countries.

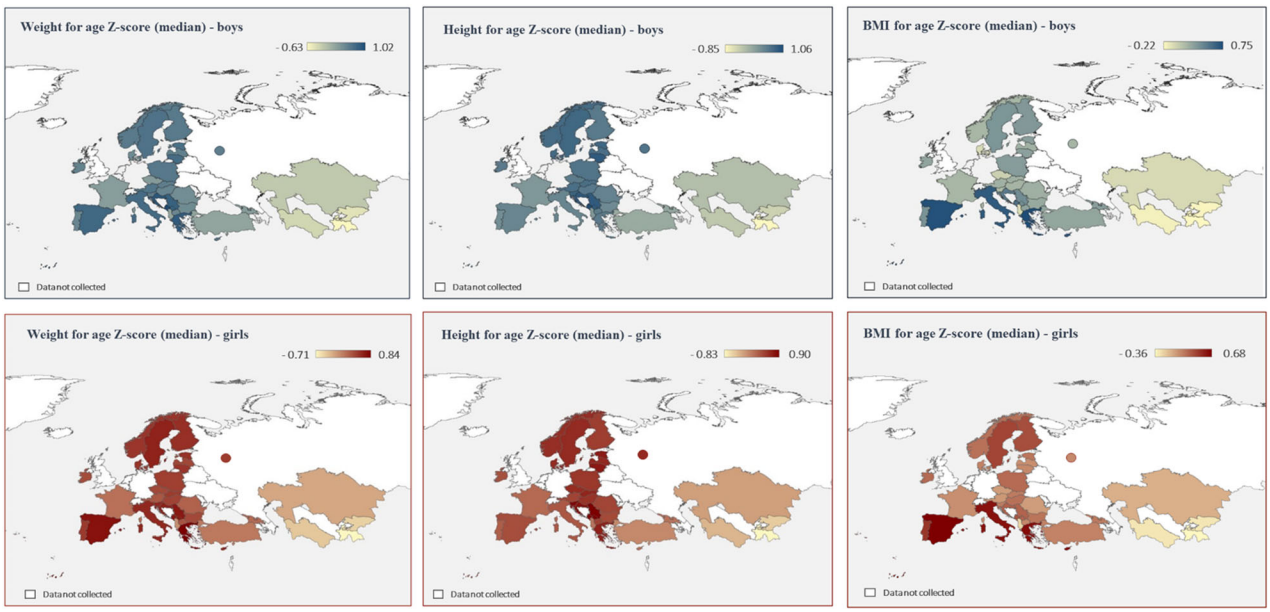

FIGURE 1 Median values for weight-for-age *Z*-scores, height-for-age *Z*-scores, BMI-for-age *Z*-scores boys and girls by country. COSI Round 4 (2015–2017).

Figures refer to: i) 7-year-olds in Bulgaria, Czechia, Denmark, Estonia, Finland; Georgia, Greece, Hungary, Ireland, Kyrgyzstan, Latvia, Lithuania, Malta, Montenegro, North Macedonia, Portugal, Russian Federation – only Moscow, Serbia, Slovakia, Slovenia, Spain, Tajikistan, Turkey and Turkmenistan ii) 8-year-olds in Albania, Austria, Croatia, France, Italy, Norway, Poland, Romania, San Marino and Sweden and iii) 9-year-olds in Cyprus and Kazakhstan

TABLE 3 Prevalence values (%) of overweight and obesity—according to the WHO growth references—by age, sex, and country (COSI Round 4 [2015–2017])

	Boys (%)				Girls (%)			
Country	6-year-olds	7-year-olds	8-year-olds	9-year-olds	6-year-olds	7-year-olds	8-year-olds	9-year-olds
Overweight (including obesity)								
EST[a]	n.a.	28.6	29.7	n.a.	n.a.	23.3	23.0	n.a.
FIN[b,e]	n.a.	28.3	31.3	36.0	n.a.	26.7	29.8	32.6
FRA[a]	n.a.	18.2	24.6	n.a.	n.a.	20.2	23.4	n.a.
GRE[a]	n.a.	42.0	n.a.	46.3	n.a.	37.8	n.a.	41.8
ITA[e]	n.a.	n.a.	41.9	40.9	n.a.	n.a.	38.5	33.7
KGZ	n.a.	10.9	10.6	n.a.	n.a.	8.8	8.4	n.a.
LVA[a]	n.a.	24.8	n.a.	30.5	n.a.	20.6	n.a.	23.5
SPA[b,e]	34.9	42.2	42.5	48.0	32.4	40.4	42.1	42.6
SVN[b,e]	21.1	24.3	30.3	36.4	18.0	24.5	28.9	30.4
SWE[a,c]	22.9	n.a.	27.5	n.a.	21.3	n.a.	28.2	-
Obesity (including severe obesity)								
EST[a]	n.a.	11.4	12.4	n.a.	n.a.	7.9	7.3	n.a.
FIN[b,d]	n.a.	11.5	14.5	17.4	n.a.	9.0	11.6	12.5
FRA	n.a.	6.4	8.9	n.a.	n.a.	6.4	6.2	n.a.
GRE	n.a.	20.1	n.a.	21.8	n.a.	14.3	n.a.	12.2
ITA[a,e]	n.a.	n.a.	21.0	19.3	n.a.	n.a.	14.0	11.1
KGZ	n.a.	3.5	3.6	n.a.	n.a.	1.6	1.4	n.a.
LVA	n.a.	8.8	n.a.	10.5	n.a.	6.5	n.a.	6.0
SPA[b]	14.4	18.7	21.3	24.4	13.3	16.8	14.8	16.4
SVN[b,e]	8.3	10.5	13.8	17.1	5.7	8.4	9.7	10.0
SWE[c]	7.8	n.a.	10.4	n.a.	5.4	n.a.	7.1	n.a.

Abbreviation: n.a., not available: the specific age group was not targeted by the country.
[a]Statistically significant difference of proportions between different age groups for overweight/obesity (based on WHO definition) among boys—Pearson's chi-squared corrected using Rao–Scott method, p-value < 0.05.
[b]Statistically significant difference of proportions between different age groups for overweight/obesity (based on WHO definition) among boys—Pearson's chi-squared corrected using Rao–Scott method, p-value < 0.0001.
[c]Statistically significant difference of proportions between different age groups for overweight/obesity (based on WHO definition) among girls—Pearson's chi-squared corrected using Rao–Scott method, p-value < 0.05.
[d]Statistically significant difference of proportions between different age groups for overweight/obesity (based on WHO definition) among girls—Pearson's chi-squared corrected using Rao–Scott method, p-value < 0.001.
[e]Statistically significant difference of proportions between different age groups for overweight/obesity (based on WHO definition) among girls—Pearson's chi-squared corrected using Rao–Scott method, p-value < 0.0001.

3.2 | Weight-for-age, height-for-age, and BMI-for-age

Figure 1 shows, for each country, the median Z-scores for weight-for-age, height-for-age, and BMI-for-age. In Table S1, their interquartile ranges and the values for four macroregions are also reported. Because only three countries provided data for children aged 6 and they also targeted other age groups, these children were included only in Table 3.

The results for weight-for-age indicate that, for the macroregions, on average, the boys and girls of Southern Europe are the heaviest, followed by Northern Europe and Eastern Europe, and the lightest are from the Central Asian countries. The differences between the three European macroregions are relatively small (Figures 1 and 2 and Table S1). These results are similar for both boys and girls, with generally lower body weight among girls. There are considerable differences among the countries within each macroregion with greater variability in Southern Europe (Table S1 and Figure 1). The average weights-for-age Z-scores were highest in Montenegro (MNE boys) and Greece (GRE girls) and lowest in Tajikistan (TJK boys and girls).

Meanwhile, the children of Northern Europe are shown to be taller than those of Eastern Europe, followed by Southern Europe and the Central Asian countries. Again, the results are similar for boys and girls. Within each macroregion, there are important differences in height for age Z-scores among countries, with the tallest in Montenegro (MNE boys) and Serbia (SRB girls) and the shortest in Tajikistan (Table S1 and Figure 1).

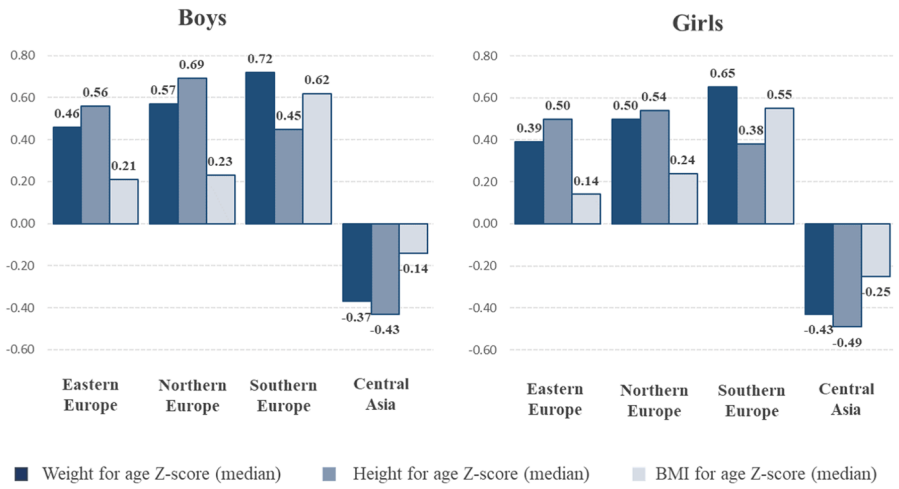

FIGURE 2 Median values for weight-for-age *Z*-scores, height-for-age *Z*-scores, BMI-for-age *Z*-scores boys and girls by macroregions. COSI Round 4 (2015–2017). Macro-regions include the following countries-age groups: i) 7-year-olds in Bulgaria, Czechia, Denmark, Estonia, Finland, Greece, Hungary, Ireland, Kyrgyzstan, Latvia, Lithuania, Malta, Montenegro, North Macedonia, Portugal, Serbia, Slovakia, Slovenia, Spain, Tajikistan and Turkmenistan; ii) 8-year-olds in Albania, Croatia, Italy, Norway, Poland, Romania, San Marino and Sweden and iii) 9-year-olds in Kazakhstan. Estimates for Western Europe and Western Asia were not calculated because only few countries belonging to these two macro-regions participated in COSI

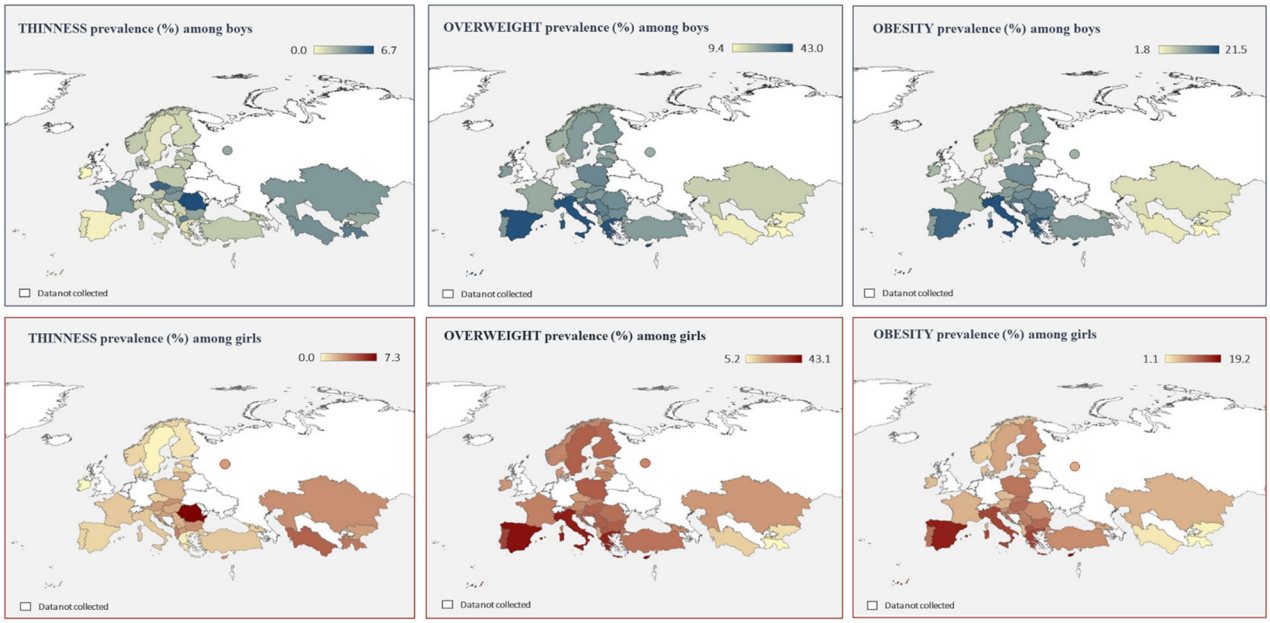

FIGURE 3 Prevalence values (%) of thinness, overweight, and obesity—according to the WHO growth references—among 7- to 9-year-old boys and girls by country. COSI Round 4 (2015–2017).
Figures refer to: i) 7-year-olds in Bulgaria, Czechia, Denmark, Estonia, Finland; Georgia, Greece, Hungary, Ireland, Kyrgyzstan, Latvia, Lithuania, Malta, Montenegro, North Macedonia, Portugal, Russian Federation - only Moscow, Serbia, Slovakia, Slovenia, Spain, Tajikistan, Turkey and Turkmenistan ii) 8-year-olds in Albania, Austria, Croatia, France, Italy, Norway, Poland, Romania, San Marino and Sweden and iii) 9-year-olds in Cyprus and Kazakhstan

The ranking of the macroregions for BMI for age *Z*-scores is similar to that observed for weight-for-age *Z*-scores, with Southern Europe having the highest median and Central Asia the lowest. However, the difference between Southern Europe and the other two European macroregions (North and East) is greater. Given that children in the Central Asian macroregion are lighter and shorter than children in the European regions, Figure 2 shows, as expected, that the median BMI for age *Z*-scores for the Central Asian region although lower is closer to those in the European macroregions, especially Eastern and Northern European macroregions. At the same time, the medians of Eastern and Northern Europe are very similar, and these values are included in the Central Asia CI. This is more related to the BMI score central distribution rather than the tails.

Greece (GRE) is the country with the highest value of BMI-for-age *Z*-scores for boys, whereas Cyprus (CYP) and Spain (SPA) have the highest value for girls, and Tajikistan (TJK) has the lowest for both boys and girls (Figure 1 and Table S1).

Among the countries not included in the macroregions, the results for Cyprus are similar to those of Southern Europe. Russian Muscovites, who were not included in Eastern Europe estimates because they were not representative of the whole country, have similar values to the countries that make up this macroregion.

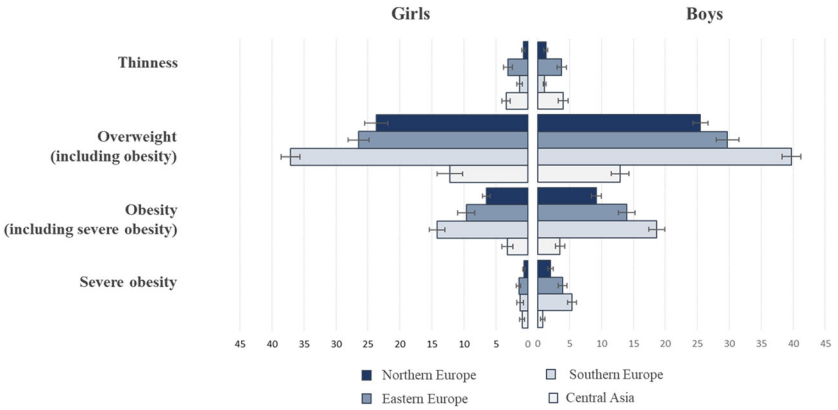

FIGURE 4 Prevalence values (%) of thinness, overweight (including obesity), obesity (including severe obesity), and severe obesity—according to the WHO growth references—among 7- to 9-year-old boys and girls by macroregion. COSI Round 4 (2015–2017).
Macro-regions include the following countries-age groups: i) 7-year-olds in Bulgaria, Czechia, Denmark, Estonia, Finland, Greece, Hungary, Ireland, Kyrgyzstan, Latvia, Lithuania, Malta, Montenegro, North Macedonia, Portugal, Serbia, Slovakia, Slovenia,Spain, Tajikistan and Turkmenistan; ii) 8-year-olds in Albania, Croatia, Italy, Norway, Poland, Romania, San Marino and Sweden and iii) 9-year-olds in Kazakhstan. Estimates for Western Europe and Western Asia were not calculated because only few countries belonging to these two macro-regions participated in COS

3.3 | Prevalence of thinness, overweight, obesity, and severe obesity

Table 2 and Figures 3 and 4 show the main results of the survey, the percentage distribution of BMI according to the WHO definitions of thinness, overweight, obesity, and severe obesity by country, macro-region, and sex. In these table and figures, and in the following tables and figures, obesity always includes severe obesity and overweight includes obesity (and as a consequence severe obesity).

The first general indication provided by Table 2 and Figures 3 and 4 is that thinness is rare in the countries belonging to the WHO European Region, although in 2015–2017, 4.0% of boys and 3.4% of girls were classified as "thin" in Central Asia and 3.8% of boys and 3.1% of girls in Eastern Europe. The highest prevalence was observed in Romania (ROM, 6.7% of boys and 7.3% of girls). Overall, 2.5% of boys and 1.9% of girls were thin in the WHO European Region.

In Table S2, the prevalence of stunting and underweight are also reported. The highest values were observed in Tajikistan (TJK) with 10.5% of boys and 9.0% of girls classified as stunted and 8.2% of boys and 7.8% of girls as underweight.

Overweight and obesity are more common among children of the WHO European Region, with pooled estimates of 28.7% among boys and 26.5% among girls (Table 2). The higher percentages were in the macroregion Southern Europe, followed by Eastern Europe and Northern Europe, whereas the prevalence rates observed in Central Asian countries were much lower (Figure 3). The highest level of obesity was observed in Cyprus (CYP, 21.5% of boys and 19.2% of girls) and the lowest in Tajikistan (TJK, 1.8% and 1.1%, respectively). In North Macedonia (MKD) and in Malta (MAT), more than 7% of boys had severe obesity, whereas less than 1% had severe obesity in Central Asia.

Although the prevalence rates differ markedly among and within the macroregions, for all the nonnormal weight categories, the prevalence rates tend to be higher for boys than for girls (Table 2 and Figure 4). Thus, for thinness, the prevalence rates were higher for boys in five out of seven countries in Eastern Europe, in six out of eight in Northern Europe, six out of 12 in Southern Europe, and three out of four in Central Asian countries. For severe obesity, higher rates were observed for boys than for girls in all 36 countries (Table 2).

Studies of body weight in children generally use either the definitions derived by WHO or the definitions proposed by the International Obesity Task Force (IOTF). These definitions of normal and nonnormal BMI categories are not the same and may lead to differences in the estimated prevalence of normal weight, thinness, overweight, and obesity. For completeness, and to facilitate comparisons between our results and those of other studies, Table S3 shows the prevalence of overweight (including obesity) and obesity (including severe obesity) for the countries included in this study but calculated using the IOTF growth reference.[29] The ranking of these two prevalence rates by macroregion is the same using the IOTF or the WHO growth references; overweight and obesity are both most common in the macroregion Southern Europe, followed by Eastern Europe and Northern Europe, and they are least common in the Central Asian macroregion. However, the prevalence estimates calculated using the IOTF cut-off values are lower, in particular for boys.

3.4 | Trend of overweight and obesity by age

Table 3 shows the prevalence of overweight and obesity in those countries that collected data for more than one age group in order to evaluate the trend with age. The data confirm that for both overweight and obesity, the prevalence rates were higher among boys than girls in all age groups. Furthermore, in all countries, with the exception of Kyrgyzstan (KGZ), there were significant differences in overweight prevalence, with these generally increasing with age in both boys and girls. The prevalence of obesity also increased with age for both sexes. For example, this is clear in Spain and Slovenia, the two countries that have measured children from all age groups: the overweight (including obesity) prevalence in boys in Spain increased from 34.9% at age 6 to 42.2% at age 7, 42.5% at age 8, and to 48.0% at age 9; in Slovenia, it increased from 21.1% to 24.3%, 30.3%, and 36.4% respectively.

4 | DISCUSSION

This paper provides estimates of the prevalence of thinness, overweight, and obesity from 203,323 children living in 36 countries participating in the fourth round of COSI (2015–2017). These accurate measurements, taken by trained staff according to a common protocol, enable public health officials to examine the prevalence of thinness, overweight, obesity, and severe obesity in more than half of the countries in the WHO European Region and grouped by some UN macroareas. To the best of our knowledge, this is the largest study (in terms of number of countries involved and number of children measured) to examine body weight status among children using primary data that were collected following a standardized methodology.

The results of this study show great geographic variability in height, body weight, and BMI among children aged 6–9 years old. If on average the children of Northern Europe are the tallest, those of Southern Europe are the heaviest and those living in Central Asia are the lightest and shortest. However, there is wide variation within each region. Similar differences have been found in other studies reviewing the results of single countries[31] and may be mainly explained by genetic, nutritional, socio-economic, and environmental factors.[32–35]

Levels of thinness, stunting, and underweight were relatively low, except in Eastern Europe (for thinness) and the four Central Asian countries where these conditions reached a prevalence similar to that of obesity (around 3%–4%), as observed in other countries in this part of the world.[7,8] This "double burden" of malnutrition is common in many lower-middle-income countries and describes the coexistence of undernutrition along with overweight and obesity or diet-related noncommunicable diseases, within individuals, households, and populations, and across the life course.[36] The double burden of malnutrition is the result of changing food systems and is often observed in the context of increased urbanization, demographic change, and globalization. Children living in low- and middle-income countries are generally more vulnerable to inadequate prenatal, infant, and young child nutrition. At the same time, these children are exposed to high-fat, high-sugar, high-salt, energy-dense, and micronutrient-poor foods, which tend to be lower in cost but also lower in nutrient quality. These dietary patterns, in conjunction with lower levels of physical activity, result in sharp increases in childhood obesity while undernutrition tends to decrease but remains unsolved.[36,37] The dual burden of malnutrition poses a threat to the health of these children. Countries from other WHO regions, with increasing prevalence of overweight and obesity and persistence of thinness, underweight, and stunting, may need to strengthen surveillance using systems as COSI to improve the comparability of data, further develop strategies to address underweight or overweight issues, and investigate potential "double-duty actions."[38,39]

Similar to the previous rounds of COSI[20–23] and other studies,[7] the highest rates of overweight and obesity were found in Cyprus (43% of children having overweight—including obesity—and 20% having obesity) and in the Southern European countries. In this part of Europe, in 2015–2017, more than one child out of three had overweight (including obesity) and about one out of six had obesity. These results are similar to those found measuring waist circumference in 10 countries participating in COSI.[40] As argued in previous articles,[20,21] different explanations have been proposed for this excess in Southern Europe, such as lower height-for-age,[41] higher birth weight,[42,43] shorter sleep duration,[44] shorter period of breastfeeding,[45] less healthy dietary habits,[46] less physical activity,[47] less correct parental perceptions of their children's body weight status,[48] and less consideration of childhood obesity as key public health challenge.

Severe obesity is a problem in several countries in Europe, especially among boys. One out of 20 boys had severe obesity in Southern Europe and one out of 25 in Eastern Europe, reaching 7.9% in North Macedonia and 7.4% in Malta; values higher than those observed in 2012–2013.[49]

The observed lower prevalence of overweight (including obesity) and obesity (including severe obesity) in Central Asian countries may be due to the need for appropriate BMI cut-offs for Asian populations, as was discussed for adults in a WHO expert consultation in 2004.[50] However, to date, there is no recommendation for new BMI cut-off points for people of Asian descent.

In general, boys showed a less favorable weight status situation, with higher prevalence rates of thinness, overweight, obesity, and severe obesity than girls. However, using the growth references proposed by IOTF, these differences between boys and girls disappear or are reversed, especially with regard to being overweight, as observed in previous studies.[49,51,52] The analysis of global data in 2016, using the WHO growth curves, also showed a clear regional patterns in gender comparison, with more girls than boys with obesity in almost all countries in sub-Saharan Africa and in a few other countries, but more boys than girls with obesity across the rest of the world.[7]

Although the age span investigated is 4 years maximum (children aged 6- to 9-years-old) and only 10 countries collected data in more than one age group, our results show a general tendency for the prevalence of overweight (including obesity) and obesity to increase with age in both boys and girls. This finding needs to be confirmed in the future rounds, but the same trend by age has been found in the United States, where 12.4% of children aged 5–6 years had obesity versus 18.6% at mean age 9[53] and in England, where the prevalence of obesity was 9.5% in children aged 4–5 and 20.1% at age 10–11 in 2017–2018.[54] However, this tendency seems to change at older ages: according to the latest data of the Health Behaviour in School-age Children study,[55] children aged 15 are less likely to be overweight or obese than 11 and 13 year olds.

The major strength of this study is the availability of national representative samples of children measured by trained staff, with similar equipment and using a common protocol. Moreover, for the first time, data were collected in some countries of Central Asia allowing a comparison also with this part of the world. In this round, all countries, except Lithuania, were able to give all the information needed to calculate weights to adjust for sampling design, oversampling, and nonresponse.

The main limitations are that in two countries, the proportion of children who participated in measurement was less than 60% and five

countries failed to estimate the response proportion. Eleven countries were not able to reach the minimum final effective sample size of about 2800 children per age group, as recommended in the study protocol, and the comparison is not made between children of the same age but ranging 7–9 years. However, these limitations should not seriously alter the conclusions of the study.

5 | CONCLUSIONS

The Childhood Obesity Surveillance Initiative provides robust data on the prevalence of children's weight status in Europe and Central Asia. The latest data show that the prevalence of overweight and obesity is high in many countries, in particular in Southern Europe, and thinness is still present, especially in Eastern Europe and Central Asia. To ensure that more children fall into healthy weight categories (being neither underweight or overweight), it will be necessary not only to recognize the extent of these problems but also to acknowledge the importance of prevention and to plan and implement population based interventions. The WHO recommends several strategies to address unhealthy weight in children, requiring the coordinated contributions of all governmental sectors and institutions contributing to policy development and implementation. Resources need to be dedicated to policy implementation and workforce capacity strengthening, and regular monitoring of body weight and height is also crucial.[56,57] COSI is a valuable system for monitoring the prevalence of and trends in thinness, overweight, and obesity in 6- to 9-year-old school children[58] and can contribute evidence toward assessing the effects of policies, actions, and interventions in individual countries.

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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.

AUTHOR CONTRIBUTIONS

A.S., M.B., and P.N. conceptualized and drafted 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. J.W. was involved in critically reviewing the drafts of the manuscript. G.S., T.H., P.B.J., A-S. F., D.W., S.M., M.G.S, A.C., L.B., A.I.R., V.A.K., M.H., E.H., and P.M. commented on the draft of the paper and contributed with data collection and data cleaning. H.R., I.R., M.W.W., A.F.H., M.M., and D.S. commented on the draft of the paper. S.A., S.R., V.D., V.F.S., A.F., A.G., E.S., M.Ha., J.H., C.K., E.K., M.K., E.M.I., S.O., V.P., A.P., S.P., I.P., K.R.J., M.A.D.S, B.S., L.S., I.S., M.T., L.T., Z.U., L.H.O., A.A., K.S., and K.B. contributed with data collection and data cleaning. All authors contributed to and approved the paper.

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Country Office in Turkmenistan and Ministry of Health; Turkey: Turkish Ministry of Health and World Bank.

DISCLAIMER

J.B., J.W., I.R., and M.W.W. are staff members of WHO and M.B. is a consultant with WHO. The authors alone are responsible for the views expressed in this article, and they do not necessarily represent the views, decisions, or policies of the institutions with which they are affiliated.

ETHICS STATEMENT

The COSI study follows the International Ethical Guidelines for Biomedical Research Involving Human Subjects. Local ethics approval was also granted.

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SUPPORTING INFORMATION

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