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Prevalence and Trends of Overweight and Obesity in European Children From 1999 to 2016
A Systematic Review and Meta-analysis

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IMPORTANCE Studies of trends in excess weight among European children throughout the last few decades have rendered mixed results. Additionally, some studies were outdated, were based on self-reported weight and height, or included only a few European countries.

OBJECTIVE To assess prevalence trends in measured overweight and obesity among children across Europe from 1999 to 2016 using a systematic methodology.

DATA SOURCES MEDLINE, Embase, CINAHL, and Web of Science were searched from their inception until May 2018. Moreover, searches were conducted on health institutions' websites to identify studies not published in scientific journals.

STUDY SELECTION The inclusion criteria were: (1) studies reporting the population-based prevalence of excess weight (overweight plus obesity) or obesity according to body mass index cutoffs proposed by the International Obesity Task Force; (2) cross-sectional or follow-up studies; and (3) studies including populations aged 2 to 13 years.

DATA EXTRACTION AND SYNTHESIS Literature review and data extraction followed established guidelines. The Mantel-Haenszel method was used to compute the pooled prevalence estimates and their 95% CI whenever there was no evidence of heterogeneity (I^2 < 50%); otherwise, the DerSimonian and Laird random-effects method was used. Subgroup analyses by study year, country, or European region (Atlantic, Iberian, Central, and Mediterranean) were conducted. Prevalence estimates were calculated as an aggregate mean, weighted by the sample size and the number of individuals in each study.

RESULTS A total of 103 studies (477 620 children aged 2 to 13 years) with data from 28 countries were included. The combined prevalence of overweight and obesity in the Iberian region tended to decrease from 30.3% (95% CI, 28.3%-32.3%) to 25.6% (95% CI, 19.7%-31.4%) but tended to increase in the Mediterranean region from 22.9% (95% CI, 17.9%-27.9%) to 25.0% (95% CI, 14.5%-35.5%). No substantial changes were observed in Atlantic Europe or Central Europe, where the overweight and obesity prevalence changed from 18.3% (95% CI, 14.0%-23.9%) to 19.3% (95% CI, 17.7%-20.9%) and from 15.8% (95% CI, 13.4%-18.5%) to 15.3% (95% CI, 11.6%-20.3%), respectively.

CONCLUSIONS AND RELEVANCE The prevalence of childhood overweight and obesity is very high, but trends have stabilized in most European countries. There are substantial between-country differences in the current levels and trends of overweight and obesity. The rising prevalence in some Mediterranean countries is worrisome.

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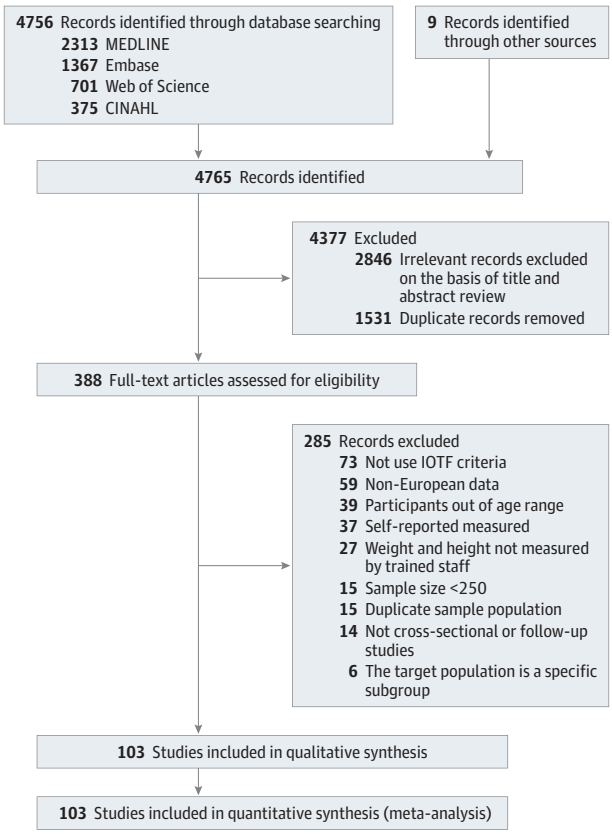
The prevalence of obesity and overweight has markedly risen in the last 2 decades in Europe, even though noticeable variations in the estimations across countries have been reported.[1-3] According to estimates from the World Health Organization's Childhood Obesity Surveillance Initiative, using the International Obesity Task Force (IOTF) criteria, approximately one-quarter of European children aged 6 to 9 years had overweight or obesity in 2010, with estimates ranging from 10.8% (Belgium) to 39.9% (Greece).[4] The prevalence of overweight and obesity among children and adolescents is growing in low- and middle-income countries,[5] although some country-specific analyses have suggested a recent plateau, or even a decrease, in the frequency of excess weight, especially in high-income countries.[3,6]

Although obesity is a multidimensional health problem, unhealthy dietary habits and sedentary lifestyles are the main immediate drivers.[5] The adverse consequences of childhood obesity go far beyond some unfavorable health and psychosocial conditions in infancy and adolescence because children with overweight or obesity are at greater risk of obesity in adulthood[7-9] than their peers with normal weight, with the ensuing burden of chronic diseases, including type 2 diabetes, cardiovascular diseases, cancer, and mental health disorders.[10-14]

In Europe, several studies on excess-weight trends among children in recent decades yielded somewhat mixed results.[1,3,15]

Figure 1. PRISMA Flow Diagram



IOTF indicates International Obesity Task Force.

Key Points

Question What are the prevalence and trends of overweight and obesity in European children?

Findings In this meta-analysis of 103 studies that included 477 620 children aged 2 to 13 years in 28 European countries, the combined prevalence of overweight and obesity in children increased from 1999 to 2006 to 2011 to 2016. Additionally, the weighted prevalence of obesity increased during the same period.

Meaning Despite a recent stabilization of the trends in childhood excess weight in most European countries, current interventions to address the excess weight epidemic should be maintained or strengthened because the prevalence of excess weight is still very high.

Additionally, some studies were outdated,[16] covered narrow age groups,[4] relied on self-reported weight and height,[16-18] or included only a few countries.[4] Thus, this study was aimed at assessing the trends in prevalence of measured overweight and obesity among children aged 2 to 13 years in Europe from 1999 to 2016 using a systematic methodology. This information is important to assess the progress achieved in the control of the childhood obesity epidemic and to identify specific regions where additional measures must be implemented to address unfavorable excess-weight trends.

Methods

The systematic review and meta-analysis were conducted according to the Meta-analysis of Observational Studies in Epidemiology (MOOSE) reporting guideline[19] and the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) reporting guideline[20] (**Figure 1**). We have registered and published this review on PROSPERO, and its protocol has been published elsewhere.[21]

Search Strategy

We systematically searched the MEDLINE (via PubMed), Embase, CINAHL, and Web of Science databases from their inception until May 2018. The following terms were combined to design the search strategy: (1) population (*children*, *childhood*, *schooler*, *schoolchildren*, *preadolescent*, *adolescent*, *school aged*, *school-aged*); (2) outcome (*obesity*, *overweight*, *body composition*, *body constitution*, *weight status*, *anthropometry*); (3) study design (*prevalence*, *trend*, *epidemiology*, *observational*, *cross-sectional*, *longitudinal*); and (4) location (includes terms for different European countries) (eTable 1 in the Supplement). Additionally, we scanned the reference lists of the included studies. Finally, we conducted an open search on national and international institutional public health and health ministry websites to identify weight status estimates not reported in scientific journals. The literature search, the data extraction, and the quality assessment were performed independently by 2 investigators (M.G.-M. and C.Á.-B.), and disagreements were resolved by consensus or involving a third researcher (V.M.-V.).

Study Selection

The inclusion criteria were (1) studies reporting the population-based prevalence of excess weight (overweight plus obesity) or obesity, according to body mass index (calculated as weight in kilograms divided by height in meters squared) cutoffs proposed by the IOTF[22,23]; (2) cross-sectional or follow-up studies and panel surveys with weight and height measured by trained personnel; and (3) studies including populations aged 2 to 13 years.

Studies were excluded from the analyses when (1) they were published in languages other than English, Spanish, Italian, or Portuguese; (2) the sample was less than 250 children (on the rationale that smaller samples may lead to a lack of precision in the prevalence estimates); (3) the target population was a specific subgroup, such as aboriginal groups, immigrants, or those with a single socioeconomic status; and (4) they were duplicate reports of the same study. When more than one article provided data on the same sample, the one reporting the most detailed results and/or with the largest sample size was retained in data synthesis.

Search and Data Extraction

The main characteristics of the selected studies are summarized in eTable 2 in the Supplement, including information regarding (1) country; (2) European region[24]; (3) period of the study; (4) study design; (5) level of representativeness (regional or national); (6) population characteristics (age distribution and sample size); and (7) prevalence of overweight and obesity combined and obesity alone based on the IOTF definition.[22,23]

When some important data were not reported in the articles, we asked the authors to provide these data if possible. Inconsistencies in data reporting across studies underlie the differences in data presentation in eTable 2 in the Supplement.

Quality Assessment

We used the Joanna Briggs Institute tool[25] to evaluate the risk of bias in the prevalence studies. This tool consists of a rating list with 10 criteria, which can be assessed as yes (coded as 1), no (coded as 0), not applicable (coded as NA), or unclear (coded as ?); thus, the score for each study ranged from 0 to 10. Depending on its score, we rated each study as low risk (7-10), moderate risk (4-6), or high risk of bias (1-3).

For longitudinal studies, we used the Effective Public Health Practice Project tool.[26] This instrument evaluates the risk of bias according to 7 domains: selection bias, study design, confounders, blinding, data collection method, withdrawals, and dropouts. Each domain can be considered strong (with no weak domains), moderate (with 1 weak domain), or weak (with 2 or more weak domains).

Statistical Analysis

Data used to estimate the pooled prevalence means were obtained from cross-sectional studies as well as from baseline or final measurements of longitudinal studies. When studies reported estimates of morbid obesity (body mass index, ≥35 at age 18 years), these were included in the obesity category to estimate a single value for obesity (body mass index, ≥30 at age 18 years). We used the weighted pooling to study size method in each analysis.[27] Therefore, the prevalence estimates were calculated as an aggregate mean, weighted by the sample size and the number of individuals with excess weight of each study. Thus, we calculated the general point estimate and performed subgroup analyses according to sex, age group (2 to 6 years and 7 to 13 years), period, country, and European region. The Mantel-Haenszel fixed-effects method[28] was used to compute the pooled prevalence estimate and its 95% CI whenever there was no evidence of heterogeneity; otherwise, the DerSimonian and Laird random-effects method[29] was used. The heterogeneity of results across studies was evaluated with the I^2 statistic,[30] which was interpreted as not important (0%-40%), moderate heterogeneity (30%-60%), substantial heterogeneity (50%-90%), or large heterogeneity (75%-100%).[31] Considering the overlapping between these heterogeneity categories, we decided to use the Mantel-Haenszel fixed-effects method when I^2 was less than 50%.

In the subgroup analyses, we distinguished 3 periods: the wealthy period (1999-2006), the peak of the economic crisis (2007-2010), and the years that followed the crisis (2011-2016), hereafter precrisis, crisis, and postcrisis periods, respectively. We also distinguished 4 European regions[24]: Atlantic (France, Ireland, United Kingdom, Belgium, the Netherlands, Finland, Norway, and Sweden), Iberian (Portugal and Spain), Central (Germany, Czech Republic, Switzerland, Poland, Romania, Lithuania, Estonia, Hungary, and Latvia), and Mediterranean (Cyprus, Greece, Italy, Malta, Slovenia, Republic of North Macedonia, Serbia, Bulgaria, and Turkey). Additionally, random-effects meta-regression analyses were used to evaluate whether the prevalence estimate differed according to the gross national income per capita based on the purchasing power parity of each European country.

The significance value of the pooled effect size was estimated based on the 95% CI. Two-sided P values of .05 or less were significant. Statistical analyses were performed using Stata SE software, version 15 (StataCorp).

Results

Study Selection and Characteristics

The PRISMA diagram with the flow of studies through the review is presented in Figure 1. From the 4310 articles identified, 103 studies (2.4%) met the inclusion criteria (eTable 2 in the Supplement).[4,15,32-132] Of these, 5 studies displayed data for several European countries.[4,15,33,34,39] Studies were conducted in 28 European countries: Belgium (3 reports), Bulgaria (2), Cyprus (5), Czech Republic (1), Estonia (2), Finland (1), France (5), Germany (8), Greece (9), Hungary (4), Ireland (8), Italy (13), Latvia (2), Lithuania (3), Malta (2), the Netherlands (4), Norway (6), Poland (7), Portugal (13), Romania (1), Serbia (2), Slovenia (3), Spain (14), Sweden (8), Switzerland (2), Turkey (5), United Kingdom (4), and Republic of North Macedonia (1).

A total of 477 620 children aged 2 to 13 years were included in this review, with sample sizes of analyzed studies

ranging from 259 to 124 113. The reports were published between 1999 and 2016, including 97 cross-sectional prevalence studies and 6 longitudinal studies. Furthermore, 27 studies were based on national samples, and 76 were based on samples from regions of a country.

Study Quality

As evaluated by the Joanna Briggs Institute tool,[25] 8 prevalence studies (8.8%) showed a high risk of bias, 25 (25.2%) showed a moderate risk, and 64 (66.0%) showed a low risk. In 66 studies (68.2%), the measurement of weight and height was described in detail. Only 63 studies (64.9%) met the criteria for sample representativeness (eTable 3 in the Supplement).

From 6 longitudinal studies in which quality was assessed using the Effective Public Health Practice Project tool,[26] 5 scored as moderate and 1 as weak. Where studies were analyzed by individual domains, all studies included information regarding data collection, but 4 studies (66.7%) had limitations in the control of confounders and in blinding (eTable 4 in the Supplement).

Prevalence and Trends of Overweight and Obesity

Overall, the prevalence of overweight and obesity combined in European children aged 2 to 13 years changed from 20.6% (95% CI, 18.8%-22.4%) during 1999 to 2006 to 21.3% (95% CI, 19.2%-23.6%) during 2011 to 2016. Additionally, the prevalence of obesity in this age group changed from 4.4% (95% CI, 3.8%-5.1%) during 1999 to 2006 to 5.7% (95% CI, 5.0%-6.6%) during 2011 to 2016. When we used only studies with representative samples and assessed as moderate or high quality, the trends estimates were similar, in such a way that the prevalence estimates for overweight and obesity combined changed from 20.0% (95% CI, 17.6%-22.6%) during 1999 to 2006 to 22.9% (95% CI, 20.1%-25.9%) during 2011 to 2016; similarly, the prevalence of obesity changed from 4.2% (95% CI, 3.3%-5.3%) to 6.3% (95% CI, 5.4%-7.4%) (eTable 5 in the Supplement).

Time Trends by Country

The **Table** shows the prevalence of overweight and obesity combined and obesity alone in children (aged 2-6 and 7-13 years) for 28 European countries from 1999 to 2016, using IOTF definition criteria.[22,23] From 1999 to 2006, the lowest prevalences of overweight and obesity were observed in Belgium (9.0%; 95% CI, 8.0%-10.0%) and the Netherlands (10.2%; 95% CI, 8.4%-12.3%), and the highest prevalences were in Greece (40.8%; 95% CI, 38.0%-43.6%) and Spain (31.9%; 95% CI, 29.2%-34.7%). However, during 2011 to 2016, the lowest figures were seen in Poland (12.3%; 95% CI, 11.4%-13.3%) and Switzerland (14.4%; 95% CI, 13.1%-15.8%), and the highest were in Greece (36.8%; 95% CI, 24.4%-51.3%) and Italy (35.2%; 95% CI, 32.4%-38.1%).

In regards to the prevalence of obesity, during 1999 to 2006, the lowest estimates were reported in Belgium (1.6%; 95% CI, 1.2%-2.1%) and Switzerland (1.7%; 95% CI, 1.4%-2.1%), and the highest were in Greece (14.1%; 95% CI, 12.3%-16.2%) and Spain (10.4%; 95% CI, 7.7%-13.9%). Nevertheless, during 2011 to 2016, the lowest prevalences were observed in Switzerland (2.4%; 95% CI, 1.9%-3.1%) and Sweden (2.9%; 95% CI, 2.2%-3.9%), and the highest prevalences were in Italy (16.8%; 95% CI, 11.3%-24.2%) and Malta (14.2%; 95% CI, 11.9%-16.8%). eFigure 1 in Supplement shows the trends of overweight and obesity in children (aged 2-13 years) from 1999 to 2016. Girls presented a higher prevalence of overweight and obesity than boys in most European countries, although sex differences in the levels and trends of overweight and obesity were small (eTable 6 in Supplement provides sex-specific prevalence in each age group and country).

Time Trends by Regions

Figure 2 displays trends in the pooled prevalence estimates of overweight and obesity in children (aged 2-6 and 7-13 years) from the 4 regions of Europe from 1999 to 2016. During 1999 to 2006, the Atlantic region showed the lowest prevalence (12.8%; 95% CI, 9.5%-16.2%), whereas the highest was observed in the Iberian region (31.0%; 95% CI, 28.8%-33.3%). However, during 2011 to 2016, the Central region presented the lowest prevalence (13.2%; 95% CI, 11.3%-15.4%), and the Mediterranean region had the highest prevalence (30.4%; 95% CI, 25.8%-35.9%).

For obesity prevalence, during 1999 to 2006, the Central region presented the lowest estimate (2.7%; 95% CI, 1.3%-4.1%), and the Iberian region had the highest (10.4%; 95% CI, 7.7%-13.9%). From 2011 to 2016, the Central region showed the lowest prevalence (3.2%; 95% CI, 2.3%-4.6%), and the Mediterranean region had the highest prevalence (10.1%; 95% CI, 6.1%-14.1%) (**Figure 3**).

Meta-regression

Random-effects meta-regression models showed a negatively significant association between the combined prevalence of overweight and obesity and gross national income per capita in European countries during 3 periods, 1999 to 2006 (95% CI, −0.23 to −0.16), 2007 to 2010 (95% CI, −0.15 to −0.08), and 2011 to 2016 (95% CI, −0.20 to −0.12) ($P < .001$) (eFigures 2 and 3 in the Supplement and Figure 3). However, no significant differences were found in the 2- to 6-year subgroup during 2011 to 2016 (95% CI, −0.04 to 0.03) (Figure 3A). Otherwise, the trends in the combined prevalence of overweight and obesity from 1999 to 2016 was also negatively associated with gross national income per capita in different countries in Europe for the age range of 7 to 13 years ($P < .001$; 95% CI, −0.15 to −0.08) (**Figure 4**). Nevertheless, no significant differences were found for the age range of 2 to 6 years (95% CI, −0.03 to 0.12) (Figure 4A).

Discussion

This systematic review and meta-analysis provides a comprehensive picture of the trends from 1999 to 2016 in the prevalence of overweight and obesity in children aged 2 to 13 years across the European region. Overall, our results indicate a stabilization of the obesity epidemic in Europe, although substantial differences between countries in both current levels

Table. Trends in the Prevalence of Childhood Overweight and Obesity Combined and Obesity Alone for 28 European Countries Using IOTF Definition Criteria[4,15,32-132]

	Pooled Estimate (95% CI)					
	1999-2006		2007-2010		2011-2016	
Country	Overweight and Obesity	Obesity	Overweight and Obesity	Obesity	Overweight and Obesity	Obesity
Belgium						
2-6 y	9.0 (8.0-10.1)	1.6 (1.2-2.1)	12.9 (12.7-13.1)	3.3 (3.0-3.6)	NA	NA
7-13 y	14.0 (13.1-15.0)	3.1 (2.7-3.6)	15.5 (14.1-16.9)	4.3 (3.8-4.8)	NA	NA
Bulgaria						
2-6 y	NA	NA	NA	NA	NA	NA
7-13 y	NA	NA	22.0 (20.4-23.7)	7.7 (6.6-8.8)	24.0 (21.0-27.2)	6.1 (4.6-8.1)
Cyprus						
2-6 y	14.1 (12.4-16.0)	5.4 (4.4-6.8)	21.0 (19.1-23.1)	7.7 (6.5-9.2)	19.9 (15.9-24.6)	8.1 (5.6-11.6)
7-13 y	26.3 (20.4-33.1)	7.9 (7.3-8.5)	30.6 (28.8-32.4)	10.8 (9.6-12.1)	34.3 (30.4-38.4)	12.3 (9.8-15.3)
Czech Republic						
2-6 y	NA	NA	NA	NA	NA	NA
7-13 y	NA	NA	15.2 (13.0-17.7)	3.9 (2.9-5.4)	NA	NA
Estonia						
2-6 y	NA	NA	8.5 (6.7-10.6)	1.8 (1.1-3.1)	NA	NA
7-13 y	NA	NA	20.4 (17.9-23.3)	6.7 (5.2-8.5)	14.7 (11.4-18.9)	3.8 (2.2-6.4)
Finland						
2-6 y	NA	NA	NA	NA	NA	NA
7-13 y	NA	NA	13.1 (10.5-16.4)	4.5 (2.8-6.2)	NA	NA
France						
2-6 y	NA	NA	9.5 (8.6-10.4)	2.2 (1.8-2.7)	NA	NA
7-13 y	14.9 (12.3-18.0)	3.2 (2.7-3.7)	15.6 (14.6-16.7)	2.9 (2.4-3.4)	NA	NA
Germany						
2-6 y	15.0 (11.6-19.3)	3.1 (2.6-3.6)	12.7 (10.9-14.8)	3.3 (2.4-4.5)	NA	NA
7-13 y	19.2 (16.1-22.8)	3.5 (2.6-4.8)	22.4 (19.6-25.4)	5.4 (4.0-7.2)	18.9 (14.6-24.2)	5.4 (4.0-7.2)
Greece						
2-6 y	NA	NA	NA	NA	16.0 (14.5-17.6)	3.3 (2.6-4.1)
7-13 y	40.8 (38.0-43.6)	14.1(12.3-16.2)	39.7 (35.6-43.9)	10.5 (8.6-12.7)	36.8 (24.4-51.3)	10.0 (3.8-23.9)
Hungary						
2-6 y	NA	NA	11.9 (10.3-13.8)	4.7 (3.7-5.9)	NA	NA
7-13 y	NA	NA	22.9 (21.5-24.4)	6.8 (5.5-8.3)	21.3 (16.9-26.5)	4.7 (2.7-7.9)
Ireland						
2-6 y	27.4 (20.9-35.0)	6.3 (5.1-7.6)	26.9 (22.4-32.0)	8.0 (5.5-11.6)	NA	NA
7-13 y	26.2 (25.5-26.9)	6.8 (6.3-7.3)	23.7 (19.3-28.8)	6.2 (4.5-8.4)	19.5 (17.9-21.3)	4.1 (3.3-5.1)
Italy						
2-6 y	25.4 (20.4-31.3)	8.4 (6.0-11.7)	36.5 (33.9-39.1)	16.7(14.8-18.7)	NA	NA
7-13 y	28.2 (26.4-30.1)	7.0 (5.6-8.8)	37.3 (33.5-41.3)	12.5 (10.0-15.4)	35.2 (32.4-38.1)	12.2 (10.6-14.0)
Latvia						
2-6 y	NA	NA	NA	NA	NA	NA
7-13 y	NA	NA	16.0 (14.4-17.7)	4.5 (3.2-6.1)	NA	NA
Lithuania						
2-6 y	NA	NA	NA	NA	NA	NA
7-13 y	NA	NA	17.3 (16.0-18.6)	5.0 (4.6-5.4)	NA	NA
Malta						
2-6 y	NA	NA	23.7 (21.9-25.5)	9.8 (8.6-11.1)	NA	NA
7-13 y	NA	NA	NA	NA	34.5 (31.3-37.9)	14.2 (11.9-16.8)
Netherlands						
2-6 y	10.2 (8.4-12.3)	2.2 (1.5-3.2)	9.1 (8.1-10.2)	2.3 (1.8-2.9)	NA	NA
7-13 y	17.1 (15.4-19.0)	3.8 (3.0-4.8)	16.9 (15.5-18.5)	3.7 (3.1-4.5)	NA	NA

(continued)

Table. Trends in the Prevalence of Childhood Overweight and Obesity Combined and Obesity Alone for 28 European Countries Using IOTF Definition Criteria[4,15,32-132] (continued)

Country	Pooled Estimate (95% CI)					
	1999-2006		2007-2010		2011-2016	
	Overweight and Obesity	Obesity	Overweight and Obesity	Obesity	Overweight and Obesity	Obesity
Norway						
2-6 y	13.1 (11.5-14.7)	1.9 (1.4-2.7)	NA	NA	NA	NA
7-13 y	15.7 (13.3-18.4)	2.6 (2.1-3.2)	17.7 (14.4-21.6)	3.3 (2.4-4.4)	NA	NA
Poland						
2-6 y	16.4 (10.9-24.0)	3.1 (2.2-4.4)	17.1 (13.9-20.8)	4.8 (3.1-7.1)	12.3 (11.4-13.3)	3.7 (3.2-4.3)
7-13 y	14.8 (12.4-17.6)	2.5 (1.7-3.7)	19.2 (17.5-21.0)	4.7 (2.9-7.6)	NA	NA
Portugal						
2-6 y	NA	NA	26.8 (21.6-32.7)	8.2 (6.1-10.9)	26.9 (18.2-37.8)	8.0 (5.7-11.1)
7-13 y	29.8 (26.1-33.8)	8.2 (5.4-12.3)	30.5 (27.4-33.8)	9.0(7.4-10.9)	26.4 (25.1-27.8)	8.8 (7.9-9.7)
Romania						
2-6 y	NA	NA	20.9 (17.7-24.5)	6.1 (4.4-8.5)	NA	NA
7-13 y	NA	NA	23.7 (22.2-25.3)	6.9 (6.0-7.9)	NA	NA
Serbia						
2-6 y	NA	NA	NA	NA	23.8 (21.0-26.8)	8.4 (6.7-10.5)
7-13 y	25.5 (24.4-26.8)	7.0 (6.3-7.7)	NA	NA	24.1 (22.1-26.3)	6.3 (5.3-7.4)
Slovenia						
2-6 y	NA	NA	18.2 (16.5-20.1)	5.9 (5.1-6.8)	NA	NA
7-13 y	NA	NA	24.5 (23.6-25.5)	7.2 (6.4-8.1)	NA	NA
Spain						
2-6 y	27.0 (22.8-31.7)	10.4 (7.7-13.9)	22.4 (14.0-34.8)	7.2 (4.2-12.1)	19.7 (18.8-20.6)	6.7 (4.3-10.4)
7-13 y	31.9 (29.2-34.7)	8.1 (7.1-9.2)	33.9 (30.4-37.7)	8.5 (6.6-10.7)	32.1 (29.0-35.3)	9.2 (6.5-12.8)
Sweden						
2-6 y	NA	NA	9.9 (8.2-12.0)	1.6 (1.0-2.6)	NA	NA
7-13 y	19.5 (17.3-22.0)	3.1 (2.5-3.8)	18.1 (15.4-21.1)	3.1 (2.7-3.5)	15.0 (6.3-31.4)	2.9 (2.2-3.9)
Switzerland						
2-6 y	NA	NA	NA	NA	14.4 (13.1-15.8)	3.2 (2.6-4.0)
7-13 y	13.7 (12.8-14.7)	1.7 (1.4-2.1)	NA	NA	17.4 (16.0-18.9)	2.4 (1.9-3.1)
Turkey						
2-6 y	NA	NA	15.9 (13.1-19.1)	3.3 (2.1-5.2)	NA	NA
7-13 y	13.3 (11.7-15.1)	1.9 (1.3-2.7)	18.6 (14.5-23.6)	3.3 (1.6-6.7)	NA	NA
United Kingdom						
2-6 y	NA	NA	NA	NA	NA	NA
7-13 y	21.3 (17.5-25.5)	5.2 (4.9-5.6)	23.0 (21.6-24.5)	5.5 (4.7-6.3)	NA	NA
Republic of North Macedonia						
2-6 y	NA	NA	NA	NA	NA	NA
7-13 y	NA	NA	24.5 (23.0-26.2)	10.2 (9.2-11.4)	NA	NA

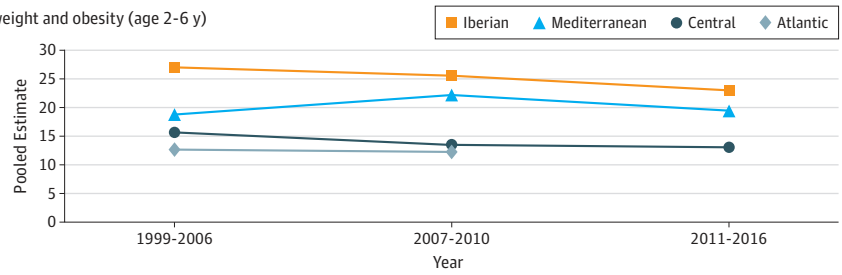
Abbreviations: IOTF, International Obesity Task Force; NA, not applicable (no published article that examined the prevalence of childhood obesity in the selected years was found).

and trends should be noted. For example, while a downward trend in excess weight is occurring in the Iberian region, the prevalence is increasing in most Mediterranean countries. Otherwise, data from Atlantic and Central Europe indicate a stabilization or even a decrease in both regions.

There is evidence of a worldwide increase in the overweight and obesity prevalence in children that started in approximately 1980.[133] However, during the first decade of the 21st century, in some European countries as well as Australia, China, and the United States, this growing trend has reached a plateau or shown a slight decline.[1,3,6,134] Since this phenomenon has been reported in countries with different prevalence rates, it is plausible that the increased population awareness of this public health problem, as well as interventions promoting daily physical activity and healthy diets, have contributed to the stabilization of childhood obesity rates.[134] Nevertheless, given that prevalence rates are still increasing in some European countries, other cultural or socioeconomic factors could underlie the marked differences in obesity prevalence. Specifically, in Europe, there are distinct cultural differences by geographical region. In our study, as has been noted in previous studies,[4,15] children residing in countries across the

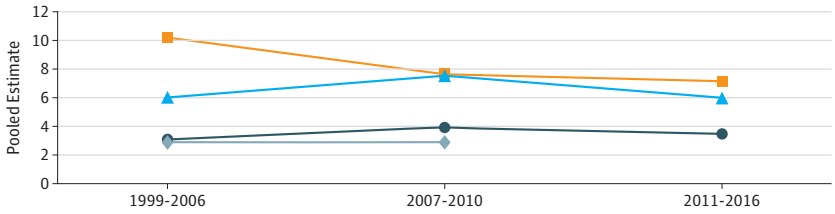
Figure 2. Pooled Estimate for the Prevalence of Overweight and Obesity in Children Aged 2-13 Years Across European Regions According to International Obesity Task Force Definition Criteria

A Overweight and obesity (age 2-6 y)



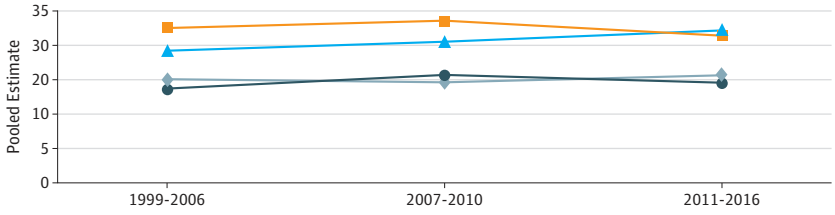
Region	No. of Studies (I^2)	Pooled Estimate (95% CI)	No. of Studies (I^2)	Pooled Estimate (95% CI)	No. of Studies (I^2)	Pooled Estimate (95% CI)
Atlantic	8 (92.31)	12.8 (9.5-16.2)	7 (97.26)	12.3 (9.6-15.9)	NA	NA
Iberian	1 (0)	27.0 (22.8-31.7)	4 (91.62)	25.5 (21.1-30.0)	4 (93.24)	23.0 (19.4-27.0)
Central	4 (94.53)	15.7 (12.8-19.1)	5 (92.24)	13.6 (10.3-17.9)	2 (84.57)	13.2 (11.3-15.4)
Mediterranean	3 (95.33)	18.8 (10.5-33.4)	7 (97.83)	22.2 (16.7-29.5)	3 (92.0)	19.5 (14.8-25.8)

B Obesity (age 2-6 y)



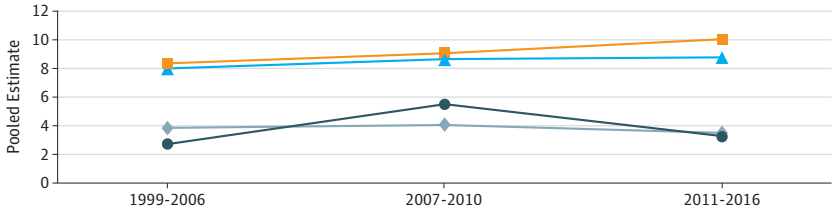
Atlantic	8 (93.60)	2.9 (1.4-4.5)	7 (92.13)	2.9 (2.0-4.2)	NA	NA
Iberian	1 (0)	10.4 (7.7-13.9)	4 (86.38)	7.8 (6.1-9.5)	4 (89.93)	7.3 (5.6-9.5)
Central	4 (4.03)	3.1 (2.8-3.3)	5 (89.62)	4.0 (2.5-5.5)	2 (15.74)	3.5 (2.1-3.9)
Mediterranean	3 (76.93)	6.2 (5.2-7.4)	7 (97.47)	7.7 (4.9-12.1)	3 (94.6)	6.1 (3.1-11.6)

C Overweight and obesity (age 7-13 y)



Atlantic	15 (98.40)	18.3 (14.0-23.9)	22 (93.20)	17.6 (15.3-20.4)	3 (86.2)	19.3 (17.7-20.9)
Iberian	7 (83.69)	31.0 (28.8-33.3)	13 (95.47)	32.5 (30.0-35.1)	5 (90.5)	29.0 (23.4-34.6)
Central	10 (95.10)	16.3 (11.9-20.7)	16 (92.25)	19.4 (17.3-21.8)	4 (41.04)	17.6 (16.4-18.9)
Mediterranean	11 (98.40)	25.3 (19.0-33.6)	23 (96.50)	27.5 (23.7-31.9)	10 (92.2)	30.4 (25.8-35.9)

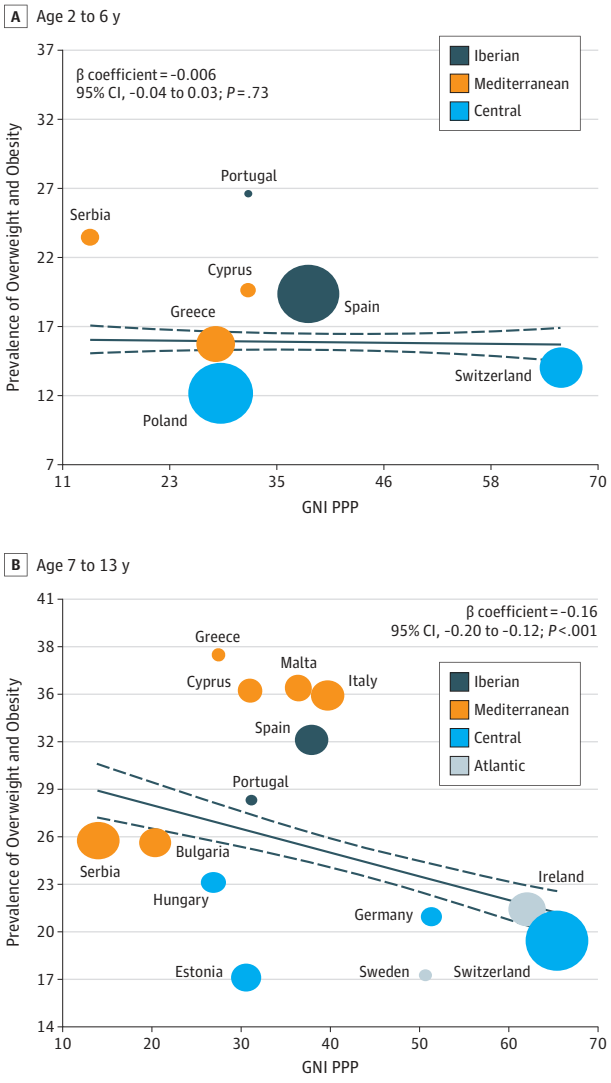
D Obesity (age 7-13 y)



Atlantic	15 (97.12)	3.8 (2.7-5.5)	22 (86.83)	4.0 (3.3-4.7)	3 (79.5)	3.4 (2.3-4.6)
Iberian	7 (97.14)	8.1 (7.1-9.1)	13 (91.65)	8.7 (7.6-9.9)	5 (55.3)	8.8 (7.9-9.6)
Central	10 (93.68)	2.7 (1.3-4.1)	16 (76.17)	5.5 (4.7-6.4)	4 (55.3)	3.2 (2.3-4.6)
Mediterranean	11 (94.7)	8.4 (6.3-11.2)	23 (88.4)	9.1 (7.6-10.8)	10 (93.7)	10.1 (6.1-14.1)

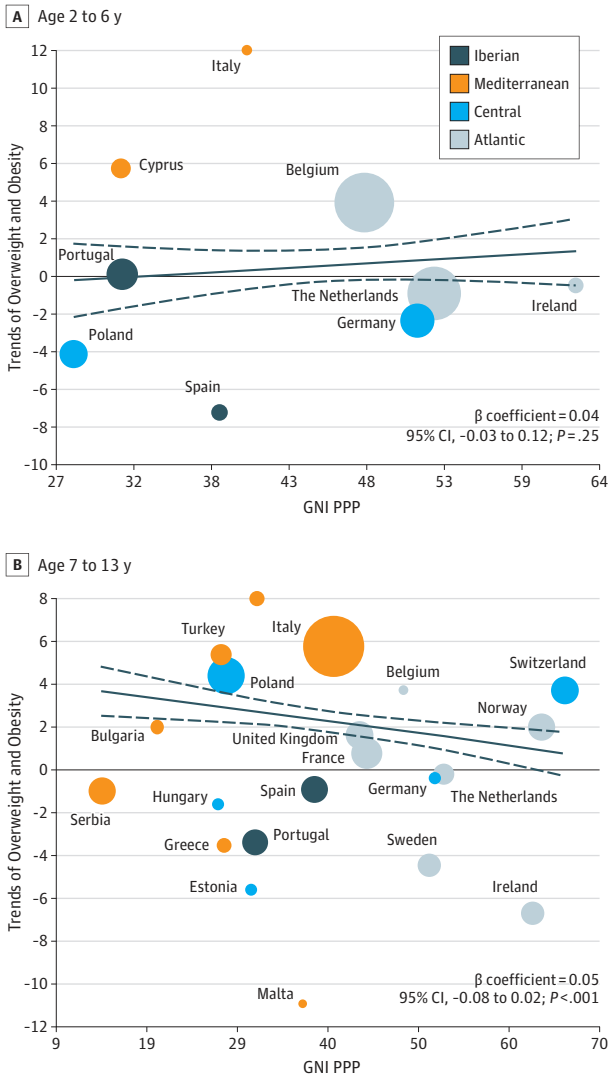
Pooled estimate and trends are presented for the combined prevalence of overweight and obesity in children aged 2 to 6 years (A) and prevalence of obesity in children aged 2 to 6 years (B). Pooled estimate and trends are presented for the prevalence of overweight and obesity combined in children aged 7 to 13 years (C) and prevalence of obesity in children aged 7 to 13 years (D). NA indicates not available.

Figure 3. Meta-regression Plot of Prevalence



Plot shows the prevalence of the combined overweight and obesity of different countries in Europe during 2011 to 2016 according to their gross national income (GNI) per capita based on purchasing power parity (PPP). Dotted lines indicate the confidence interval and solid lines, regression.

Figure 4. Meta-regression Plot of Trends



Plot shows the trends of combined overweight and obesity in different countries of Europe during 1999 to 2016 according to their gross national income (GNI) per capita based on purchasing power parity (PPP). Dotted lines indicate the confidence interval and solid lines, regression.

Mediterranean basin showed the highest prevalence rates of overweight/obesity (24% to 37%), while those in Atlantic and Central Europe showed substantially lower prevalence (14% to 21%). The high prevalence of childhood obesity in Cyprus, Greece, Malta, Italy, Spain, and Portugal could be partially attributed to the gradual shift from the healthy Mediterranean diet to a more Westernized diet,[135] indicated a recent study in which only 5% of Italian children aged 8 to 9 years adhered to the Mediterranean diet.[136] Additionally, physical activity levels in children living in the Mediterranean countries are lower than in those living in Atlantic and Central Europe.[137,138]

Socioeconomic status is usually inversely associated with childhood obesity[139]; thus, the abrupt socioeconomic changes resulting from the financial crisis of 2007, which mostly affected some southern European countries, may have contributed to the observed trends in excess weight. In these southern countries, between 2005 and 2010, the proportion of children at risk of poverty increased from 20.6% to 23.7%, and the proportion of those living in unemployed families rose from 3.7% to 11.2%.[140] Some studies have also observed the highest rates of overweight and obesity in the most disadvantaged population groups, in part, due to their lower diet quality.[139,141] Our results showed that during the crisis the prevalence rates of overweight and obesity were highest, especially in some southern European countries, such as Greece, Spain, Malta, Italy, or Portugal, where the effect of this crisis was more serious. However, during the postcrisis period, the prevalence rates of overweight and obesity stabilized, dropping lower than the precrisis period in many European countries.

Girls showed a higher prevalence of overweight/obesity than boys in most countries in Europe; however, sex differences were small, which is consistent with the results of other studies.[3,6] Boys and girls differ in patterns of body weight gain and hormone biology, but it seems that the shared obesogenic environment minimizes sex differences in excess weight trends.[142]

Limitations

There were some limitations of this meta-analysis that should be acknowledged. Some of these are common to meta-analyses (eg, selection bias and limited availability of complete information from study reports), but others are particularly important in our study. First, only studies that defined overweight and obesity with the IOTF criteria were included,[22,23] which limited the comparability with other relevant studies. Second, studies using the 2 versions of these IOTF criteria were included,[22,23] and although differences in the cutoffs were small, they may have affected prevalence estimates. Third, not all studies ensured representative samples of the population, which posed a threat to the validity of their estimates. Fourth, there were limited data for children aged 2 to 6 years during 2011 to 2016; thus, our findings for this age group should be taken with caution. Fifth, the selection of unbalanced periods can be responsible for a sampling bias, but we considered that establishing socioeconomic-related periods could provide more valuable information because the potential influence that the socioeconomic circumstances could have on the excess weight prevalence. Sixth, for our analyses, because of the scarcity of follow-up studies involving the same people over time, the analysis of time series was discarded. Seventh, differences in sample characteristics, number of studies by country, limited number of national based samples, especially in the postcrisis period, geographic location, and the quality of the included data may have increased heterogeneity between studies, which may have reduced the quality of evidence on excess weight trends.

Conclusions

Despite a recent stabilization of the trends in childhood excess weight in most European countries, current interventions to address the excess weight epidemic should be maintained or strengthened because the prevalence of excess weight is still very high. The Mediterranean countries show a worrying upward trend in childhood excess weight, which requires urgent appropriate public health measures.

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