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Research paper

Ten-Year obesity and overweight prevalence in Greek children: A systematic review and meta-analysis of 2001-2010 data

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ABSTRACT

OBJECTIVE: While the US today has the highest rates worldwide of obesity, Europe, and particularly Southern Europe, is catching up fast. The aim of this study was to report the prevalence of obesity in Greek children, aged 1-12 years. DESIGN: A systematic review—including all studies published in English and Greek from January 2001 until December 2010 regarding childhood obesity, using the IOTF criteria—was performed. Twenty-five out of 134 published studies were finally selected, including 219,996 boys and 210,772 girls. RESULTS: Meta-analysis revealed that 10.2% (CI 95%: 9.8-10.7%) of Greek children (1-12 years) are obese, 23.7% (CI 95%: 22.7-24.8%) are overweight and the combined prevalence of overweight and obesity is 34% (CI 95%: 32.7-35.3%). Subgroup analysis by gender showed that 11% of the boys and 9.7% of the girls were obese, while 24.1% of the boys and 23.2% of the girls were overweight. The combined prevalence of excess in body weight predominated in boys (35%), while in girls the above prevalence was 32.7%. Cumulative analysis revealed an upward trend of the phenomenon (2001-2003), followed by a stabilization (2003-2010). CONCLUSIONS: During the decade 2001-2010, 1/10 Greek children was obese and 3/10 were overweight. The implementation of policies to reverse childhood obesity is of the utmost urgency.

Key words: Children, Europe, Greece, Meta-analysis, Obesity, Overweight, Prevalence

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INTRODUCTION

Three elements appear to contribute to the development of the obesogenic environment prevalent in the Western world but also rising fast in developing countries: food availability, urbanization and sedentary lifestyle. Their both independent and synergistic

interactions have resulted in the obesity epidemic, contributing to 2.6 million deaths worldwide on an annual basis.[1] Childhood and adolescence have been deemed critical periods for the development of the condition, since approximately one half of overweight adolescents and over one third of overweight children become obese adults, all with an increased risk for premature death during early adult life.[2,3] Additionally, obesity is hallmarked by a plethora of comorbidities, all contributing to an increased health care economic cost, especially in youth aged 6-17 years.[4]

With regard to Europe, according to recent data there is wide geographical variation across European countries of obesity and overweight rates among children and adolescents.[5] The over-time trend of the phenomenon is uneven, following an augmentative trend in some countries, while in others there is evidence that the rates have leveled off.[5,6]

One of the first arrows in the quiver of health care providers and policy formations is appropriate research assessing the epidemiologic transitions of childhood overweight and obesity at both a national and an international level. The accurate assessment and classification of the obesity phenomenon will enable recognition and understanding of the epidemiology, this leading to high quality data describing the problem and determining the burden of disease.

Different protocols focusing on the problem of pediatric obesity in Greece have been implemented during the last few years. Previously published reviews have sought to elucidate the phenomenon in a national context. However, to date no research has integrated the outcomes reported from all different available epidemiological protocols and reviews from a meta-analytic perspective.

The aims of this study were a) to provide an accurate overview of the recent relevant data by performing a systematic review of the last ten years' literature and b) to conduct a meta-analysis of the best evidence available (meta-analysis of prevalence rates) in order to determine the current extent of the problem and to estimate the over-time trend of childhood obesity.

MATERIALS AND METHODS

Meta-analysis is a well-established method in medical research, used to combine and analyze large collections of previous research outcomes in order to arrive at a clear scientific hypothesis.[7] Meta-analytic approaches are typically, but not necessarily, applied to randomized controlled trials and generally require methodological homogeneity of the studies included to assess the outcome of a treatment or the effect of a risk factor in any particular pathology. However, the present meta-analysis combines methodologically highly heterogeneous protocols to synthesize and meta-analyze prevalence rates reported from different samples of a national childhood population. This type of meta-analysis has previously been developed and widely used to estimate the prevalence of a specific phenomenon/disease.[8,9]

Search strategy

The study was designed according to the Meta-analysis of Observational Studies in Epidemiology group guidelines for reporting meta-analysis of observational studies.[10] Two of the investigators (E.P.K. and M.G.G.) collected all available data on the prevalence of pediatric overweight (OW) and obesity (OB) in Greece, published from January 2001 until December 2010. A literature search was conducted in MEDLINE, EMBASE, SCOPUS, Web of Science and Google Scholar, during October-November 2010, and updated again in January 2011. The search terms were: "children", "childhood", "obesity", "overweight", "weight status", "body composition", "Greece", "Greek".

In order to avoid language publication bias, an additional literature search was performed using the abovementioned terms in the Greek language via the two national scientific search engines Iatrotek Online and Openarchives.gr as well as the electronic database of Google.gr. Furthermore, a search in the electronic versions of the two Greek pediatric journals through the links *www.e-child.gr* and *www.paediatriki.gr* was performed. The reference lists of all retrieved manuscripts were checked for additional data.

In cases where relevant data were missing or it was not possible to obtain full-text papers, the corresponding authors were contacted via e-mail for additional information. The search procedure yielded 134 publications, published between January 2001 and December 2010.

Eligibility of relevant studies

To identify studies eligible for the meta-analysis, two of the reviewers independently screened all collected papers on the basis of their abstract and full-text. In the event of disagreement, a consensus was reached after the consultation of a third independent investigator.

Research reporting the prevalence of OW/OB in Greek children was considered relevant only when the following criteria were met: (a) definition of OW and OB according to the International Obesity Task Force (IOTF) criteria,[11] (b) studies included pre-pubertal children aged up to the age of 12 years (the age cutoff was based on the educational unit format of Greece, since the majority of the identified studies selected school-based samples) and (c) published between January 2001-December 2010. Studies were excluded from the analyses when: (a) they reported only mean BMI values without investigating the prevalence of OW/OB, (b) they did not segregate data into gender group, (c) they referred to data collected prior to the year 2000, to prevent systematic bias, or (d) if they referred to apparently non-healthy children. When one population was reported in more than one publication, only the most recent one or the one providing the maximum of information was included to avoid sample overlapping.

Data coding and classification

A predefined standard information extraction sheet was used in order to solicit data from each eligible study. Study general profile *(authors, year, journal, design, study name, setting),* methodology *(measurement, sample collection, time of data collection),* sample characteristics *(size, age range, source, geographical origination, rural/urban, response rate),* outcomes *(prevalence of OW/OB in the total sample and according to gender)* were extracted from each publication. When a study reported the prevalence of childhood OW/OB for more than one population separately or for more than one data collection time milestones – e.g. for 6-year-old and 12-year-old participants separately or prevalence measured in 2002 and prevalence measured in 2004 – these subsamples were classified as two discrete study populations and treated as independent.

Quality assessment of studies

In order to assess quality of the eligible studies and to control for possible bias, specific study characteristics suggested by Lien et al. and the criteria proposed in the Newcastle-Ottawa Scale for non-randomized studies were selected, adopted and applied.[5,12] The final scoring system (Table 1) comprised 9 criteria rating different quality elements for each eligible paper. Authors recommended scale weights

Table 1. Items used to measure quality of the selected studies

Quality item		Points
Sample size (n)	≤500/501-1000/1001-2000/2001-3999/≥4000	0/0.5/1/1.5/2
Geographic area of origination	Local/National	0/1
Sample Source Methodology (School sample/ Randomized sample)	Reported/NR	1/0
Sample Unit Selection Methodology (All units/ Randomized units)	Reported/NR	1/0
Participants Selection Methodology (All participants of each unit/ Randomization of participants in each unit)	Reported/NR	1/0
Data Collection Time	Reported/NR	1/0
Adequate Response Rate	≥75%/61-75%/≤60%/NR	1/0.5/0/0
Urban/Rural Sample	Urban + Rural sample/ Isolated Urban/ Isolated Rural	1/0/0
Data Measurement Methodology	Data measured by the investigators/ Data reported/NR	2/0/0
Reporting outcome per age/per year of birth	Yes/No	1/0
	Maximum score	12 points

NR: Not Reported.

for each element of the scoring system, as proposed in other meta-analyses. Studies were classified into three quality groups and labeled A if they managed to obtain 8-12 points, B when 4-7 points were collected and C when they scored less than 4 points. Studies of high quality, with less estimated risk of bias, were allocated to class A and were subsequently used in the sensitivity analyses.

Assessment of heterogeneity

The null hypothesis of the existence of homogeneity in the prevalence reported in the studies was tested with I^2 and Cochrane's Q.[13,14] Cochrane's Q statistic, an approximate to the x^2 test of heterogeneity, with k-1 degrees of freedom where k is the number of prevalence rates, was tested in an a-level of 0.10.[13] I^2 describes the total variation across studies and was used to identify violation in the assumption of homogeneity when $I^2 \geq 75\%$.[14]

Statistical Methods

Comprehensive Meta Analysis version 2.0 (Comprehensive Meta Analysis©, Biostat, Inc Englewood, USA) served as the statistical platform. The effect size of the meta-analysis was the prevalence of childhood OW/OB, computed – when not referred to – as the ratio of the events (number of OW or OB participants)/total (total number of participants). Effect size was pooled from all eligible studies using the DerSimonian-Laird Random effects model (REM) for meta-analysis.[15] This model was preferred to a fixed effect model, since it is based on the assumption that a distribution of effects exists, resulting in heterogeneity among study results.[7] For space economy, results are presented in tables and forest plots where prevalence rates and 95% confidential intervals (CI) are figured out for every study inserted in the model and for the overall estimate.

To retrieve the extent of publication bias, funnel plots were scattered and tested for asymmetry and, additionally, Egger's test was computed. Subgroups analysis was conducted for each gender. The effect of aberrant studies was examined via sensitivity analyses after the exclusion of studies with low and poor quality, as classified by the quality scoring system (B and C class studies). Over-time trend in the prevalence of OW/OB was estimated via cumulative analyses which calculate the cumulative evidence at the time of the appearance of each data set. To avoid systematic bias, studies were entered into the model of each cumulative meta-analysis successively according to the data collection time and not to the publication time. Publications not reporting the year of data collection were not included in the cumulative analyses.

RESULTS

Literature records selection

The search yielded 167 studies, 34 of which were excluded at the first step on the basis of their title, since it was considered irrelevant to the research hypothesis (Figure 1). Of the remaining 133 studies, 36 were omitted because of reporting of duplicate data and use of overlapping samples. The remaining 97 studies underwent discrete examination by two independent reviewers. Thirteen studies were excluded due to defining OW/OB differently from the IOTF criteria, 4 studies due to grouping OW and OB participants together and 14 studies because of failure to report the prevalence separately in each sex. Furthermore, 28 of the retrieved publications either failed to report the prevalence of OW/OB or used pediatric samples with excess in body weight only, thus omitting to calculate prevalence. Moreover, one study was excluded because of reference to non-phenotypically healthy children and 3 additional publications were excluded due to collection of data prior to the year 2001. Of the remaining records, 9 studies that examined the prevalence in children and adolescents older than 12 years were also excluded. Overall, 109 publications did not meet inclusion criteria and thus only 25 of the retrieved studies were used in the meta-analyses.[6,16-39]

Characteristics of studies included in the analyses

Evidence extracted from the 25 eligible studies consisted of epidemiological data published in Greek and international peer-reviewed journals during 2004-2010 (Table 2). They reported the rates of OW/OB from 31 different pediatric populations, since two publications included more than one sample collected during multiple cross-sectional wave recruitments,[6,20] which were treated separately. A subscript after the reference was used to distinguish samples.

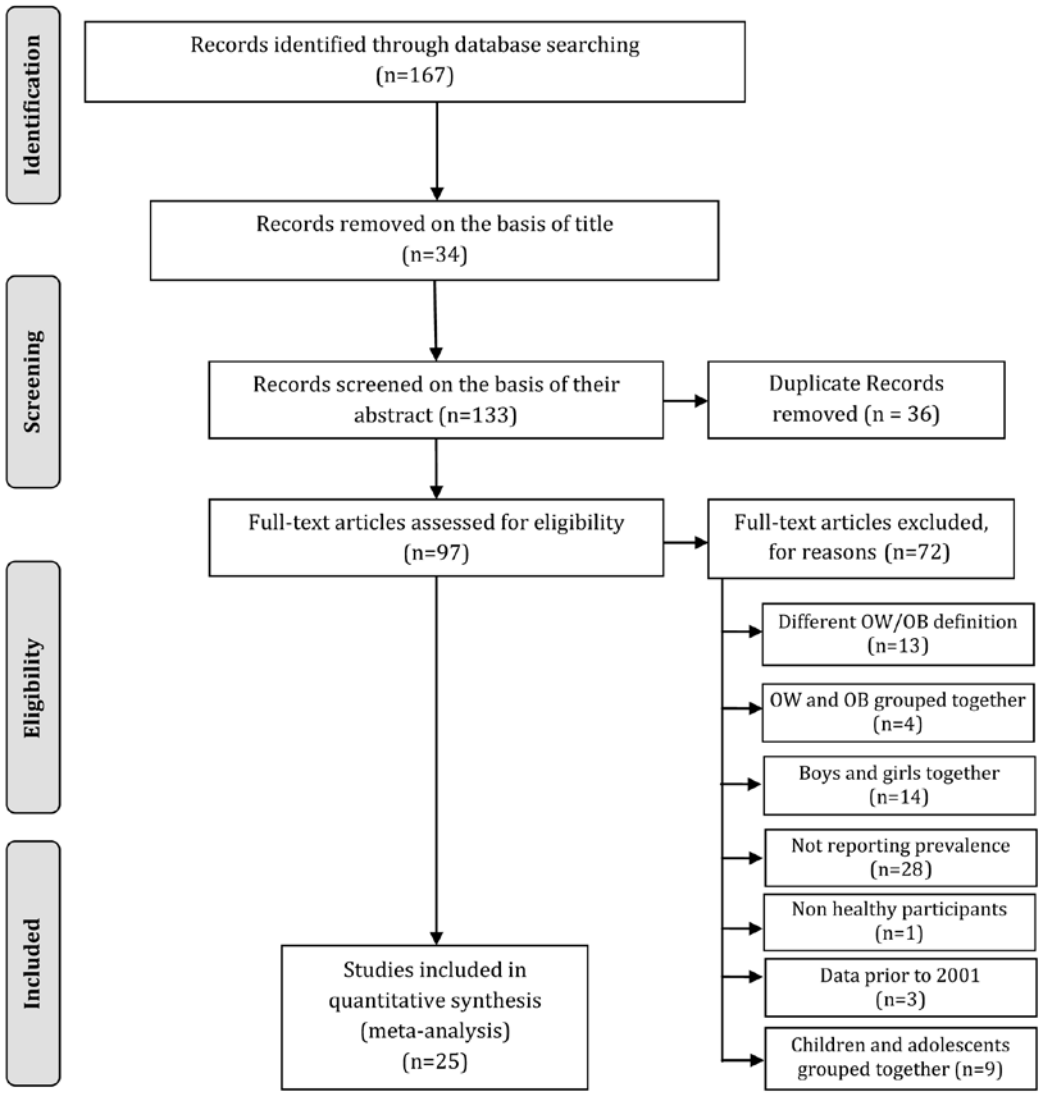


Figure 1. Flow chart of the selection process for the studies included in the analyses.

Thus, 31 different studies covering a total of 430,768 Greek children, 219,996 boys and 210,772 girls, were used for the meta-analyses. Sample size ranged from 73 to 71,227 participants, inhabitants of the mainland as well as of the Greek islands. The majority (28/31) were school-based samples aiming at detecting the prevalence of excess in body weight among Greek pupils. Descriptive characteristics and quality scoring of the studies are presented in detail in Table 2.

Main analyses – Prevalence of OW and OB

Prevalence of OW and OB in the whole sample and according to gender for each analysis is presented in Table 3. Obesity in Greek children during the last decade is reported to range from 3.35-23.29%.[17,27] However, since the studies were found to be highly heterogeneous ($Q=415.8$ $p<0.001$, $I^2=92.8\%$), a REM was applied. The overall rate of obesity prevalence in Greek children was estimated at 10.2% (CI 95%: 9.8–10.7%). The funnel plot appeared quite symmetrical but Egger's test revealed evidence of publication bias (Egger's test $p=0.045$). The prevalence of OW ranged from 12.1-34.3%[18,35] among the selected studies. Meta-analysis yielded an overall pooled prevalence of 23.7% (CI 95%: 22.7–24.8%) but increased heterogeneity was demonstrated among the studies ($Q=1355.3$, $p<0.001$, $I^2=97.8\%$). Fun-

Table 2 (continues in next page). Descriptive information of eligible studies included in the analyses

Reference	Krassas et al[16]	Angelopoulos et al[17]	Angelopoulos et al[18]	Christodoulos et al[19]	Magkos et al[20a]	Magkos et al[20b]	Magkos et al[21]	Papadimitriou et al[22]	Tokmakidis et al[23]	Vlacho/lou et al[24]	Manios et al[25]	Christodoulos et al[26]	Kamtsios et al[27]	Linardakis et al[28]	Panagiotakos et al[29]	Hassapidou et al[30]
Study Name			The Children								GENESIS				PANACEA	
Published	2004	2005	2006	2006	2006	2006	2006	2006	2006	2006	2007	2008	2008	2008	2008	2009
Age range	6-10	7-12	11	9	9	12	11.6±0.4	6-11	8.9±1.6	9.07±1	1-5	11	11-12	4-7	10-12	8-12
Sample size (n)	1.226	73	312	178	106	274	198	4.131	709	4.648	2.374	378	775	856	700	266
Study Design	CSS	CSS	CSS	CSSx3	CSSx3, CH	CSSx3, CH	CSS	CSS	CSS	CSS	CSS	CSS	CSS	CSS	CSS	CSS
Data collection time	2001	2002-3	NR	NR	2002	2002	2002	2003-4	NR	2001-3	2003-4	NR	NR	NR	2005-6	NR
Local/National Sample	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Sample source	SS	SS	SS	SS	NR	NR	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS
Sample unit selection (unit=school)	R	NR	R	NR	NR	NR	R	NR	NR	NR	R	R	NR	R	R	NR
Participants collection	NR	NR	T	NR	R	R	T	T	T	T	T	T	NR	T	T	NR
Response Rate (%)	NR	NR	96%	97%	75%	82%	73%	89%	94%	NR	75%	96%	NR	49%	95%	NR
Urban/Rural Sample	U+R	U	U+R	U	U+R	U+R	U+R	U+R	R	U	U+R	U	U+R	U+R	U	U+R
Data collection	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Prevalence per year of birth	NO	YES	YES	YES	YES	YES	NO	YES	NO	YES	YES	YES	NO	NO	YES	NO
Quality Score	7	5	8	5	7.5	8	7.5	10	5.5	8	9	5	4.5	6.5	8.5	4

CSS x n: Cross-Sectional Study number of measurement points, CH: Cohort Study, L: Local sample, N: National sample, SS: School sample, R: As referred by participants, M: Measured by investigators, U: Urban, R: Rural, U+R: Urban+Rural, NR: Not Reported, T: Total, R: Random.

Table 2. Descriptive information of eligible studies included in the analyses and quality scoring of each study

Reference	Kollias et al[31]	Koroni et al[32]	Mantzouranis et al[33]	Mavrakanas et al[34]	Chaniotis et al[35]	Kontogianni et al[36]	Manios et al[37]	Moschonis et al[38]	Tambalis et al[6a]	Tambalis et al[6b]	Tambalis et al[6c]	Tambalis et al[6d]	Tambalis et al[6e]	Tambalis et al[6f]	Yannakoulia et al[39]
Study Name			GOAL												GENDAI
Published	2009	2009	2009	2009	2010	2010	2010	2010	2010	2010	2010	2010	2010	2010	2010
Age range	9.2±1.8	9-11	10.2±1.3	4-10	6-12	3-12	10-12	9-13	8-9	8-9	8-9	8-9	8-9	8-9	11.2±0.7
Sample size (n)	797	1.861	2.056	572	2.065	751	481	729	61.774	65.332	65.284	69.817	70.196	71.227	1.132
Study Design	CSS	CSS	CSS-CH	CSS	CSSx5	CSS	CSS	CSS	CSSx10	CSSx10	CSSx10	CSSx10	CSSx10	CSSx10	CSS
Data collection time	NR	NR	NR	2007	2002-7	NR	2005-6	2007	2001	2003	2004	2005	2006	2007	NR
Local/National Sample	L	L	N	L	L	L	L	L	N	N	N	N	N	N	L
Sample source	SS	SS	SS	SS	SS	R	SS	SS	SS	SS	SS	SS	SS	SS	SS
Sample unit selection (unit=school)	NR	NR	R	T	NR	R	NR	R	NR	NR	NR	NR	NR	NR	R
Participants collection	NR	NR	R	T	NR	R	NR	T	NR	NR	NR	NR	NR	NR	T
Response Rate (%)	NR	NR	NR	NR	NR	89%	92%	61%	NR	NR	NR	NR	NR	NR	NR
Urban/Rural Sample	U	U+R	U+R	U	U+R	U+R	U+R	U	U+R	U+R	U+R	U+R	U+R	U+R	U
Data collection	NR	NR	M	M	M	R	M	M	M	M	M	M	M	M	M
Prevalence per year of birth	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES	NO
Quality Score	1.5	3	8.5	6	6.5	6	6.5	7	9	9	9	9	9	9	6

CSS x n: Cross-Sectional Study number of measurement points, CH: Cohort Study, L: Local sample, N: National sample, SS: School sample, R: As referred by participants, M: Measured by investigators, U: Urban, R: Rural, U+R: Urban+Rural, NR: Not Reported, T: Total, R: Random.

Table 3. Collective results of the pooled and sensitivity analyses

	Boys					Girls					Total				
	%	95%CI	n	Q	I^2 (%)	%	95%CI	n	Q	I^2 (%)	%	95%CI	n	Q	I^2 (%)
Pooled analyses															
OW	24.1	22.9–25.4	51170	846.6	96.57	23.2	22.1–24.3	50044	601.3	95.51	23.7	22.7–24.8	101214	1355.3	97.78
OB	11.0	10.5–11.6	26063	237.8	87.38	9.7	9.2–10.3	22260	215.0	86.97	10.2	9.8–10.7	48323	415.8	92.78
OW+OB	35.0	33.6-36.6	77233	1020.9	97.15	32.7	31.4–34.1	72304	767.7	96.48	34.0	32.7–35.3	149537	1691.3	98.22
Sensitivity analyses															
OW	23.4	21.8–25.1	49699	559.7	97.85	23.7	22.3–25.1	48738	372.4	97.04	23.8	22.4–25.3	98437	903.0	98.67
OB	11.3	10.7–11.9	25425	147.3	91.85	10.2	9.6–10.7	21712	110.7	90.00	10.7	10.2–11.2	47137	230.6	94.79
OW+OB	34.7	32.7–36.7	75124	604.3	98.01	33.8	32.1–35.5	70450	390.4	97.18	34.4	32.6–36.2	145574	953.6	98.74

OW: overweight, OB: obese, OW+OB: overweight and obese.

nel plot symmetry in accordance with Egger's test (p=0.95) suggested lack of publication bias. The combined pooled prevalence of OW and OB ranged from 17.63-56.16%,[17,35] but the sample was not homogenous (Q=1691.3, p<0.001, I^2=98.3%). The overall combined prevalence of OW and OB in Greek children reached 34% (CI 95%: 32.7-35.3%), without evidence of publication bias (Egger's test p=0.54).

Subgroups

The prevalence of OB ranged from 2.5-23.1%[17,27] in the boys and between 4.1-23.5%[17,27] in the girls. The prevalence of OW ranged from 11.69-35.87%[35,39] in the boys and 12.50-38.99%[18,35] in the girls. Subgroups gender analysis failed to determine possible sources of heterogeneity among the studies. Eleven percent of the boys [CI 95%: 10.5–11.6%, Q=237.8 p<0.001, I^2=87.4%] and 9.7% of the girls [CI 95%: 9.2–10.3%, Q=214.9 p<0.001, I^2=86.9%] were classified as OB. Overweight was apparent in 24.1% of the boys [CI 95%: 22.9-25.4%, Q=846.6 p<0.001, I^2=96.6%], and 23.2% of the girls [CI 95%: 22.1–24.3%, Q=601.3 p<0.001, I^2=95.5%]. Combined prevalence of OW and OB was 35% in the boys [CI 95%: 33.6-36.6%, Q=1020.9 p<0.001, I^2=97.2%] and 32.7% in the girls [CI 95%: 31.4–34.1%, Q=767.6 p<0.001, I^2=96.5%).

Sensitivity analyses

Sensitivity analyses were performed for all of the studied effect sizes (OW, OB and combined prevalence rates) by removing data from the meta-analytic model in order to examine influence of low quality and high-bias-risk studies on the overall estimate. According to the quality score (Table 2), only studies of higher quality (n=13, 41.9%) were included in the sensitivity analyses. The sensitivity analyses yielded an OB prevalence of 10.7% [CI 95%: 10.2–11.2%, Q=230.6 p<0.001, I^2=94.8%] and an OW rate equal to 23.8% [CI 95%: 22.4–25.3%, Q=902.9 p<0.001, I^2=98.7%]. Combined prevalence of OW and OB was 34.4% [CI 95%: 32.6–36.2%, Q=953.6 p<0.001, I^2=98.7%]. Gender analysis revealed that among the boys 11.3% were diagnosed with OB [CI 95%: 10.7–11.9%, Q=147.3 p<0.001, I^2=91.9%) and 23.4% were OW [CI 95%: 21.8–25.1%, Q=559.7 p<0.001, I^2=97.9]. In the girls' group 10.2% were OB [CI 95%: 9.6–10.7%, Q=110.7 p<0.001, I^2=90%) and 23.7% were OW [CI 95%: 22.3–25.1%, Q=372.4 p<0.001, I^2=97%]. Combined prevalence of OW and OB was estimated for the boys at 34.7% [CI 95%: 32.7–36.7%, Q=604.3 p<0.001, I^2=98%] and at 33.8% for the Greek girls [CI 95%: 32.1–35.5%, Q=390.4 p<0.001, I^2=97.2%].

Cumulative meta-analyses

Cumulative meta-analyses forest plots confirmed the upgrading trend of the OB prevalence during the first 3 years of the decade (2001-2003) and provided evidence for the rates' stabilization trend during the last 5 years. Similar evolutionary patterns (leveling off and stabilizing thereafter) were also exhibited when cumulative meta-analyses were run for each gender separately (Figure 2).

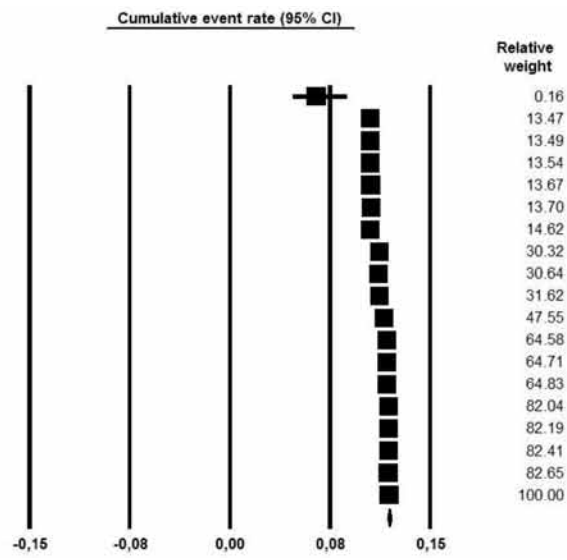
DISCUSSION

The prevalence of OW and OB in Greek children appears alarming, with approximately 1/3 of the children demonstrating excess in body weight. During the studied decade 2001-2010, the rate of OB increased and appears to have reached a plateau some time during the year 2005. No data collected after 2007 were found in the literature or included in the analyses, therefore it is difficult to approximate the latest trend of the condition in the Greek pediatric population.

Both genders exhibited a peak in the prevalence of OB during the year 2005. As OB is also socially mediated, it is possible that the 2004 Olympics that were hosted in Greece served as a motive for increasing physical activity and participation in sports, as the number of OB children appears to have leveled off after the event. It is also likely that the characterization of OB as an epidemic, which took place during the early 2000's,[40] alarmed Greek parents. According to Rokholm et al,[41] stabilization, leveling off or a decrease in the prevalence of pediatric OB has been noted in Europe since the year 1999. Prior to the year 1999, the number of OW and OB children was significantly lower in Greece and, according to Manios et al,[42] a threefold increase was noted in 2005 compared to the 1980's. Tambalis and colleagues[6] demonstrated an augmentation in the prevalence of pediatric OB during 1997-2004, followed by a leveling off in the ensuing 2004-2007 period, for both sexes. It is possible that the stabilization observed by Tambalis stems from the fact that only children of a particular

(a)

Authors	References	Time point	Cumulative statistics				Relative weight
			Point	Z-Value	p-Value	Total	
Krassas et al.	16	2001	0.065	-16.123	0.000	39 / 602	0.16
Tambalis et al. (a)	6a	2001	0.105	-117.657	0.000	3383 / 32152	13.47
Magkos et al. (II)	21	2002	0.105	-117.819	0.000	3389 / 32244	13.49
Magkos et al. (Ia)	20a	2002	0.105	-118.005	0.000	3402 / 32350	13.54
Magkos et al. (Ib)	20b	2002	0.105	-118.492	0.000	3434 / 32624	13.67
Angelopoulos et al.	17	2003	0.106	-118.509	0.000	3443 / 32663	13.70
Vlachopapadopoulou et al.	24	2003	0.105	-122.776	0.000	3672 / 35028	14.62
Tambalis et al. (b)	6b	2003	0.112	-170.830	0.000	7678 / 68688	30.32
Manios et al. (I)	25	2004	0.111	-172.271	0.000	7754 / 69906	30.64
Papadimitriou et al.	22	2004	0.112	-174.729	0.000	8006 / 71960	31.62
Tambalis et al. (c)	6c	2004	0.115	-210.499	0.000	12087 / 105135	47.55
Tambalis et al. (d)	6d	2005	0.118	-242.736	0.000	16456 / 140369	64.58
Manios et al. (II)	37	2006	0.118	-242.912	0.000	16491 / 140600	64.71
Panagiotakos et al.	29	2006	0.118	-243.197	0.000	16519 / 140923	64.83
Tambalis et al. (e)	6	2006	0.119	-272.148	0.000	20930 / 176786	82.04
Mavrakanas et al.	34	2007	0.119	-272.358	0.000	20969 / 177073	82.19
Moschonis et al.	38	2007	0.119	-272.614	0.000	21027 / 177452	82.41
Chaniotis et al.	35	2007	0.119	-273.331	0.000	21085 / 178453	82.65
Tambalis et al. (f)	6f	2007	0.119	-299.821	0.000	25525 / 214849	100.00
			0.119	-299.821	0.000		



(b)

Authors	References	Time point	Cumulative statistics				Relative weight
			Point	Z-Value	p-Value	Total	
Krassas et al.	16	2001	0.050	-16.018	0.000	31 / 624	0.15
Tambalis et al. (a)	6a	2001	0.092	-116.050	0.000	2842 / 30848	13.24
Magkos et al. (II)	21	2002	0.092	-116.244	0.000	2849 / 30954	13.28
Angelopoulos et al.	17	2003	0.093	-116.249	0.000	2857 / 30988	13.31
Vlachopapadopoulou et al.	24	2003	0.092	-120.474	0.000	3046 / 33271	14.20
Tambalis et al. (b)	6b	2003	0.099	-167.689	0.000	6402 / 64933	29.61
Papadimitriou et al.	22	2004	0.099	-170.362	0.000	6607 / 67010	30.56
Manios et al. (I)	25	2004	0.099	-171.834	0.000	6701 / 68166	31.00
Tambalis et al. (c)	6c	2004	0.103	-207.708	0.000	10329 / 100275	47.53
Tambalis et al. (d)	6d	2005	0.105	-240.304	0.000	14044 / 134358	64.52
Panagiotakos et al.	29	2006	0.105	-240.646	0.000	14078 / 134735	64.68
Manios et al. (II)	37	2006	0.105	-240.871	0.000	14103 / 134985	64.80
Tambalis et al. (e)	6	2006	0.105	-269.789	0.000	17777 / 169318	81.65
Mavrakanas et al.	34	2007	0.105	-269.987	0.000	17818 / 169603	81.83
Moschonis et al.	38	2007	0.105	-270.257	0.000	17841 / 169953	81.94
Tambalis et al. (f)	6f	2007	0.106	-296.438	0.000	21742 / 204784	99.73
Chaniotis et al.	35	2007	0.106	-297.133	0.000	21798 / 205848	100.00
			0.106	-297.133	0.000		

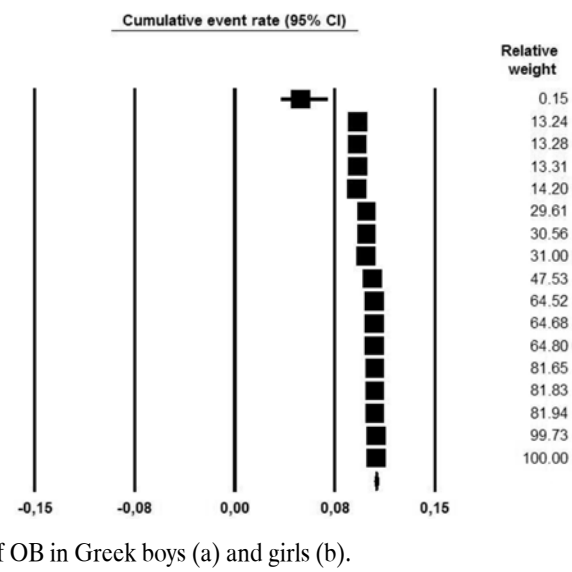


Figure 2. Cumulative analyses of the prevalence of OB in Greek boys (a) and girls (b).

age (8 years old only) were included in the study and not a wider age-range sample. In any case, pediatric OW rates were reported as continuously rising, for both boys and girls.[6]

Georgiadis and Nassis[43] studied the 1990-1991 data of a nationwide sample of Greek youngsters aged 6-17 year-old and found that the prevalence of OB was comparable to previously reported rates from Greece, as well as to rates originating from most European countries at the same period. When the sample was divided by gender, the number of OW children demonstrated an irregular augmentation in the boys and a non-linear decrease in the girls. The finding was attributed to the dieting habit frequently adopted by girls when entering adolescence.[43] Despite the guidelines for reporting the prevalence of OW/OB by year of birth,[44] the majority of studies retrieved used wide age samples and did not report the prevalence of each age. Thus, it is difficult to obtain an accurate image of the pediatric OW and OB age trends in Greece. However, since the BMI at 6 years of age comprises a good indicator of BMI during adulthood,[45] the situation in Greece appears dire and everything strongly indicates that now is the

right time for intervention in order to sustain health in the future adult populations.

Europe appears to be a multi-leveled pattern area regarding prevalence rates in the childhood obesity epidemic. The European North exhibits sustained levels of childhood weight disorders, since in 7-9 year-old Swedish children only 15.6% are OW, including 2.6% OB.[46] Likewise, in Norway the rate of primary school children with excess in body weight is 17%.[47] In England the overweight and obesity trend have stabilized in recent years; odds ratio for being an OW or OB child in UK has leveled off (OR=0.99) or remained the same (OR=1.06), respectively, when comparing data of 2002-3 to 2006-7.[48]

On the other hand, the European South presents alarming rates of OW and OB over the last decade. In Spain, 10.3% of children aged 2-15 year-old are OB and 18.8% are OW,[49] a result similar to the present study where approximately 1/3 of Greek children demonstrated excess in body weight. Combined prevalence of OW and OB reaches 28.1% in Portuguese children aged 7-9 years old.[50] It is uncertain if the current economic crisis will reduce the phenomenon of hyperphagia or if it will actually refuel obesity by increasing the consumption of cheap fat/sugar-dense foods. However, in Italy, another European country affected by the economic crisis, a slight decrease has been noted in childhood overweight during 2010-11 when compared to the beginning of the 2000's.[51]

Obesity during childhood is a complex phenomenon attributed to both nature (genetics) and nurture (behavior).[52] Diet appears to be an important behavioral factor in the development of childhood OW. "High fiber and low sugar-added beverages" and "dinner, cooked meals and vegetables pattern" are dietary patterns negatively associated with all obesity indices in Greek children.[39] Kindergarten children in Crete who consume sugar-added beverages frequently demonstrated double odds in being OW/OB,[28] while Greek childhood BMI has been positively correlated to the frequency of fast-food meals consumed.[18]

Among the most important predictors for childhood OW/OB is hyperphagia and reduced physical activity, with numerous studies in Greek children associating excess in body weight with surplus in the energy and fat intake.[53,54] Since this increased energy intake is usually concomitant to a reduced physical activity level, Greek normal-weight children are found to exhibit less sedentary activities.[55] Likewise, Greek girls participating in more than 3 hours of extracurricular sport activities are 59% less likely to be OW/OB than their non-participating counterparts.[56]

A plethora of research has evaluated the effect of the family environment on the weight status of children. Parental and children's BMI appear to be directly correlated;[24,25,30,57,58] based on the authority of this unanimous finding, Lean[59] suggested that in order to combat pediatric OB one would have to "shrink a parent". Family status is equally important in pediatric OW in Greece, as a significant association was noted between family divorce and children's OW.[57] On the other hand, high parental education and a smaller number of children in the family have been shown to inversely affect a child's BMI.[57,58] Additionally, Greek grandmothers appear to be overfeeding their grandchildren, as higher odds for childhood OW/OB (OR:1.38) has been demonstrated in Greek families where grandmothers are the child's primary caregivers.[30,60] Economic factors such as residence ownership and annual family income of 12,000–20,000€ have been found to increase the odds for childhood OW/OB, while Greek children with excess in body weight are more likely to receive more pocket-money compared to their non-overweight peers.[60,61]

According to Naukkarinen,[62] the majority of research on the causes and consequences of acquired OB is encumbered by the incomplete ability to control for genetic influences. What is the actual weight of nature versus nurture and why do researchers focus only on the latter? The independent genetic predispositions associated with OB are difficult to disentangle in humans.[62] Additionally, OB treatment is mainly based on behavioral approaches. Thus, we are in need of evidence on the environmental aspects of the condition in order to be able to design interventions. Kafatos[63] designed a school-based "Health and Nutrition Education" program and demonstrated that it had positive long-term effects on the BMI of Greek school children. According to Manios,[64] such programs have a positive effect on the level of physical activity and also mediate the level of serum lipids of the participating children. In any case, a holistic approach is needed in order to engage in this public

health discourse and thereby fruitfully combat the childhood obesity epidemic.

Study limitations of the present report include the great heterogeneity in the samples of the retrieved studies regarding size, origination, age range and methods of data collection. In order to explore the source of heterogeneity, a number of subgroup analyses have been performed, while on a second level sensitivity analyses, after controlling for methodological and epidemiological issues of studies, have been applied. Research using large samples like the Tambalis[6] study inevitably produced bias in the results. Important strengths of the present study include the conduct of systematic review, the endorsement of the quality metric scale system and the application of sensitivity analyses in the entire body of data and within subgroups as well.

The present study showed that due to the easy application of the IOTF criteria, a plethora of low quality studies have been published, each suggesting a different pediatric prevalence of OW/OB in Greece. Due to this, readers need to apply caution and should not extrapolate findings. Frequent systematic reviews are required in order to define the accurate weight status of Greek children, while continuous research is essential so as to actualize and to clarify the trend of excess in body weight in Greek children. Moreover, it would be of great interest to demonstrate the extent to which the economic crisis has had an effect on the disease of abundance, obesity.

CONFLICT OF INTEREST

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