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# **Trends in Overweight and Obesity Among Children and Adolescents in China from 1991 to 2015: A Meta-Analysis**

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**Abstract:** This meta-analysis of overweight and obesity (ow/ob) among children and adolescents in China from 1991 to 2015 provides a reference for promoting the healthy development of children and adolescents. The studies were retrieved from the China National Knowledge Infrastructure, Wanfang, and PubMed databases for the period from January 1991 to January 2018. The data were combined and analyzed, and the combined effect magnitude odds ratio and the 95% confidence interval were calculated. Publication bias was determined using Stata/SE12.0. We found that (1) the prevalence of ow/ob increased from 5.0% and 1.7% in 1991–1995 to 11.7% and 6.8% in 2011–2015, respectively, and the overweight rate was the greatest in 2006–2010; (2) from 1991 to 2015, the prevalence of ow/ob was greater in urban areas than in rural areas; (3) compared with girls, boys were more likely to be ow/ob; and (4) the prevalence rates of ow and ob were greater in infancy than in other growth stages, with values of 11.7% and 7.0%, respectively. The prevalence of ow/ob among Chinese children and adolescents showed significant differences based on region, sex, and age. An overall upward trend was observed that decreased slightly from 2011 to 2015.

Keywords: Chinese children and adolescents; overweight; obesity; prevalence

# 1. Introduction

The global overweight and obesity rates in childhood and adolescence continue to increase [1]. In China, the rapid development of the economy, the improvement in living standards, and changes in lifestyle, physical inactivity, sedentary behavior, and excessive energy intake have all resulted in a rapid increase in overweight and obesity rates among children and adolescents [2–4].

The prevalence rates of overweight and obesity in Chinese children continuously increased from 1985 to 2014, and the annual mean increase rate of obesity was the highest in 2010–2014 [5]. The obesity rate of urban children increased rapidly in 1995–2005, with a mean annual increase of 6.9% [6]. The obesity rate in rural areas increased from 0.71% in 1990 to 1.21% in 2006 [7,8]. Most of these obese adolescents have shown varying degrees of decline in self-esteem, accompanied by related mental health problems, such as anxiety, stress, loneliness, and high-risk behavior [9,10]. Of obese adolescents, 75%–80% are still obese after adulthood, during which obesity continues to facilitate the development of other diseases and reduce life expectancy [11,12]. Overweight and obesity, as important factors affecting the physical and mental health of children and adolescents in China, have attracted considerable attention from many fields.

The research on the prevalence rate of overweight and obesity in children and adolescents in China is mostly regional or restricted to certain age groups or specific years. Summaries about different genders, regions, and ages are lacking in the research on prevalence trends of overweight and obesity among Chinese children and adolescents in the last 25 years. These conditions are disadvantageous to the healthy development of the physique of children and adolescents. Therefore, a meta-analysis of overweight and obese children and adolescents in China from 1991 to 2015 can accurately reflect the current situation as well as changes to promote the healthy development of children and adolescents and to provide a reference.

# 2. Materials and Methods

# 2.1. Literature Retrieval Strategy

Our meta-analysis was conducted in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (File S1). The relevant literature on overweight and obesity in Chinese children and adolescents was retrieved from the China National Knowledge Infrastructure (CNKI), Wanfang database, Wip Chinese sci-tech journal full-text database (VIP), and PubMed for the period from January 1991 to January 2018. The database search strategy was formulated around terms "China OR Chinese" AND "infant OR childhood OR children OR toddler OR adolescence OR adolescents OR youth OR teen OR teenager" AND "obesity OR overweight OR body mass index OR BMI OR weight gain" AND "incidence OR frequency OR prevalence OR epidemiology".

#### 2.2. Documentation Inclusion and Exclusion Criteria

#### 2.2.1. Literature Inclusion Criteria

The inclusion criteria were (1) samples with children and adolescents aged 0–18 in China, (2) the number or detection rate of overweight and obesity in the original literature, and (3) the study type was cohort or cross-sectional. Some of the literature used body mass index (BMI = weight/height<sup>2</sup> (kg/m<sup>2</sup>)) to determine overweight and obesity, including the criteria of the Working Group for Obesity in China (WGOC) [13], World Health Organization (WHO/NCHS) [14], International Obesity Task Force (IOTF) [15], and Centers for Disease Control and Prevention (CDC, USA) [16]. We also included studies that classified overweight and obesity on the basis of ideal weight deviations. The ratio of body weight (W) to ideal weight (IW) was calculated, with W/IW > 1.1 defined as overweight and W/IW > 1.2 defined as obesity [17].

# 2.2.2. Literature Exclusion Criteria

We excluded articles that contained one of the following characteristics: (1) study of non-overweight and non-obese, (2) study on a population selected on the basis of specific diseases, (3) repeated publication and study of a region or population in the same year, (4) a sample size below 1000, and (5) low quality (Figure 1).

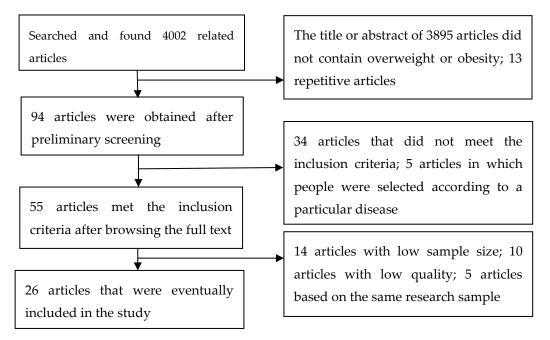


Figure 1. Flowchart of article screening and selection process.

#### 2.3. Data Extraction

The two researchers independently screened and analyzed the literature according to the inclusion and exclusion criteria, and any differences in opinion were resolved through third-party consultation. The information extracted from the literature mainly included the author, publication year, survey time, research design, representation of the target population, sample selection, sample size, response rate, reasons for non-selection, data sources, data collection, personal and demographic characteristics (obesity, overweight, sex, age, and urban and rural descriptions), epidemic recall period, study objectives, criteria for overweight/obesity, and data collection. The quality assessment extraction form (Table S1) reported by Yu et al. [18] was used to evaluate the quality of the included documents. A score above 14 (the highest is 19 points) is high-quality literature, a score of 11–14 indicates medium-quality literature, and a score below 11 is low-quality literature. Articles with less than 11 points that were classified as low quality, were excluded.

### 2.4. Statistical Analysis

The literature was divided into five periods according to the year of investigation (1991–1995, 1996–2000, 2001–2005, 2006–2010, and 2011–2015) and compared and analyzed according to sex, age, and place of residence (urban and rural). Open-Meta (Agency for Healthcare Research & Quality, Rockville, MD, USA) was used to calculate the positive rate of overweight or obesity by time, sex, age, and residence and the 95% confidence interval (CI). The data were analyzed using Review Manager 5.1.4 (Nordic Cochrane Center, Copenhagen, Denmark), and the combined effect odds ratio (OR) value and 95% CI were calculated. For the heterogeneity test, the test level was  $\alpha = 0.05$ . If there was no statistical heterogeneity, the fixed effects model was used; otherwise, the random effects model was used [19]. Sensitivity analysis was used to determine sample size, study quality, diagnostic criteria, geographic distribution, and whether the type of survey affected the research findings. Publication bias was assessed by inspecting funnel plots, and formal testing for funnel plot asymmetry was performed using the Begg and Egger tests, which were conducted using Stata/SE12.0 (Stata Corp., College Station, TX, USA) [20].

# 3. Results

#### 3.1. Included Document Characteristics

# 3.1.1. Literature Search Results

A total of 4002 related studies were found by searching four databases. We included 26 articles (41 studies), of which 14 were from national surveys and 12 were from regional surveys (18 in Chinese and 8 in English).

# 3.1.2. General Situation and Quality Evaluation of the Literature

In the quality evaluation of the 26 articles, we found 9 high-quality and 17 medium-quality documents (Table 1).

# 3.2. Meta-Analysis Results

# 3.2.1. Prevalence of Overweight in Children and Adolescents

# Sex Differences

Irrespective of sex, overweight rates showed an overall upward trend over time, with a slight decline in 2011–2015 (Table S2). Overall, the overweight rate increased from 5.0% in 1991–1995 to 13.2% in 2006–2010, and it dropped to 11.7% in 2011–2015. In 1991–1995, the overweight rates of boys and girls were 5.7% and 4.3%, respectively. The rate peaked in 2006–2010, rising to 16.0% for boys and 10.3% for girls. Between 2011 and 2015, the rates for boys and girls fell to 14.4% and 9.1%, respectively. In the same period, the rate of overweight boys was higher than that of overweight girls.

An absolute comparison of overweight boys and girls (OR) was performed, and a forest map was drawn. Overall, the difference in the prevalence of overweight was statistically significant (p < 0.05); that is, the overweight rate was related to sex, and the sex difference in the detection rate of overweight was increasing each year (Figure 2).

Author, Year	Time Period	Sample Size	Age (Years)	Criteria	Target Population	Grade	Overweight, Prevalence, %	Obesity, Prevalence, %
		Na	tional Survey on C	Childhood Obesity (N	ISCO)			
Ding et al., 1998 [21]	1996	208,513	0–7	NCHS/CDC	Urban children	15	4.2	2.1
NTFCOC, 2008 [22]	2006	84,766	0–7	W/IW (WHO)	Urban children	15	19.8	7.2
Xie et al., 2014 [8]	2006	38,923	3–7	BMI(WHO)	Rural	13	4.2	1.2
Cao et al., 2011 [23]	2008	7100	7–18	BMI (WGOC)	Urban/rural	15	7.4	3.5
Chen et al., 2017 [24]	2013	120,275	7–18	BMI (WGOC)	Urban/rural	16	12.2	7.2
		(	China Health and N	Nutrition Survey (CH	INS)			
Cui et al., 2010 [25]	1991/1993/1997/ 2000/2004/2006	2581/2392/2389/ 2290/1463/1174	7–17	BMI (WGOC)	Urban/rural	13	3.8/4.7/5.1/ 5.9/7.9/8.3	1.4/1.7/1.6/ 1.6/3.1/4.9
		Chinese	e National Nutritic	on and Health Survey	(CNNHS)			
Li et al., 2008 [26]	1992/2002	15,501/44,880	7–17	BMI(WHO)	Urban/rural	17	3.7/4.4	0.9/0.9
		Chinese Nationa	al Survey on Child	ren Constitution and	l Health (CNSCCH)			
Wang et al., 2017a [27]	1995/2005/2010	7916/7492/14,301	7–18	BMI (WGOC)	Not reported	14	7.1/11.2/13.9	2.6/3.7/7.0
Gu et al., 2017a [28]	2005/2010	18,524/21,701	7–18	BMI (WGOC)	Urban/rural	14	10.7/12.2	5.0/5.5
Huang et al., 2012 [29]	2010	6607	7–18	BMI (WGOC)	Urban/rural	15	9.1	6.6
Ji CY and Sun JL, 2005a [30]	2000	266,431	7–18	BMI (WGOC)	Urban/rural	17	6.1	2.3
Wang et al., 2017b [5]	2014	214,354	7–18	BMI (WGOC)	Urban/rural	17	12.1	7.3
Zhang YX and Wang SR, 2008a [31]	1995/2005	7198/8580	7–18	BMI (WGOC)	Urban/rural	15	6.2/11.6	2.3/8.3
Zhai et al., 2017 [32]	2010	15,568	7–18	BMI (WGOC)	Urban/rural	16	13.7	9.0
		Re	gional Survey on (	Childhood Obesity (I	RSCO)			
Zhang et al., 2003b [33]	2002	6088	1–7	W/IW(WHO)	Urban/rural	12	7.2	4.2
Wei, 2007 [34]	2002	58,030	0–6	W/IW(WHO)	Urban	12		4.8
Xiong et al., 2005 [35]	2004	23,292	3–18	BMI (IOTF)	Urban	12	12.4	3.7
Wang JL and Wang NR, 2008c [36]	2006	18,320	0–18	BMI (CDC)	Urban	12	13.4	8.3

**Table 1.** General information and quality ratings included in the literature from 1991 to 2015.

Author, Year	Time Period	Sample Size	Age (Years) Criteria		Target Population	Grade	Overweight, Prevalence, %	Obesity, Prevalence, %		
Regional Survey on Childhood Obesity (RSCO)										
Zhang et al., 2012c [37]	2003/2008	70,431/85,605	6–18	BMI (IOTF)	Rurban	12	13.7/15.4	3.7/4.6		
Niu et al., 2016 [38]	2005/2014	4956/5308	7–18	BMI (WGOC)	Urban/rural	14	5.9/10.5	2.2/5.1		
Liu et al., 2014 [39]	2007/2011	27,944/38,284	5-18	BMI (WGOC)	Not reported	11	10.3/10.9	6.4/6.9		
Ji et al., 2016b [40]	2009-2012	2319	6–17	BMI(WHO/WGOC)	Urban/rural	11	7.1	4.4		
Gu et al., 2013b [41]	2011	33,256	7–18	BMI (WGOC)	Not reported	12	10.6	5.3		
Jiang et al., 2014 [42]	2011	5902	8–15	BMI (IOTF)	Not reported	11	16.4	11.6		
Ma et al., 2014 [43]	2007/2009/2011	17,157/26,381/36,328	12–18	BMI (WGOC)	Not reported	12	8.1/9.6/9.9	3.1/4.7/4.2		
Zhang YX and Wang SR, 2013d [44]	2010	42,275	7–18	BMI (IOTF)	Urban/rural	11	13.5	4.3		

Table 1. Cont.

Study or Subgroup	Bo <u>e</u> Events		Gir Events		Weight	Odds Ratio M-H. Random. 95% Cl	Odds Ratio M-H. Random. 95% Cl
1.1.1 1991-1995		1000		1010	4 101	0.00 10 50 1.011	
Cui et al., 1991	47	1333	50	1248	1.4%	0.88 [0.58, 1.31]	
Cui et al., 1993	64	1248	48	1144	1.5%	1.23 [0.84, 1.81]	
Li et al., 1992 Wang et al., 1995a	306 344	8048 3955	261 217	7453 3961	2.5% 2.4%	1.09 [0.92, 1.29] 1.64 [1.38, 1.96]	
Zhang YX and Wang,1995a	271	3600	176	3598	2.4%	and the second of the second se	
Subtotal (95% CI)	271	18184	170	17404	10.1%	1.58 [1.30, 1.92] 1.29 [1.03, 1.61]	
Total events	1032	10104	752	11404	10.170	1.25 [1.05, 1.01]	-
Heterogeneity: Tau <sup>2</sup> = 0.05; Chi <sup>2</sup> Test for overall effect: Z = 2.23 (	² = 18.18, d	df = 4 ( <i>P</i> =		<sup>2</sup> = 78%			
1.1.2 1996-2000							
Cui et al., 1997	67	1269	56	1120	1.5%	1.06 [0.74, 1.52]	— <u> </u>
Cui et al., 2000	86	1216	50	1074	1.6%	1.56 [1.09, 2.23]	
Ding et al., 1996	4662	110993	4096	97520	2.9%	1.00 [0.96, 1.04]	+
Ji CY and Sun JL, 2000a	9847	133821	6382	132610	2.9%	1.57 [1.52, 1.62]	
Subtotal (95% CI)		247299		232324	8.9%	1.27 [0.91, 1.76]	
Total events	14662		10584				
Heterogeneity: Tau <sup>2</sup> = 0.10; Chi <sup>2</sup> Test for overall effect: Z = 1.41 (		df = 3 ( <i>P</i>	< 0.0000	1); I² = 99	9%		
1.1.3 2001-2005	05	770	-		4 50/		
Cui et al., 2004	65	770	51	693	1.5%	1.16 [0.79, 1.70]	
Gu et al., 2005a	1271	9298	706	9226	2.8%	1.91 [1.73, 2.11]	-
Li et al., 2002	1139	23242	844	21638	2.8%	1.27 [1.16, 1.39]	
Niu et al., 2005	395	6077	316	6001	2.5%	1.25 [1.07, 1.46]	
Wang et al., 2005a	526	3596	315	3896	2.6%	1.95 [1.68, 2.26]	-
Xiong et al., 2003-2004	1731	12037	1168	11253	2.8%	1.45 [1.34, 1.57]	
Zhang et al., 2002b	226	3099	212	2989	2.3%	1.03 [0.85, 1.25]	-
zhang et al., 2003c	6140	35982	3489	34449	2.9%	1.83 [1.75, 1.91]	
Zhang YX and Wang, 2005a Subtotal (95% CI)	620	4341 98442	372	4239 94384	2.6% 22.7%	1.73 [1.51, 1.98] 1.50 [1.31, 1.72]	•
Total events	12113		7473				
Heterogeneity: Tau² = 0.04; Chi² Test for overall effect: Z = 5.96 (			< 0.0000	1); l² = 93	3%		
1.1.4 2006-2010							
1 <b>.1.4 2006-2010</b> Cao et al., 2008	347	3704	177	3396	2.4%	1.88 [1.56, 2.27]	
	347 63	3704 626	177 35	3396 548	2.4% 1.3%	1.88 [1.56, 2.27] 1.64 [1.07, 2.52]	
Cao et al., 2008							
Cao et al., 2008 Cui et al., 2006	63	626	35	548	1.3%	1.64 [1.07, 2.52]	
Cao et al., 2008 Cui et al., 2006 Gu et al., 2010a	63 7004	626 43890	35 3751	548 44113	1.3% 2.9%	1.64 [1.07, 2.52] 2.04 [1.96, 2.13]	
Cao et al., 2008 Cui et al., 2006 Gu et al., 2010a Huang et al., 2010 Liu et al., 2007 Ma et al., 2007	63 7004 300	626 43890 3238	35 3751 304	548 44113 3369	1.3% 2.9% 2.5%	1.64 [1.07, 2.52] 2.04 [1.96, 2.13] 1.03 [0.87, 1.22]	
Cao et al., 2008 Cui et al., 2006 Gu et al., 2010a Huang et al., 2010 Liu et al., 2007	63 7004 300 1845	626 43890 3238 14328	35 3751 304 1020	548 44113 3369 13616	1.3% 2.9% 2.5% 2.8%	1.64 [1.07, 2.52] 2.04 [1.96, 2.13] 1.03 [0.87, 1.22] 1.83 [1.68, 1.98]	
Cao et al., 2008 Cui et al., 2006 Gu et al., 2010a Huang et al., 2010 Liu et al., 2007 Ma et al., 2007	63 7004 300 1845 865	626 43890 3238 14328 8235	35 3751 304 1020 526	548 44113 3369 13616 8922	1.3% 2.9% 2.5% 2.8% 2.7%	1.64 [1.07, 2.52] 2.04 [1.96, 2.13] 1.03 [0.87, 1.22] 1.83 [1.68, 1.98] 1.87 [1.67, 2.10]	
Cao et al., 2008 Cui et al., 2006 Gu et al., 2010a Huang et al., 2010 Liu et al., 2007 Ma et al., 2007 Ma et al., 2009	63 7004 300 1845 865 1742	626 43890 3238 14328 8235 13502	35 3751 304 1020 526 798	548 44113 3369 13616 8922 12879	1.3% 2.9% 2.5% 2.8% 2.7% 2.8%	1.64 [1.07, 2.52] 2.04 [1.96, 2.13] 1.03 [0.87, 1.22] 1.83 [1.68, 1.98] 1.87 [1.67, 2.10] 2.24 [2.05, 2.45]	
Cao et al., 2008 Cui et al., 2006 Gu et al., 2010a Huang et al., 2010 Liu et al., 2007 Ma et al., 2009 NTFCOC, 2006	63 7004 300 1845 865 1742 10021	626 43890 3238 14328 8235 13502 45139	35 3751 304 1020 526 798 6737	548 44113 3369 13616 8922 12879 39627	1.3% 2.9% 2.5% 2.8% 2.7% 2.8% 2.9%	1.64 [1.07, 2.52] 2.04 [1.96, 2.13] 1.03 [0.87, 1.22] 1.83 [1.68, 1.98] 1.87 [1.67, 2.10] 2.24 [2.05, 2.45] 1.39 [1.35, 1.44]	
Cao et al., 2008 Cui et al., 2006 Gu et al., 2010a Huang et al., 2010 Liu et al., 2007 Ma et al., 2009 NTFCOC, 2006 Wang et al., 2010a	63 7004 300 1845 865 1742 10021 1332	626 43890 3238 14328 8235 13502 45139 7185	35 3751 304 1020 526 798 6737 661	548 44113 3369 13616 8922 12879 39627 7116	1.3% 2.9% 2.5% 2.8% 2.7% 2.8% 2.9% 2.7%	1.64 [1.07, 2.52] 2.04 [1.96, 2.13] 1.03 [0.87, 1.22] 1.83 [1.68, 1.98] 1.87 [1.67, 2.10] 2.24 [2.05, 2.45] 1.39 [1.35, 1.44] 2.22 [2.01, 2.46]	
Cao et al., 2008 Cui et al., 2006 Gu et al., 2010a Huang et al., 2010 Liu et al., 2007 Ma et al., 2007 Ma et al., 2009 NTFCOC, 2006 Wang ut al., 2010a Wang JL and Wang NR,2006c Xie et al., 2006 Zhai et al., 2010	63 7004 300 1845 865 1742 10021 1332 1126 866 1264	626 43890 3238 14328 8235 13502 45139 7185 8312 19736 7795	35 3751 304 1020 526 798 6737 661 1048 761 871	548 44113 3369 13616 8922 12879 39627 7116 7864 19187 7773	1.3% 2.9% 2.5% 2.8% 2.7% 2.8% 2.9% 2.7% 2.8% 2.7% 2.8%	1.64 [1.07, 2.52] 2.04 [1.96, 2.13] 1.03 [0.87, 1.22] 1.83 [1.68, 1.98] 1.87 [1.67, 2.10] 2.24 [2.05, 2.45] 1.39 [1.35, 1.44] 2.22 [2.01, 2.46] 1.02 [0.93, 1.12] 1.11 [1.01, 1.23] 1.53 [1.40, 1.68]	
Cao et al., 2008 Cui et al., 2010a Gu et al., 2010a Huang et al., 2010 Liu et al., 2007 Ma et al., 2007 Ma et al., 2009 NTFCOC, 2006 Wang et al., 2010a Wang JL and Wang NR,2006c Xie et al., 2010 Zhai et al., 2010 zhang et al., 2008c	63 7004 300 1845 865 1742 10021 1332 1126 866	626 43890 3238 14328 8235 13502 45139 7185 8312 19736	35 3751 304 1020 526 798 6737 661 1048 761 871 4889	548 44113 3369 13616 8922 12879 39627 7116 7864 19187	1.3% 2.9% 2.5% 2.8% 2.7% 2.8% 2.9% 2.7% 2.8% 2.7%	$\begin{array}{c} 1.64 & [1.07, 2.52] \\ 2.04 & [1.96, 2.13] \\ 1.03 & [0.87, 1.22] \\ 1.83 & [1.68, 1.98] \\ 1.87 & [1.67, 2.10] \\ 2.24 & [2.05, 2.45] \\ 1.39 & [1.35, 1.44] \\ 2.22 & [2.01, 2.46] \\ 1.02 & [0.93, 1.12] \\ 1.11 & [1.01, 1.23] \\ 1.53 & [1.40, 1.68] \\ 1.73 & [1.67, 1.80] \end{array}$	
Cao et al., 2008 Cui et al., 2010a Gu et al., 2010a Huang et al., 2010 Liu et al., 2007 Ma et al., 2007 Ma et al., 2009 NTFCOC, 2006 Wang et al., 2010a Wang JL and Wang NR,2006c Xie et al., 2006 Zhai et al., 2010 zhang et al., 2008c Zhang YX and Wang, 2010d	63 7004 300 1845 865 1742 10021 1332 1126 866 1264	626 43890 3238 14328 8235 13502 45139 7185 8312 19736 7795 44148 21222	35 3751 304 1020 526 798 6737 661 1048 761 871	548 44113 3369 13616 8922 12879 39627 7116 7864 19187 7773 41457 21053	1.3% 2.9% 2.5% 2.8% 2.7% 2.8% 2.7% 2.8% 2.7% 2.8% 2.9% 2.9%	$\begin{array}{c} 1.64 & [1.07, 2.52] \\ 2.04 & [1.96, 2.13] \\ 1.03 & [0.87, 1.22] \\ 1.83 & [1.68, 1.98] \\ 1.87 & [1.67, 2.10] \\ 2.24 & [2.05, 2.45] \\ 1.39 & [1.35, 1.44] \\ 2.22 & [2.01, 2.46] \\ 1.02 & [0.93, 1.12] \\ 1.11 & [1.01, 1.23] \\ 1.53 & [1.40, 1.68] \\ 1.73 & [1.67, 1.80] \\ 1.60 & [1.52, 1.70] \end{array}$	
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Figure 2. Forest plot of overweight in boys compared with girls aged 0–18 years in China.

#### Urban and Rural Differences

Overall, both urban and rural overweight rates showed an upward trend over time, with a slight decline in 2011–2015 (Table S3). Among them, the overweight rate of urban children and adolescents reached a peak of 16.1% in 2001–2005 and then decreased. The overweight rate of children and adolescents in rural areas reached a peak of 12.3% in 2006–2010, 3.7 times higher than the peak rate of 3.3% in 1991–1995. In the same period, the detection rate of overweight in urban areas was higher than that in rural areas.

Overall, the difference in the overweight detection rate between urban and rural areas was statistically significant (p < 0.05), meaning that a correlation existed between the overweight rate and residence, and the difference between urban and rural areas became smaller (Figure 3).

Study or Subgroup	Urba Events		Rui Events		Weight	Odds Ratio M-H, Random, 95% Cl	Odds Ratio M-H. Random, 95% Cl
2.1.1 1991-1995	Lvents	Total	Lycins	TOID	weight	m-n, Nanuolli, 55 /0 Ol	
Cui et al., 1991	36	661	61	1920	4.6%	1.76 [1.15, 2.68]	
Cui et al., 1993	36	600	76	1792	4.8%	1.44 [0.96, 2.17]	
Zhang YX and Wang,1995a	344	3599	103	3599	6.5%	3.59 [2.86, 4.49]	
Subtotal (95% CI)	011	4860	100	7311	15.9%	2.13 [1.14, 3.96]	
Total events	416		240				
Heterogeneity: Tau <sup>2</sup> = 0.27; Cl		df = 2(k)		1): l <sup>2</sup> = 90	%		
Test for overall effect: Z = 2.37			0.000	.,,			
2.1.2 1996-2000							
Cui et al., 1997	43	707	80	1682	5.0%	1.30 [0.89, 1.90]	
Cui et al., 2000	46	640	91	1650	5.1%	1.33 [0.92, 1.91]	
Ji CY and Sun JL, 2000a	10907	133629	5322	132802	7.7%	2.13 [2.06, 2.20]	
Subtotal (95% CI)		134976		136134	17.9%	1.60 [1.08, 2.36]	
Total events	10996		5493				
Heterogeneity: Tau <sup>2</sup> = 0.10; Cl			<sup>o</sup> = 0.002	); I² = 84%	, D		
Test for overall effect: Z = 2.34	4 ( <i>P</i> = 0.02	)					
2.1.3 2001-2005							
Cui et al., 2004	44	427	72	1036	4.9%	1.54 [1.04, 2.28]	
zhang et al., 2003c	4967	30121	4662	40310	7.7%	1.51 [1.45, 1.58]	-
Zhang YX and Wang, 2005a	601	4267	390	4313	7.3%	1.65 [1.44, 1.89]	
Subtotal (95% CI)		34815	_	45659	19.9%	1.52 [1.46, 1.59]	•
Total events	5612	w 0/5	5124				
Heterogeneity: Tau <sup>2</sup> = 0.00; Cl			= 0.48); I	2 = 0%			
Test for overall effect: Z = 20.1	17 ( <i>P</i> < 0.0	0001)					
2.1.4 2006-2010							
Cao et al., 2008	379	3505	145	3595	6.8%	2.88 [2.37, 3.51]	-
Cui et al., 2006	35	351	63	823	4.5%	1.34 [0.87, 2.06]	
Huang et al., 2010	320	3403	284	3204	7.0%	1.07 [0.90, 1.26]	
Zhai et al., 2010	1252	8368	883	7200	7.5%	1.26 [1.15, 1.38]	-
zhang et al., 2008c	5133	29230	8063	56375	7.7%	1.28 [1.23, 1.33]	-
Zhang YX and Wang, 2010d	2868	21318	1923	20957	7.7%	1.54 [1.45, 1.64]	
Subtotal (95% CI)		66175		92154	41.2%	1.46 [1.24, 1.73]	-
Total events	9987		11361				
Heterogeneity: Tau <sup>2</sup> = 0.04; Cl	hi² = 92.44	df = 5 ( <i>I</i>	P < 0.000	01); I² = 9	5%		
Test for overall effect: Z = 4.50	0 ( <i>P</i> < 0.00	001)					
2.1.5 2011-2015							
Ji et al., 2009-2012b	130	1449	41	870	5.2%	1.99 [1.39, 2.86]	
Subtotal (95% CI)		1449	-	870	5.2%	1.99 [1.39, 2.86]	
Total events	130		41				
Heterogeneity: Not applicable							
Test for overall effect: Z = 3.74	(P = 0.00)	02)					
Total (95% CI)		242275		282128	100.0%	1.64 [1.42, 1.89]	•
Total events	27141		22259				
Heterogeneity: Tau <sup>2</sup> = 0.07; Cl			(P<0.0	0001); l² =	= 97%		0.5 0.7 1 1.5 2
Test for overall effect: Z = 6.82	2(P < 0.00)	001)					Rural Urban
	Chi <sup>2</sup> = 3.4						

**Figure 3.** Forest plot of overweight in urban children and adolescents compared with rural children and adolescents aged 0–18 years.

#### Differences in Growth and Development Stages

The overweight prevalence showed an increasing trend each year in different growth and development stages. In 1996–2000, the overweight detection rates in infants, early childhood, and preschool children were 4.7%, 1.4%, and 1.9%, respectively. Between 2006 and 2010, the overweight rates increased to 19.4%, 17.6%, and 11.0%, respectively. In 1991–1995, the rates of overweight among school-aged children and adolescents were 4.2% and 3.3%, respectively. In 2011–2015, the overweight rates rose to 12.8% and 10.2%, respectively. The detection rate of overweight in different growth and development stages was 11.7% in infancy, followed by 9.7% in school age, 5.6% in preschool age, and 8.2% in adolescence (Table 2).

**Table 2.** Subgroup analysis by development stage of the prevalence of overweight in Chinese children and adolescents aged 0–18 years (%).

Time Period	Infancy (Age 0–1 Years)	Toddlers (Age 1–3 Years)	Preschool Children (Age 4–6 Years)	School Children (Age 7–13 Years)	Adolescents (Age 14–18 Years)
1991–1995	-	-	-	4.2 (3.8-4.5)	3.3 (2.9–3.7)
1996-2000	4.7 (4.5–5)	1.4 (1.3–1.5)	1.9 (1.8-2.0)	6.0 (5.9-6.2)	6.3 (6.1-6.4)
2001-2005	-	9.7 (8.1–11.2)	11.8 (10.8-12.9)	6.6 (6.4–6.8)	7.1 (6.8–7.5)
2006-2010	19.4 (18.9–19.9)	17.6 (17.3–18)	11.0 (10.7-11.2)	13.4 (13.2–13.7)	9.1 (8.9–9.3)
2011-2015	-	-	7.5 (6.5-8.5)	12.8 (12.6–13)	10.2 (10.0-10.4)
Total	11.7 (11.4–11.9)	7.4 (7.2–7.5)	5.6 (5.5–5.7)	9.7 (9.6–9.7)	8.2 (8.1–8.3)

# 3.2.2. Prevalence Rate of Obesity in Children and Adolescents

# Sex Differences

In general, obesity rates were increasing each year for both boys and girls. Overall, the obesity rate increased from 1.7% in 1991–1995 to 6.8% in 2011–2015 (Table S4). In 1991–1995, the obesity rates of boys and girls were 2.0% and 1.3%, respectively; in 2011–2015, it increased to 8.8% and 4.8%, respectively, which represent 4.4-fold and 3.7-fold increases, respectively. In the same period, the obesity rate of boys was higher than that of girls.

Overall, the difference in the obesity detection rate between boys and girls was statistically significant (p < 0.05). The obesity rate was correlated with sex, and the difference between boys and girls was increasingly significant (Figure 4).

Study or Subgroup	Bo Events	Contraction of the second s	Gir Events		Weight	Odds Ratio M-H. Random. 95% Cl	Odds Ratio M-H. Random, 95% Cl
1.2.1 1991-1995							
Cui et al., 1991	17	1333	17	1248	1.0%	0.94 [0.48, 1.84]	
Cui et al., 1993	20	1248	21	1144	1.1%	0.87 [0.47, 1.62]	
Li et al., 1992	80	8048	60	7453	2.0%	1.24 [0.88, 1.73]	+
Wang et al., 1995a	138	3955	70	3961	2.2%	2.01 [1.50, 2.69]	
Zhang YX and Wang,1995a	105	3600	62	3598	2.1%	1.71 [1.25, 2.35]	
Subtotal (95% CI)		18184		17404	8.3%	1.40 [1.04, 1.88]	-
Total events	360		230				
Heterogeneity: Tau <sup>2</sup> = 0.07; Chi <sup>2</sup>		df = 4 (P =	0.03); l²	= 62%			
Test for overall effect: Z = 2.23 (	P = 0.03)						
1.2.2 1996-2000							
Cui et al., 1997	25	1269	12	1120	0.9%	1.86 [0.93, 3.71]	
Cui et al., 2000	23	1216	14	1074	1.0%	1.46 [0.75, 2.85]	
Ding et al., 1996	2442	110993	1853	97520	3.0%	1.16 [1.09, 1.23]	-
Ji CY and Sun JL, 2000a	3900	133821	2155	132610	3.0%	1.82 [1.72, 1.92]	
Subtotal (95% CI)		247299		232324	7.9%	1.51 [1.05, 2.16]	-
Total events	6390		4034				
Heterogeneity: Tau <sup>2</sup> = 0.10; Chi <sup>2</sup>	= 117.94,	df = 3 (P	< 0.0000	1); l <sup>2</sup> = 97	%		
Test for overall effect: Z = 2.25 (	P = 0.02)						
1.2.3 2001-2005							
Cui et al., 2004	23	770	23	693	1.2%	0.90 [0.50, 1.61]	
Gu et al., 2005a	608	9298	327	9226	2.8%	1.90 [1.66, 2.18]	·
Li et al., 2002	256	23242	130	21638	2.5%	1.84 [1.49, 2.28]	
Niu et al., 2005	177	6077	91	6001	2.3%	1.95 [1.51, 2.52]	· · · · ·
Wang et al., 2005a	200	3596	75	3896	2.3%	3.00 [2.29, 3.93]	· · · ·
Wei, 2002	1622	30084	1177	27946	2.9%	1.30 [1.20, 1.40]	-
Xiong et al., 2003-2004	601	12037	265	11253	2.8%	2.18 [1.88, 2.52]	
Zhang et al., 2002b	148	3099	108	2989	2.3%	1.34 [1.04, 1.72]	
zhang et al., 2003c	1914	35982	706	34449	2.9%	2.69 [2.46, 2.93]	-
Zhang YX and Wang, 2005a	469	4341	243	4239	2.7%	1.99 [1.70, 2.34]	
Subtotal (95% CI)		128526	2.0	122330	24.7%	1.86 [1.49, 2.32]	•
Total events	6018		3145				
Heterogeneity: Tau <sup>2</sup> = 0.11; Chi <sup>2</sup>		df = 9 (P)		(1): $ ^2 = 95$	5%		
Test for overall effect: Z = 5.51 ( 1.2.4 2006-2010		/					
Cao et al., 2008	168	3704	82	3396	2.3%	1.92 [1.47, 2.51]	
Cui et al., 2006	33	626	25	548	1.3%	1.16 [0.68, 1.98]	
Gu et al., 2010a	3420	43890	1452	44113	3.0%	2.48 [2.33, 2.64]	-
Huang et al., 2010	232	3238	202	3369	2.6%	1.21 [1.00, 1.47]	
		14328	576	13616	0.00/		
Liu et al., 2007	1202	11020	570	10010	2.9%	2.07 [1.87, 2.30]	-
Liu et al., 2007 Ma et al., 2007	1202 346	8235	187	8922	2.9%		-
						2.07 [1.87, 2.30]	
Ma et al., 2007	346	8235	187	8922	2.6%	2.07 [1.87, 2.30] 2.05 [1.71, 2.45]	
Ma et al., 2007 Ma et al., 2009	346 932	8235 13502	187 309	8922 12879	2.6% 2.8%	2.07 [1.87, 2.30] 2.05 [1.71, 2.45] 3.02 [2.65, 3.44]	
Ma et al., 2007 Ma et al., 2009 NTFCOC, 2006 Wang et al., 2010a Wang JL and Wang NR,2006c	346 932 4017 651 829	8235 13502 45139 7185 8312	187 309 2100 355 518	8922 12879 39627 7116 7864	2.6% 2.8% 3.0% 2.8% 2.9%	2.07 [1.87, 2.30] 2.05 [1.71, 2.45] 3.02 [2.65, 3.44] 1.75 [1.65, 1.84] 1.90 [1.66, 2.17] 1.57 [1.40, 1.76]	
Ma et al., 2007 Ma et al., 2009 NTFCOC, 2006 Wang et al., 2010a Wang JL and Wang NR,2006c Xie et al., 2006	346 932 4017 651 829 245	8235 13502 45139 7185 8312 19736	187 309 2100 355 518 225	8922 12879 39627 7116 7864 19187	2.6% 2.8% 3.0% 2.8% 2.9% 2.6%	2.07 [1.87, 2.30] 2.05 [1.71, 2.45] 3.02 [2.65, 3.44] 1.75 [1.65, 1.84] 1.90 [1.66, 2.17]	
Ma et al., 2007 Ma et al., 2009 NTFCOC, 2006 Wang get al., 2010a Wang JL and Wang NR,2006c Xie et al., 2006 Zhai et al., 2010	346 932 4017 651 829 245 865	8235 13502 45139 7185 8312 19736 7795	187 309 2100 355 518 225 535	8922 12879 39627 7116 7864 19187 7773	2.6% 2.8% 3.0% 2.8% 2.9% 2.6% 2.9%	2.07 [1.87, 2.30] 2.05 [1.71, 2.45] 3.02 [2.65, 3.44] 1.75 [1.65, 1.84] 1.90 [1.66, 2.17] 1.57 [1.40, 1.76] 1.06 [0.88, 1.27] 1.69 [1.51, 1.89]	
Ma et al., 2007 Ma et al., 2009 NTFCOC, 2006 Wang et al., 2010a Wang JL and Wang NR,2006c Xise et al., 2006 Zhai et al., 2010 zhang et al., 2008c	346 932 4017 651 829 245 865 2909	8235 13502 45139 7185 8312 19736 7795 44148	187 309 2100 355 518 225 535 1008	8922 12879 39627 7116 7864 19187 7773 41457	2.6% 2.8% 3.0% 2.8% 2.9% 2.6% 2.9% 3.0%	2.07 [1.87, 2.30] 2.05 [1.71, 2.45] 3.02 [2.65, 3.44] 1.75 [1.65, 1.84] 1.90 [1.66, 2.17] 1.57 [1.40, 1.76] 1.06 [0.88, 1.27] 1.69 [1.51, 1.89] 2.83 [2.63, 3.04]	
Ma et al., 2007 Ma et al., 2009 NTFCOC, 2006 Wang et al., 2010a Wang JL and Wang NR,2006c Xie et al., 2006 Zhai et al., 2010 zhang et al., 2008c Zhang YX and Wang, 2010d	346 932 4017 651 829 245 865	8235 13502 45139 7185 8312 19736 7795 44148 21222	187 309 2100 355 518 225 535	8922 12879 39627 7116 7864 19187 7773 41457 21053	2.6% 2.8% 2.8% 2.9% 2.6% 2.9% 3.0% 2.9%	2.07 [1.87, 2.30] 2.05 [1.71, 2.45] 3.02 [2.65, 3.44] 1.75 [1.65, 1.84] 1.90 [1.66, 2.17] 1.57 [1.40, 1.76] 1.06 [0.88, 1.27] 1.69 [1.51, 1.89] 2.83 [2.63, 3.04] 3.20 [2.87, 3.57]	
Ma et al., 2007 Ma et al., 2009 NTFCOC, 2006 Wang et al., 2010a Wang JL and Wang NR,2006c Xie et al., 2006 Zhai et al., 2010 Zhang et al., 2008c Zhang YX and Wang, 2010d Subtotal (95% CI)	346 932 4017 651 829 245 865 2909 1362	8235 13502 45139 7185 8312 19736 7795 44148	187 309 2100 355 518 225 535 1008 442	8922 12879 39627 7116 7864 19187 7773 41457	2.6% 2.8% 3.0% 2.8% 2.9% 2.6% 2.9% 3.0%	2.07 [1.87, 2.30] 2.05 [1.71, 2.45] 3.02 [2.65, 3.44] 1.75 [1.65, 1.84] 1.90 [1.66, 2.17] 1.57 [1.40, 1.76] 1.06 [0.88, 1.27] 1.69 [1.51, 1.89] 2.83 [2.63, 3.04]	
Ma et al., 2007 Ma et al., 2009 NTFCOC, 2006 Wang et al., 2010a Wang JL and Wang NR,2006c Xie et al., 2006 Zhai et al., 2010 zhang et al., 2008c Zhang YX and Wang, 2010d Subtotal (95% CI) Total events	346 932 4017 651 829 245 865 2909 1362 17211	8235 13502 45139 7185 8312 19736 7795 44148 21222 241060	187 309 2100 355 518 225 535 1008 442 8016	8922 12879 39627 7116 7864 19187 7773 41457 21053 <b>230920</b>	2.6% 2.8% 2.8% 2.9% 2.6% 2.9% 3.0% 2.9% 37.4%	2.07 [1.87, 2.30] 2.05 [1.71, 2.45] 3.02 [2.65, 3.44] 1.75 [1.65, 1.84] 1.90 [1.66, 2.17] 1.57 [1.40, 1.76] 1.06 [0.88, 1.27] 1.69 [1.51, 1.89] 2.83 [2.63, 3.04] 3.20 [2.87, 3.57]	
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Va et al., 2007 Va et al., 2009 VTFCOC, 2006 Wang ya al., 2010a Wang JL and Wang NR,2006c Kie et al., 2006 Zhai et al., 2010 zhang et al., 2008c Zhang YX and Wang, 2010d Subtotal (95% CI) Fotal events Heterogeneity: Tau <sup>2</sup> = 0.08; Chi <sup>2</sup>	346 932 4017 651 829 245 865 2909 1362 17211 = 353.95,	8235 13502 45139 7185 8312 19736 7795 44148 21222 241060 df = 13 (F	187 309 2100 355 518 225 535 1008 442 8016	8922 12879 39627 7116 7864 19187 7773 41457 21053 <b>230920</b>	2.6% 2.8% 2.8% 2.9% 2.6% 2.9% 3.0% 2.9% 37.4%	2.07 [1.87, 2.30] 2.05 [1.71, 2.45] 3.02 [2.65, 3.44] 1.75 [1.65, 1.84] 1.90 [1.66, 2.17] 1.57 [1.40, 1.76] 1.06 [0.88, 1.27] 1.69 [1.51, 1.89] 2.83 [2.63, 3.04] 3.20 [2.87, 3.57]	
Ma et al., 2007 Ma et al., 2009 NTFCOC, 2006 Wang et al., 2010a Wang JL and Wang NR,2006c Xie et al., 2006 Zhai et al., 2010 Zhang et al., 2008c Zhang YX and Wang, 2010d Subtotal (95% CI)	346 932 4017 651 829 245 865 2909 1362 17211 = 353.95,	8235 13502 45139 7185 8312 19736 7795 44148 21222 241060 df = 13 (F	187 309 2100 355 518 225 535 1008 442 8016	8922 12879 39627 7116 7864 19187 7773 41457 21053 <b>230920</b>	2.6% 2.8% 2.8% 2.9% 2.6% 2.9% 3.0% 2.9% 37.4%	2.07 [1.87, 2.30] 2.05 [1.71, 2.45] 3.02 [2.65, 3.44] 1.75 [1.65, 1.84] 1.90 [1.66, 2.17] 1.57 [1.40, 1.76] 1.06 [0.88, 1.27] 1.69 [1.51, 1.89] 2.83 [2.63, 3.04] 3.20 [2.87, 3.57]	
Ma et al., 2007 Ma et al., 2009 NTFCOC, 2006 Wang et al., 2010a Wang JL and Wang NR,2006c Xie et al., 2006 Zhai et al., 2008 Zhang et al., 2008c Zhang YX and Wang, 2010d Subtotal (95% CI) Total events Heterogeneity: Tau <sup>2</sup> = 0.08; Chi <sup>2</sup> Test for overall effect: Z = 8.40 (	346 932 4017 651 829 245 865 2909 1362 17211 = 353.95,	8235 13502 45139 7185 8312 19736 7795 44148 21222 241060 df = 13 (F	187 309 2100 355 518 225 535 1008 442 8016	8922 12879 39627 7116 7864 19187 7773 41457 21053 <b>230920</b>	2.6% 2.8% 2.8% 2.9% 2.6% 2.9% 3.0% 2.9% 37.4%	2.07 [1.87, 2.30] 2.05 [1.71, 2.45] 3.02 [2.65, 3.44] 1.75 [1.65, 1.84] 1.90 [1.66, 2.17] 1.57 [1.40, 1.76] 1.06 [0.88, 1.27] 1.69 [1.51, 1.89] 2.83 [2.63, 3.04] 3.20 [2.87, 3.57]	
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Ma et al., 2007 Ma et al., 2009 NTFCOC, 2006 Wang et al., 2010a Wang JL and Wang NR,2006c Xie et al., 2006 Zhai et al., 2010 chang et al., 2008c Zhang YX and Wang, 2010d Subtotal (95% CI) Total events Heterogeneity: Tau <sup>2</sup> = 0.08; Chi <sup>2</sup> Test for overall effect: Z = 8.40 (; 1.2.5 2011-2015 Chen et al., 2013	346 932 4017 651 829 2455 2909 1362 17211 t = 353.95, P < 0.0000 5463	8235 13502 45139 7185 8312 19736 7795 44148 21222 241060 df = 13 ( <i>F</i> 01) 59934	187 309 2100 355 518 225 535 1008 442 8016 2 < 0.000 3139	8922 12879 39627 7116 7864 19187 7773 41457 21053 <b>230920</b> 001);   <sup>2</sup> = 9 60341	2.6% 2.8% 3.0% 2.9% 2.9% 3.0% 2.9% 3.0% 37.4%	2.07 [1.87, 2.30] 2.05 [1.71, 2.45] 3.02 [2.65, 3.44] 1.75 [1.65, 1.84] 1.90 [1.66, 2.17] 1.57 [1.40, 1.76] 1.06 [0.88, 1.27] 1.69 [1.51, 1.89] 2.83 [2.63, 3.04] 3.20 [2.87, 3.57] 1.93 <b>[1.66, 2.25]</b> 1.83 [1.75, 1.91]	+ + + + + + + + +
Ma et al., 2007 Ma et al., 2009 NTFCOC, 2006 Wang et al., 2010a Wang JL and Wang NR,2006c Xie et al., 2006 Zhai et al., 2010 Zhang YX and Wang, 2010d Subtotal (95% CI) Total events Heterogeneity: Tau <sup>2</sup> = 0.08; Chi <sup>2</sup> Test for overall effect: Z = 8.40 ( 1.2.5 2011-2015 Chen et al., 2013 Gu et al., 2011b	346 932 4017 651 829 245 865 2909 1362 17211 * = 353.95, P < 0.0000 5463 1156	8235 13502 45139 7185 8312 19736 7795 44148 21222 <b>241060</b> df = 13 ( <i>F</i> 01)	187 309 2100 355 535 1008 442 8016 2 < 0.000 3139 600	8922 12879 39627 7116 7864 19187 7773 41457 21053 <b>230920</b> 001);   <sup>2</sup> = \$ 60341 16285	2.6% 2.8% 3.0% 2.9% 2.6% 2.9% 3.0% 2.9% 37.4%	2.07 [1.87, 2.30] 2.05 [1.71, 2.45] 3.02 [2.65, 3.44] 1.75 [1.65, 1.84] 1.90 [1.66, 2.17] 1.57 [1.40, 1.76] 1.06 [0.88, 1.27] 1.69 [1.51, 1.89] 2.83 [2.63, 3.04] 3.20 [2.87, 3.57] 1.93 [1.66, 2.25]	+ + + + + + + + + + + + + + + + + + +
Ma et al., 2007 Ma et al., 2009 NTFCOC, 2006 Wang yet al., 2010a Wang JL and Wang NR,2006c Xie et al., 2006 Zhai et al., 2008c Zhang et al., 2008c Zhang YX and Wang, 2010d Subtotal (95% CI) Total events Heterogeneity: Tau <sup>2</sup> = 0.08; Chi <sup>2</sup> Test for overall effect: Z = 8.40 ( 1.2.5 2011-2015 Chen et al., 2013 Gu et al., 2011b Ji et al., 2009-2012b	346 932 4017 651 8299 245 865 2909 1362 17211 * = 353.95, P < 0.0000 5463 1156 75	8235 13502 45139 7185 8312 19736 7795 44148 21222 <b>241060</b> df = 13 ( <i>F</i> 01) 59934 16971 1158	187 309 2100 355 518 225 535 1008 442 8016 2 < 0.000 3139 600 26	8922 12879 39627 7116 7864 19187 7773 41457 21053 230920 001); l <sup>2</sup> = 9 60341 16285 1161	2.6% 2.8% 3.0% 2.8% 2.9% 3.0% 2.9% 3.0% 2.9% 3.0% 2.9% 1.6%	2.07 [1.87, 2.30] 2.05 [1.71, 2.45] 3.02 [2.65, 3.44] 1.75 [1.65, 1.84] 1.90 [1.66, 2.17] 1.57 [1.40, 1.76] 1.06 [0.88, 1.27] 1.69 [1.51, 1.89] 2.83 [2.63, 3.04] 3.20 [2.87, 3.57] 1.93 [1.66, 2.25]	+ + + + + + + + + + + + + + + + + + +
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**Figure 4.** Forest plot of obesity in boys compared with girls aged 0–18 years.

#### Urban and Rural Differences

Urban and rural obesity rates generally increased over time, with a slight decline between 2011 and 2015 (Table S5). In 1991–1995, the detection rates of obesity in urban and rural children and adolescents were 3.6% and 0.9%, respectively; in 2006–2010, they reached 7% and 4.5%, respectively; and in 2011–2015, they fell to 5.1% and 3.1%, respectively. Simultaneously, the detection rate of urban obesity was higher than that in rural areas.

Overall, we found a statistically significant difference in the detection rate of obesity between urban and rural areas (p < 0.05). The obesity rate was correlated with the place of residence, and the difference in the detection rate of obesity between urban and rural areas decreased (Figure 5).

Phudu an Pulanta	Urba		Rur		Malak	Odds Ratio	Odds Ratio
<u>Study or Subgroup</u> 2.2.1 1991-1995	Events	Total	Events	Total	weight	M-H, Random, 95% Cl	M-H, Random, 95% Cl
	40	004	05	4000	4.40/		
Cui et al., 1991	10	661	25	1920	4.1%	1.16 [0.56, 2.44]	
Cui et al., 1993	13	600	28	1792	4.5%	1.40 [0.72, 2.71]	_
Zhang YX and Wang,1995a	153	3599 <b>4860</b>	14	3599 7311	5.2% 13.9%	11.37 [6.56, 19.69]	
Subtotal (95% CI)	470	4000	67	7311	13.9%	2.68 [0.54, 13.18]	
Total events	176	-H - 0 //	67	041.12 - 0	50/		
Heterogeneity: Tau² = 1.87; Cl Test for overall effect: Z = 1.21			~ 0.000	01); 1 9	0%		
2.2.2 1996-2000							
Cui et al., 1997	9	707	28	1682	4.0%	0.76 [0.36, 1.62]	
Cui et al., 2000	13	640	24	1650	4.4%	1.40 [0.71, 2.78]	+
Ji CY and Sun JL, 2000a	4471	133629	1583	132802	8.0%	2.87 [2.71, 3.04]	
Subtotal (95% CI)		134976		136134	16.4%	1.55 [0.67, 3.58]	
Total events	4493		1635				
Heterogeneity: Tau <sup>2</sup> = 0.47; C	hi² = 15.85	df = 2 ( <i>F</i>	P = 0.000	4); l² = 87	%		
Test for overall effect: Z = 1.02	2 ( <i>P</i> = 0.31	)					
2.2.3 2001-2005							
Cui et al., 2004	18	427	28	1036	4.9%	1.58 [0.87, 2.90]	+
zhang et al., 2003c	1508	30121	1112	40310	7.9%	1.86 [1.72, 2.01]	-
Zhang YX and Wang, 2005a	457	4267	255	4313	7.7%	1.91 [1.63, 2.24]	
Subtotal (95% CI)		34815		45659	20.5%	1.86 [1.74, 2.00]	•
Total events	1983		1395				
Heterogeneity: Tau <sup>2</sup> = 0.00; C			= 0.83); l	² = 0%			
Test for overall effect: Z = 17.3	36 ( <i>P</i> < 0.0	0001)					
2.2.4 2006-2010							
Cao et al., 2008	192	3505	58	3595	6.9%	3.53 [2.62, 4.76]	-
Cui et al., 2006	23	351	35	823	5.3%	1.58 [0.92, 2.71]	
Huang et al., 2010	317	3403	117	3204	7.4%	2.71 [2.18, 3.37]	
Zhai et al., 2010	965	8368	435	7200	7.8%	2.03 [1.80, 2.28]	-
zhang et al., 2008c	1583	29230	2334	56375	7.9%	1.33 [1.24, 1.42]	
Zhang YX and Wang, 2010d	1535	21318	1188	20957	7.9%	1.29 [1.19, 1.40]	
Subtotal (95% CI)		66175		92154	43.3%	1.91 [1.49, 2.46]	
Total events	4615		4167				
Heterogeneity: Tau² = 0.08; Cl Test for overall effect: Z = 5.04			P < 0.00	001); l² =	96%		
2.2.5 2011-2015							
Ji et al., 2009-2012b	74	1449	27	870	5.9%	1.68 [1.07, 2.63]	
Subtotal (95% CI)		1449	= -	870	5.9%	1.68 [1.07, 2.63]	•
Total events	74		27				
Heterogeneity: Not applicable							
Test for overall effect: Z = 2.27		)					
Total (95% CI)		242275		282128	100.0%	1.96 [1.58, 2.43]	•
Total events	11341		7291				
Heterogeneity: Tau <sup>2</sup> = 0.15; C	hi² = 486.4	5, df = 15	(P < 0.0	0001); l² =	= 97%		
Test for overall effect: Z = 6.15	5(P < 0.00)	001)					Rural Urban
Test for subaroup differences:	Chi <sup>2</sup> = 0.6	3. df = 4 (	P = 0.96	). I <sup>2</sup> = 0%			

**Figure 5.** Forest plot of obesity in urban children and adolescents compared with rural children and adolescents aged 0–18 years.

#### Differences in Growth and Development Stages

The obesity rate for all growth stages other than infancy showed an increasing trend each year. The infancy obesity rate fell from 8.3% in 1996–2000 to 6.3% in 2006–2010; in toddlers and preschool children, it increased from 4.2% and 3.1% in 1996–2000 to 5.0% and 5.3% in 2006–2010, respectively. Between 1991 and 1995, the obesity rates of school-aged children and adolescents were 1.7% and 0.3%, respectively, and they increased to 8.9% and 3.9% in 2011–2015, respectively. The comparison of obesity detection rates at different growth and development stages revealed a value of 7.0% in infancy, followed by 5.5% during school age and 2.8% in adolescence (Table 3).

**Table 3.** Subgroup analysis by development stage of the prevalence of obesity in Chinese children and adolescents aged 0–18 years (%).

Time Period	Infancy	Toddlers	Preschool Children	School Children	Adolescents
1991-1995	-	-	-	1.7 (1.4–1.9)	0.3 (0.2–0.4)
1996-2000	8.3 (8.0-8.7)	4.2 (4.0-4.3)	3.1 (3.0-3.2)	2.8 (2.7-2.9)	1.8 (1.7-1.8)
2001-2005	4.5 (4.1-5.0)	2.1 (1.9-2.2)	6.6 (6.4–6.9)	1.8 (1.7–1.9)	1.6 (1.4–1.8)
2006-2010	6.3 (5.9-6.6)	5.0 (4.8-5.2)	5.3 (5.1-5.4)	7.5 (7.3–7.7)	3.5 (3.4-3.6)
2011-2015	-	-	11.3 (10.0-12.5)	8.9 (8.7-9.1)	3.9 (3.7-4.0)
Total	7.0 (6.8–7.2)	4.1 (4.0-4.2)	4.5 (4.4–4.6)	5.5 (5.4–5.6)	2.8 (2.7–2.9)

### 3.3. Heterogeneity Test and Publication Bias

In this study, the heterogeneity ( $l^2 > 50\%$ ) of the pooled prevalence was high. Sensitivity analysis is an indirect method for analyzing heterogeneity. It mainly re-examines the combined effect by removing certain types of literature and compares the new combined results with the combined results before the exclusion. Sensitivity analysis of the sample size, study quality, diagnostic criteria, geographic distribution, and survey type showed these were important factors in research heterogeneity (Table S6).

According to the included studies, Begg's funnel plots were drawn. The Begg's test and Egger's test further showed that there was no publication bias in overweight (Figure 6a, Begg's test, p = 0.328, and Egger's test, p = 0.892; Figure 6c, Begg's test, p = 0.392, and Egger's test, p = 0.947) and obesity (Figure 6b, Begg's test, p = 0.159, and Egger's test, p = 0.976; Figure 6d, Begg's test, p = 0.192, and Egger's test, p = 0.930).

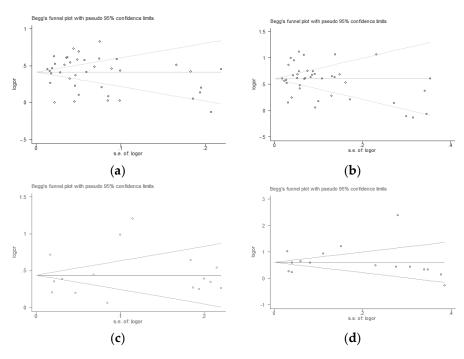


Figure 6. Publication bias in overweight and obesity.

#### 4. Discussion

From 1991 to 2015, the prevalence rate of overweight and obesity among Chinese children and adolescents increased, but it decreased slightly from 2011 to 2015. In 1991–2000, the overweight and obesity rates increased steadily, and sex differences were not obvious. This may be related to the gradual improvement in living standards and the improved nutrition of children in China after the reform and opening-up at the end of the 1970s. The decrease in the detection rate of overweight and obesity from 2010 to 2015 may be closely related to a series of important sports policies and regulations promulgated by Chinese government agencies. Since the reform and opening-up, the level of nutrition and morphological development of adolescents have continuously improved, and these trends have considerably improved the health of the people as a whole. However, the government departments of our country are aware that the unilateral pursuit of the rate of enrollment has led to schoolwork that is too heavy a burden on students, and rest and exercise time are seriously insufficient. Insufficient sports facilities and conditions create barriers to students' physical education and sports activities. Physical fitness monitoring showed that physical fitness indicators, such as endurance, strength, and speed, continued to decline in young people; additionally, the rate of poor eyesight was high, and the proportion of urban overweight and obese adolescents increased significantly. The nutritional status of some rural adolescents needs to be improved. Therefore, the government department implemented the Opinions of the Central Committee of the Communist Party of China on Strengthening Youth Sports to Enhance the Physical Fitness of Young People in 2007 [45] while emphasizing the reduction of students' schoolwork burden, ensuring an hour of exercise every day, and extensively implementing the National Million Students Sunshine Sports. The relevant survey results show that because of the promulgation and implementation of the opinions in 2007, China carried out all-round sunshine sports activities, with 95.3% of the primary school group and 85.7% of children in the middle-school group achieving passing grades for the National Student Physical Health Standard. The effect of sunshine sports is remarkable [46]. The State Sports General Administration formulated the 12th Five-Year Plan according to the overall arrangement of the CPC Central Committee and the State Council, as well as the new situation, new tasks, and new requirements faced by sports development in our country during the 12th Five-Year Plan period. Among them, the recommendation for children and adolescents was to implement the Youth Sports Promotion Program to improve the health quality of adolescents [47].

The detection rates of overweight and obesity in boys were higher than those in girls, and the gender difference increased every year, which is consistent with the results reported by Xue et al. in 2014 [48]. This may be related to cognition and dietary and physical activity behavior. For example, the tendency of parents to recognize the differences in the physical development of boys and girls may lead to feeding differences, which mainly manifest in the overfeeding of boys, thereby increasing the rate of overweight and obesity in boys compared with that in girls [49,50]. Girls and boys have different perceptions of weight and diet [51]: girls feel more pressure to be thin and suffer lower self-evaluation [52]; even if their weight is normal, they think that they need to lose weight [53]. Conversely, boys rarely think that they need to lose weight, even if they are overweight. Girls, especially adolescent girls, in pursuit of a slim figure, consciously control their diet and may have unhealthy eating behaviors, such as partial eating, picky eating, and blind dieting [54]. The 2005 risk behavior monitoring report for adolescents noted that 29.1% of boys play computer games for more than two hours a day, 2.0 times higher than girls [55].

The prevalence rates of overweight and obesity in urban children and adolescents were higher than in rural areas, but the difference between urban and rural areas decreased every year, which is consistent with the results reported by Song et al. [56]. In China, more overweight and obese children and adolescents come from economically wealthy families and have parents with higher education, and the role of socioeconomic status (SES) is opposite to that in developed countries [57–61]. This may be the result of higher SES requirements for children, whose weekly intake of meat or fish, eggs, dairy products, beans, and fruits and vegetables in urban areas is significantly higher than that of children in rural areas, resulting in overweight urban children and adolescents. The prevalence of obesity in urban

areas was much higher than that in rural areas [62]. Second, the lack of physical activity time and the increase in the stationary behavior of urban children and adolescents may also lead to overweight urban children and adolescents [2]. Finally, exposure to high concentrations of air pollution was positively correlated with overweight and obesity in 2–13-year-old children [63]. Therefore, air pollution is a potential factor of the higher rate of overweight and obese children and adolescents in urban areas compared with those in rural areas. Zhang et al. [64] pointed out that between 1985 and 2014, the prevalence of overweight and obesity in rural areas cannot be ignored. Simultaneously, China's annual growth rate of urbanization increased from 0.53% in 1991 to 1.61% in 2010 [65], consistent with the increasing trend of the rate of overweight and obese children and adolescents. This increase in urbanization may be the main factor of the gradually decreasing difference between urban and rural areas.

Overall, compared with other growth and development stages, the prevalence of overweight and obesity was the highest in infants, which is consistent with the results of Chen et al. [66]. This may be related to the rapid proliferation of adipose tissue in infants and young children in the d [67]. High energy intake in the third trimester of pregnancy and passive feeding might also have led to the highest prevalence of overweight and obesity occurring in infants [68]. In China, many parents prefer to compare the weight of their children with those of other infants, mistakenly believing that heavier children are healthier [69]. On a global scale, the rate of overweight and obesity among children under five years of age increased sharply during the period of 1990–2010, and it increased the most in lowand middle-income countries [70]. In the Iranian region, children over the age of 2–6 and 7–11 years have a higher overweight trend than the older group [71]. This is consistent with the relatively low rate of overweight and obesity in adolescence in this study. With the rapid development of the economy, parents are more likely than in the past to purchase high-fat, high-energy food, and such diets can cause children's rapid weight gain. The high obesity rate of school-aged children may be related to their poor self-control, parents' fear of providing insufficient food and thus overfeeding, and less exercise. The reason for the decline in the detection rate during adolescence may be that with the increase in age, the health consciousness of adolescents and that of their parents strengthens, the demands of body shape improve, and the regulation of exercise and diet tightens [72]. The birth cohort of preschool children in 2001–2005 has highest through ages of 4-18 years (preschool to adolescence), but it has a prevalence rate smaller than other birth cohorts when they were infants or toddlers. It may be caused from a publication bias, or use of different definition.

The key to preventing adolescent and even adult obesity is the first year of life [36]. Foreign and domestic studies have shown that breastfeeding can reduce the risk of obesity in children [73,74]. Therefore, health education should be improved to reduce the prevalence of overweight and obesity in infants. We should simultaneously strengthen primary and middle-school children's awareness of the risk of becoming overweight and obese, continue to implement and improve relevant policies, and increase the level of physical activity of children and adolescents to effectively reduce the detection rate of overweight and obesity among children may have a greater impact if healthful foods are made available and easily accessible in the home and if these healthful foods are also consumed by mothers or other family members in the household [75]. Therefore, parents should receive nutrition education to help young children develop healthy eating habits and thus improve the overall growth and development of children while preventing obesity.

Sensitivity analysis found that differences in sample size, study quality, diagnostic criteria, geographic distribution, and survey type were the reasons for the heterogeneity between studies. The Begg test results were not significant and the funnel plot did not show significant publication bias effects. However, because the included studies may be based on one or two of the three classes of gender, region and age, we are unable to obtain all levels of relevant data in the same sample, which gives us the inconvenience of conducting nine levels of research in the same sample. Therefore, this

study investigated the prevalence of overweight and obesity by gender, region and age, respectively, which may introduce a bias.

### 5. Study Limitations

To date, the criteria for dividing overweight and obesity have not been unified. Therefore, during data collection, we classified overweight and obesity according to the division method in the literature, so some errors occurred that did not affect the general trend. However, we hope that all regions and organizations will be able to unify standards when conducting research so that they can be accurately compared.

Regional differences exist in overweight and obesity among children and adolescents in China. We did not divide the results by region. In the future, follow-up studies should be conducted on the rates of overweight and obesity in different regions. Different regions vary in terms of dimensions, elevation, living habits, eating habits, and economic conditions.

In a sensitivity analysis, the sample size, study quality, diagnostic criteria, geographic distribution, and type of survey are all important factors that contribute to research heterogeneity. For example, the size of the sample will affect the weight of the overweight and obesity detection rate; the quality of the study will affect the reliability of the detection rate of overweight and obesity; the difference in diagnostic criteria will lead to differences in the detection rate of overweight and obesity. These factors may lead to the underestimation or overestimation of the problem of overweight and obesity in Chinese children.

# 6. Conclusions

The meta-analysis of overweight and obesity among Chinese children and adolescents for the period from 1991 to 2015 showed significant differences in the prevalence of overweight and obesity based on region, sex, and age. The overall trend was upward, but it decreased slightly from 2011 to 2015.

According to the actual situation of local children and adolescents, each region should formulate corresponding prevention and control strategies and pay special attention to high-risk groups.

**Supplementary Materials:** The following are available online at http://www.mdpi.com/1660-4601/16/23/4656/s1, Table S1: Summary of studies reporting the prevalence of overweight in Chinese children and adolescents aged 0–18 years; Table S2: Summary of studies and the reported prevalence of being overweight in urban and rural children and adolescents aged 0–18 years; Table S3: Summary of studies reporting the prevalence of obesity in Chinese children and adolescents aged 0–18 years; Table S4: Summary of studies and their reported prevalence of obesity in urban/rural children and adolescents aged 0–18 years; Table S5: Summary of studies and their reported prevalence of obesity in urban/rural children and adolescents age 0–18 years; Table S5: Summary of studies and their reported prevalence of obesity in urban/rural children and adolescents age 0–18 years; Table S5: Summary of studies and their reported prevalence of obesity in urban/rural children and adolescents age 0–18 years; Table S5: Summary of studies and their reported prevalence of obesity in urban/rural children and adolescents age 0–18 years; Table S6: Sensitivity analysis of the studies on the prevalence of overweight/obesity in children and adolescents; File S1: PRISMA 2009 checklist.doc.

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