Television watching and risk of childhood obesity: a meta-analysis

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Background: Over the last few decades, there has been a worldwide epidemic of childhood obesity. An important step in successful prevention in paediatrics is the identification of modifiable risk factors of childhood obesity. Many studies have evaluated the associations between television (TV) watching and childhood obesity but yielded inconsistent results. Methods: To help elucidate the role of TV watching, PubMed and Embase databases were searched for published studies on associations between TV watching and childhood obesity. Random-effects models and dose–response meta-analyses were used to pool study results. Results: Fourteen cross-sectional studies with 24 reports containing 106 169 subjects were included in the meta-analysis. Subgroup analyses were conducted by the available characteristics of studies and participants. The multivariable-adjusted overall OR of the childhood obesity for the highest vs. the lowest time of TV watching was 1.47 [95% confidence interval (95% CI): 1.33–1.62]. A linear dose–response relationship was also found for TV watching and childhood obesity (P < 0.001), and the risk increased by 13% for each 1 h/day increment in TV watching. Subgroup analysis showed a basically consistent result with the overall analysis. The association is observed in both boys and girls (for boys, OR 1.30, 95% CI 1.16–1.45; for girls, OR 1.26, 95% CI 1.11–1.41). Conclusions: our meta-analysis suggested that increased TV watching is associated with increased risk of childhood obesity. And restricting TV time and other sedentary behaviour of children may be an important public health strategy to prevent childhood obesity.
Introduction

Obesity levels are increasing rapidly in children and youngsters in both developed and developing countries.\(^1\)–\(^3\) Globally, nearly 43 million children under the age of 5 years were overweight or obese in 2010.\(^4\) Childhood obesity is linked to diabetes, asthma and sleep disorders,\(^4\)–\(^6\) and obesity in adults is linked to a higher rate of mortality.\(^7\) Obesity in adults increases the risk of diabetes mellitus, hypertension, cardiovascular disease, gallbladder disease, gout, arthritis and even some malignancies.\(^8\)–\(^9\) It is predicted that, by 2020, more than 60% of diseases and their related mortality and morbidity in the developing countries will be due to non-communicable diseases, for many of which obesity is a potential risk factor.\(^10\) Longitudinal studies have also shown that overweight children are more likely to become overweight adults.\(^11\)

An important step in successful prevention in pediatrics is the identification of modifiable risk factors of childhood obesity, e.g. sociodemographic risk factors, television (TV) and other screen exposure have typically been linked to an increased risk for paediatric obesity.\(^12\)–\(^14\) The correlation between TV and paediatric obesity may be mediated by lack of physical activity, increased consumption of unhealthy foods while watching TV, exposure to advertising of unhealthy foods and/or poor sleep patterns.\(^15\)–\(^19\)

A number of epidemiologic studies have evaluated the associations between TV watching and childhood obesity but yielded inconsistent results. In this study, we sought to conduct a meta-analysis with the following aims: (i) to estimate the association of TV watching and childhood obesity; (ii) to examine TV watching in relation to childhood obesity according to sex, age, assessment method of weight/height and study sample size and (iii) to evaluate the dose–response patterns of TV watching on childhood obesity.

Methods

Search strategy

The meta-analysis was designed to follow the principles of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). We searched PubMed and Embase databases to 24 June 2014 for studies on the relationship between television (TV) watching and incidence of obesity in children. The following key words: (Obesity or Obese or Adiposity or fat or fatness or BMI or ‘Body Mass Index’ or ‘body size’ or Overweight or weight) and (television or TV watching in children) were used to search the related studies by two independent investigators. We also reviewed the reference lists from reviews, meta-analyses and other relevant publications to search for additional relevant studies.

Eligibility criteria

Studies were included in this dose–response meta-analysis if they met the following criteria: (i) use cohort study, case–control or cross-sectional study design about children; (ii) TV watching as the exposure of interest; (iii) obesity as the outcome of interest and (iv) reporting risk estimates with the corresponding 95% confidence intervals (95% CIs) or sufficient information to calculate them. For dose–response analysis, the study had to report the estimates for at least three TV watching categories.

Data extraction

The following data were extracted from each study: first author’s surname, publication year, study location, study size, sex of population, age, assessment method of weight/height(measured or self-reported), TV watching in a day, TV watching categories and adjustment factors in the multivariable analysis. We extracted the ORs from the maximally adjusted model to reduce the risk of possible residual confounding. The median or mean level of TV watching for each category was assigned to the corresponding OR. When a study reported risk estimates and 95% CIs relative to a reference category other than the lowest normal weight, the ORs were recalculated using the lowest one as reference by the method proposed by Greenland and Longnecker.\(^20\)

Statistical analysis

For the outcome of interest, pooled estimates and 95% CIs of effect sizes were calculated by using an inverse-variance weighted random-effects meta-analysis.\(^21\) The I\(^2\) statistic was used to assess heterogeneity among studies,\(^22\) and I\(^2\) values of 0, 25, 50 and 75% represent no, low, moderate and high heterogeneity, respectively. To investigate the effect of potential confounders, subgroup analyses were conducted by the available characteristics of studies and participants if three or more studies were available per subgroup.

For dose–response analysis, a two-stage random-effects dose–response meta-analysis was performed to compute the trend from the correlated log OR estimates across levels of TV watching, taking into account the between-study heterogeneity. We used generalized least-squares regression (GLST) to compute study-specific slopes (linear trends).\(^20\) And we examined a potential non-linear dose–response relationship between TV watching and obesity using restricted cubic splines with three knots at percentiles 25, 50 and 75% of the distribution. This method required that the number of cases and subjects and the OR with its variance estimate for at least three quantitative exposure categories were known. If the median or mean consumption was not provided, we assigned the midpoint of the upper and lower bound in each category as the average intake. The lowest boundary was considered the median of the lowest category and zero if the lowest category was open. If the highest category was open-ended, we assumed that it had the same amplitude as the preceding category.
Publication bias was evaluated with Begg’s funnel plots and the Egger’s test. If publication bias was statistically suspected, we used the Duval and Tweedie ‘trim and fill’ method to further evaluate the possible effect of the publication bias. All analyses were performed with STATA version 11.0 (Stata, College Station, TX). A two-sided \( P \) values < 0.05 was considered statistically significant.

**Results**

**Literature search**

Figure 1 showed the results of literature research and selection. We identified 446 articles from PubMed and Embase. After the exclusion of duplicates and studies that did not fulfill the inclusion criteria, 14 articles with 24 reports contained 106,169 subjects were utilized in the meta-analysis, among which 12 reports with three quantitative exposure categories were used to perform dose-response analysis of TV watching and childhood obesity. All of 14 studies were cross-sectional studies design. Of the 14 studies, 7 examined boys and girls separately. The sample size of included studies ranged from 556 to 21,540. The detailed outline of the parameters of the included studies was shown in Supplementary table S1.

**Highest vs. lowest TV watching categories**

The multivariable-adjusted ORs for each study and the combined OR for the highest vs. the lowest categories of TV watching were shown in figure 2. The pooled OR was 1.47 (95% CI 1.33–1.62) with significant heterogeneity in studies (\( I^2 = 79.2\% \), \( P < 0.001 \)). When stratified by sex, as shown in table 1, there was a significant difference observed in boys: OR = 1.30 (95% CI 1.16–1.45, \( I^2 = 37.3\% \), \( P_{\text{heterogeneity}} = 0.144 \)), girls: OR = 1.26 (95% CI 1.11–1.41, \( I^2 = 79.2\% \), \( P_{\text{heterogeneity}} < 0.001 \)) and both boys and girls: OR = 1.60 (95% CI 1.31–1.94, \( I^2 = 84.3\% \), \( P_{\text{heterogeneity}} < 0.001 \)). Stratifying by age, the OR was 1.49 (95% CI 1.34–1.65, \( I^2 = 0.00\% \), \( P_{\text{heterogeneity}} = 0.603 \)) for pre-school children, 1.46 (95% CI 1.27–1.67, \( I^2 = 81.0\% \), \( P_{\text{heterogeneity}} < 0.001 \)) in school age children and 1.48 (95% CI 1.05–2.09, \( I^2 = 91.0\% \), \( P_{\text{heterogeneity}} < 0.001 \)) for mixed. Finally, the significant associations were also observed in the subgroup analysis of assessment method of weight/height (measured and

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**Table 1**

<table>
<thead>
<tr>
<th>Study ID</th>
<th>OR (95% CI)</th>
<th>% Weight</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L. de Gouw et al. (boys) (2010)</td>
<td>1.21 (1.00–1.47)</td>
<td>8.54</td>
<td>41.20</td>
</tr>
<tr>
<td>Sun et al. (boys) (2009)</td>
<td>2.02 (1.44–2.84)</td>
<td>3.92</td>
<td></td>
</tr>
<tr>
<td>Carvalhal et al. (boys) (2006)</td>
<td>1.12 (0.87–1.45)</td>
<td>4.35</td>
<td></td>
</tr>
<tr>
<td>M. Sektin et al. (boys) (2001)</td>
<td>1.30 (0.90–1.85)</td>
<td>3.23</td>
<td></td>
</tr>
<tr>
<td>Fulton et al. (boys, 2–5 old years) (2009)</td>
<td>1.42 (1.02–1.99)</td>
<td>3.64</td>
<td></td>
</tr>
<tr>
<td>Fulton et al. (boys, 6–11 old years) (2009)</td>
<td>1.25 (0.97–1.60)</td>
<td>4.48</td>
<td></td>
</tr>
<tr>
<td>Fulton et al. (boys, 12–15 old years) (2009)</td>
<td>1.28 (1.00–1.64)</td>
<td>4.49</td>
<td></td>
</tr>
<tr>
<td>Subtotal (I-squared = 85.8%, ( p = 0.000 ))</td>
<td>1.30 (1.10–1.56)</td>
<td>29.39</td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L. de Gouw et al. (girls) (2010)</td>
<td>1.25 (1.12–1.41)</td>
<td>5.84</td>
<td></td>
</tr>
<tr>
<td>Sun et al. (girls) (2009)</td>
<td>2.38 (1.62–3.50)</td>
<td>3.19</td>
<td></td>
</tr>
<tr>
<td>Carvalhal et al. (girls) (2006)</td>
<td>0.88 (0.68–1.15)</td>
<td>4.35</td>
<td></td>
</tr>
<tr>
<td>M. Sektin et al. (girls) (2001)</td>
<td>2.08 (1.45–2.99)</td>
<td>3.38</td>
<td></td>
</tr>
<tr>
<td>Fulton et al. (girls, 2–5 old years) (2009)</td>
<td>1.42 (1.02–1.99)</td>
<td>3.64</td>
<td></td>
</tr>
<tr>
<td>Fulton et al. (girls, 6–11 old years) (2009)</td>
<td>1.26 (1.04–1.54)</td>
<td>4.35</td>
<td></td>
</tr>
<tr>
<td>Fulton et al. (girls, 12–15 old years) (2009)</td>
<td>1.46 (1.10–1.97)</td>
<td>4.56</td>
<td></td>
</tr>
<tr>
<td>Subtotal (I-squared = 82.0%, ( p = 0.000 ))</td>
<td>1.50 (1.20–1.86)</td>
<td>29.22</td>
<td></td>
</tr>
<tr>
<td>Overall (I-squared = 79.2%, ( p = 0.000 ))</td>
<td>1.47 (1.33–1.62)</td>
<td>100.00</td>
<td></td>
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</tbody>
</table>

**NOTE:** Weights are from random effects analysis

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**Figure 2** Forest plot of childhood overweight and obesity with the highest vs. lowest categories of TV watching
Twelve studies that reported the OR and its 95% CI for at least three quantitative exposure categories were included for the dose–response meta-analysis. The pooled OR of risk of childhood obesity per 1 h/day increment in TV watching was 1.13 (95% CI 1.03–1.19). As shown in figure 3, some evidence of a linear relationship between TV watching and risk of childhood obesity was found ($P < 0.001$).

Assessment of heterogeneity and sensitivity analysis

Although significant heterogeneity was present ($I^2 = 79.2\%$), the sources of heterogeneity could not be determined in the meta-regression analysis. To explore study heterogeneity, we performed stratified analysis by sex, age, assessment method of weight/height and study sample size. As a result, age ($\chi^2 = 10.28, P = 0.006$) and study sample size ($\chi^2 = 4.33, P = 0.038$), but not sex and assessment method of weight/height, were found to contribute to the substantial heterogeneity. In a sensitivity analysis in which one study at a time was removed and the rest analyzed, the pooled ORs ranged from 1.22 (95% CI 1.07–1.36) to 1.54 (95% CI 1.39–1.70), which indicated that the pooled estimates were robust and not influenced by any one study (Supplementary figure S1).

Figure 3 The dose–response analysis between TV watching and childhood overweight and obesity risk in included studies with restricted cubic splines in a multivariate random-effects dose–response model. The solid line and the long dash line represent the estimated relative risk and its 95% CI. Short dash line represents the linear relationship (per 1 h/day increment)

Self-reported), study sample size (<1000 and ≥1000) and publication year (≥2010 and <2010).

Dose–response analysis

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Publication bias

The publication bias of literatures was evaluated by Begg’s funnel plot and Egger’s test. The $P$ values of Egger’s test was 0.01 (Supplementary figure S2). We attempted to detect and adjust the possible publication bias for highest vs. lowest TV watching categories by using the Duval and Tweedie ‘trim and fill’ method. As shown in Supplementary figure S2, seven negative unpublished results were incorporated to produce a hypothetically symmetrical funnel plot, and the pooled OR was modestly attenuated to be 1.13 (95% CI 1.08–1.18) but remained statistically significant ($P < 0.001$).

Discussion

In our meta-analysis, the significant association between childhood obesity and TV watching was observed both in boys and girls, and the risk between the two groups was about the same. The dose–response analysis showed that each 1 h/day increment of TV watching corresponded to a 13% increase in risk of obesity. A linear relationship between TV watching and childhood obesity risk was also found.

Researchers have proposed that time spent viewing TV may lead to obesity by one or a combination of the following mechanisms: (i) decreased physical activity, (ii) increased energy intake, (iii) increased sedentary behaviour, (iv) exposure to food advertising and (v) reduced sleep time.31,39,40 Zimmerman et al.40 found that TV viewing was more strongly associated with weight gain when the content included commercials than when viewing was limited to non-commercial programmes. More TV watching is often
accompanied by reduced amounts of exercise and increased sedentary behaviour. When watching TV, the children often consume more carbonated drinks and dessert, which are important causes of obesity.\(^{41,42}\)

Knowledge of the risk factors that play important roles in childhood obesity development can help us create prevention strategies. Meta-analysis is a powerful tool that can be used to reveal trends that may not be obvious through a single study. Strengths of this meta-analysis included the strict inclusion criteria, the large number of total subjects (106 169) and the dose-response relationship. Our sensitivity analysis also confirmed that more TV watching increased childhood obesity risk. The possible dose-response relationship was assessed by GLST and weighted linear regression. Furthermore, a linear relationship between TV watching and childhood obesity risk was found. To the best of our knowledge, this meta-analysis is the first study used to explore the dose-response relationship of TV watching and childhood obesity risk in detail. Moreover, we found that the risk of childhood obesity increases by 13% for every additional 1 h/day increment.

Our finding suggests that restricting TV time and other sedentary behaviour of children may be an important public health strategy to prevent childhood obesity. Instead of watching TV, the children should spend more time engaging in physical activity. When taking part in outdoor sports, the children can decrease sedentary behaviour, energy intake. Similarly, physical activity plays a key role on promoting health and physical and mental development. In addition, exposure to food advertising has been found to be a risk factor of childhood obesity. Some experiments demonstrate the power of food advertising in priming automatic eating behaviors and childhood obesity.\(^{43}\) More TV watching time often accompanied by exposure to food advertising and increased sedentary behaviour, which may lead to the children increasing their consumption behaviour. Finally, these unhealthy behaviors can all contribute to childhood obesity.

Like all meta-analyses, our meta-analysis also contains some limitations. First, our meta-analysis includes only published studies, it is inevitable that an observed effect might suffer from publication bias because studies with null results tend not to be published. Interestingly, the ‘trim and fill’ analysis showed that publication bias did not appreciably affect our results. Second, studies had examined risk by quartile distribution (cut-off point) of BMI, and cut-offs often varied across studies. Third, for the lowest and highest categories, there was a wide range of values for the cut-off points, which may contribute to heterogeneity in the results. Last but not least, this meta-analysis only included cross-sectional studies where causal inference is a very real concern, and the time of TV watching was self-reported which may have led to measurement error.

In conclusion, our meta-analysis suggested that increased TV watching is associated with an increased risk of childhood obesity. A statistically linear relationship between TV watching and childhood obesity risk is also found. The association is observed in both boys and girls.

### Supplementary data

Supplementary data are available at EURPUB online.

### Acknowledgements

Gang Zhang and Chunting Mao designed research; Jianrong Fan and Gang Zhang performed research; Lei Wu, Lingling Zhou and Gang Zhang analyzed data; Gang Zhang, Jianrong Fan and Lei Wu wrote the draft; all authors read, reviewed and approved the final article. Chunting Mao had primary responsibility for final content.

### Conflicts of interest
None declared.

## Key points

- **Epidemic of childhood obesity occurred worldwide.**
- **Increased TV watching is associated with increased risk of childhood obesity.**
- **Limited TV use can prevent childhood obesity.**

## References


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Do different parenting patterns impact the health and physical growth of ‘left-behind’ preschool-aged children? A cross-sectional study in rural China

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Background: Many migrants from rural China seek work in urban areas and leave their children in their home villages to be raised by relatives. These children are often referred to as ‘left-behind children’. Parental migration tends to have a profound impact on a child’s growth. This study sought to assess the prevalence of illness and malnutrition among children in rural areas raised with different parenting patterns and to explore factors affecting their health and development. Method: A cross-sectional survey was conducted to examine the physical health of children raised with different parenting patterns and to explore associated risk factors. In total, this study examined 735 children ages 3–6 years in eight rural villages in two counties of Shandong Province. Their primary caregivers were interviewed with a semi-structured questionnaire. Anthropometric measurements of the children were taken and their nutritional status was determined according to WHO Child Growth Standards. Results: This study found a relatively high prevalence of wasting, overweight and obesity among left-behind children. After potential confounders were controlled for, the parenting pattern, annual household income and health literacy of the primary caregiver significantly influenced the health and developmental indicators of children. Conclusions: This study highlighted the impact of the characteristics of the primary caregiver on a child’s health and development and the importance of practical interventions for preschool-aged children who are left behind and raised with different parenting patterns.

Introduction

With rapid economic growth and urbanization, the population migrating from rural areas to urban areas in China has increased dramatically. Approximately 15% of all rural households include at least one member that has migrated to an urban area to support their families or seek employment. However, most of these migrant workers perform low-paying jobs and live in crowded