Running title: Overweight, Obesity and Intellectual Disabilities

Prevalence of Overweight and Obesity among Children and Adolescents with Intellectual Disabilities: A Systematic Review and Meta-Analysis

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Abstract

Although there have been numerous studies examining the prevalence of overweight and obesity among children and adolescents with intellectual disabilities, they have not yet been systematically integrated and synthesized through a systematic quantitative review process. The purpose of this systematic review and meta-analysis was to determine: (a) the prevalence of overweight/obesity among children and adolescents with intellectual disabilities; (b) the sources of heterogeneity in studies reporting the prevalence of overweight/obesity in this population; and (c) the risk of overweight/obesity in this population compared with their typically developing peers. A systematic literature search was performed and 16 studies, published between 1985 and 2015, met the inclusion criteria. The resulting pooled prevalence estimates for overweight, overweight-obesity, and obesity were respectively (a) 15%, 30%, and 13% in children; and (b) 18%, 33%, and 15% in adolescents. Subgroup analyses showed significant variations in the pooled prevalence estimates as a function of geographic region, recruitment setting, additional diagnoses, and norms used to define overweight or obesity. The findings also showed adolescents with intellectual disabilities to be respectively 1.54 and 1.80 times more at risk of overweight-obesity and obesity than typically developing adolescents. Unfortunately, no such comparison is available for children.

Abbreviations used in the text: B-M: Begg and Mazumdar; DD: developmental disabilities; ID: intellectual disabilities; IOTF: International Obesity Task Force; PRISMA: Preferred Reporting Items for Systematic reviews and Meta-Analyses; STROBE: STrengthening the Reporting of OBservational studies in Epidemiology statement; TD: typically developing; USA: United States of America.

Introduction

Over the past three decades, a considerable amount of research regarding the prevalence of overweight and obesity among youth presenting various disabilities or special needs has been conducted and synthesized (1-6). However, the prevalence of overweight/obesity among children and adolescents with intellectual disabilities (ID; i.e., characterized by a deficit in intellectual functioning accompanied by a deficit in adaptive functioning and an onset during the developmental period) (7) has not been so closely examined. The first narrative review on this topic, published in 2011 (8), reported a prevalence of overweight excluding obesity ranging from 11% to 25%, and a prevalence of obesity from 7% to 36% in children and adolescents with ID.

Since then, five additional reviews have summarized the research examining the prevalence of overweight and/or obesity among children and/or adolescents with ID (10) or developmental disabilities (DD). The DD categorisation is broader than ID and encompasses Fragile X syndrome, Down syndrome, pervasive developmental disorders, fetal alcohol spectrum disorders, cerebral palsy, and ID (9,11-13). However, only a limited number of studies focusing specifically on children and/or adolescents with ID were included in these previous reviews.

Moreover, these reviews suffer from important limitations. First, five of these reviews (8-11,13) were non-systematic, and the sole systematic review (12) was restricted to the relationship between parental/parenting factors and obesity among children and/or adolescents with DD. Therefore, numerous studies on children and/or adolescents with ID could have been missed. Second, only two reviews have included studies comparing the prevalence of overweight or obesity among children and/or adolescents with ID and their typically developing (TD) peers (8,11). Furthermore, both of these reviews included very few such comparative studies, and most of them overlapped between the two reviews. Finally, no reviews have yet quantitatively examined whether the heterogeneity observed in the overweight/obesity prevalence of children and/or adolescents with ID could be attributed to the participants' characteristics (e.g., age, sex, ID severity, genetic syndromes, geographic region, or recruitment setting) or to the assessment methods (e.g., norms used to define overweight and obesity, measurement of height and weight).

Consequently, the prevalence of overweight and obesity among children and adolescents with an ID remains an underexplored area and there still remain gaps and inconsistencies in the knowledge. Still unknown is: (a) the extent to which children and adolescents with ID are at high risk for overweight, overweight-obesity or obesity; (b) whether the observed prevalence estimates reported in the literature varied when different sources of heterogeneity were considered; and (c) whether children and adolescents with ID are at greater risk for overweight, overweight-obesity or obesity than their TD peers.

In this context, a systematic review and meta-analysis of the prevalence rates of overweight/obesity among children and adolescents with ID appears to be of significant importance. Indeed, a better estimation of this critical public health problem in children and adolescents with ID would encourage scholars, practitioners and policy makers to further develop lifestyle intervention programs (i.e., healthy diet, physical activity, health promotion-education and behavioral modification) designed for tackling or managing weight problems in this population. Therefore, following the Meta-Analysis of Observational Studies in Epidemiology Statement (14), the aims of the current review were to determine, among children and adolescents with ID: (a) the prevalence of overweight, overweight-obesity, and obesity; (b) the sources of heterogeneity in studies reporting the prevalence of overweight, overweight-obesity and obesity; and (c) the risk of overweight, overweight-obesity and obesity, compared with their TD peers.

Method

Sources of Information and Search Strategy

A systematic electronic search was conducted in nine databases without imposing any year restriction [Academic Search Complete (1887–2015), Medline (1946–2015), PsycARTICLES (1904–2015), Psychology and Behavioral Sciences Collection (1965–2015), Scopus (1996–2015), CINAHL (1981–2015), Education Sources (1900–2015), ERIC (1966–2015) and SocINDEX (1908–2015)]. Studies were identified using all possible combinations of the following three groups of search terms: (a) intellectual* disab* OR learning disab* OR learning difficult* OR mental* retard* OR developmental dis* OR developmental del* OR cogniti* dis* OR mental dis*; AND (b) obes* OR overweight* OR fat* OR weight* OR body mass index OR nutritional status OR adiposit*; AND (c) child* OR adolescen*OR student*OR youth* OR paediatric* OR pediatric*. In addition, a hand search was carried out in reference lists of relevant articles and previous literature reviews on children and adolescents with disabilities (1-6), with ID (8,10), or with DD (11-13). Finally, an additional search was also performed in content pages of specific peer-reviewed journals devoted to ID or DD (e.g., *American Journal on Intellectual and Developmental Disabilities*, *Journal of Intellectual Disabilities Research*, *Intellectual and Developmental Disabilities*, *Journal of Applied Research in Intellectual Disabilities*, *Journal of Intellectual and Developmental Disability*, *Research in Developmental Disabilities*). This literature was last updated by hand-search on 5 December 2015.

Inclusion Criteria

Only studies meeting four specific inclusion criteria were considered eligible for this review. First, study participants had to present an ID. Studies based on mixed samples of participants presenting multiple disabilities were also considered eligible if specific data regarding the prevalence of overweight, overweight-obesity, or obesity were available for children and/or adolescents with ID.

Second, study participants had to be composed of children (age range ≥ 4 – 11 years) and/or adolescents (age range ≥11 – 18 years). Studies including mixed samples of children and adolescents were considered eligible if specific data on the relevant outcomes were available for children and/or adolescents subgroups separately. Studies or samples in a study were not included when the age range of the participants overlapped multiple age categories: infants and children (e.g., 2-10 years), children and adolescents (e.g., 7-12 years, 10-13 years), adolescents and adults (e.g., 12-19 years, 17-20 years), etc.

Third, studies were retained if the prevalence estimates of overweight, overweight-obesity, or obesity were the primary outcome of the study and if they were assessed by means of height/weight measurement indicators, such as the body mass-index (BMI; Cole, 15) and the weight-for-length index (WLI; DuRant and Linder, 16). Here, children/adolescents with ID are categorized as overweight (excluding obesity) when their value of BMI or WLI is > cut-offs values for normal weight and < cut-offs values for obesity. Additionally, children/adolescents with ID are categorized as obese when their value of BMI or WLI is ≥ cut-offs values for obesity. Finally, children/adolescents with ID are categorized as overweight-obese (a combined category including overweight and obesity) when their value of BMI or WLI is ≥ the cut-offs values for overweight. This last combined category was considered to permit the consideration of studies in which no distinction was made between overweight and obesity.

The indicators based on height and weight measurement were preferred to other measures of adiposity (e.g., skinfold thickness, waist circumference, bioelectrical impedance analysis) for two reasons. First, previous reviews (8-13) showed that they were the most largely used in overweight/obesity prevalence studies among children and adolescents with ID. Second, a recent

scoping review (17) showed that the validity, reliability and/or sensitivity of other methods (i.e., skinfold thickness, bioelectrical impedance analysis) measuring adiposity in individuals with ID were limited and questionable. Additionally, the use of alternative fatness measurements can be limited or unfeasible in certain occasions (e.g., heterogeneous samples including various subtypes of ID, individuals with additional diagnoses, lack of national norms), and they can introduce a high level of noncompliance in this population (e.g., reluctance to undress). Consequently, we considered that the use and comparison of other body composition measures with the BMI or WLI is premature. When some participants' characteristics (e.g., sex ratio, age) and key information on ID subgroups used to calculate the overweight/obesity rate (e.g., sample size) were not reported in the manuscript, authors were contacted directly to provide the information. Finally, when the same dataset was used in various studies, only one study was included.

Fourth, only original cohort, cross-sectional and case-control studies were included. Reviews, reports, theoretical papers, or single-case studies were excluded. However, a hand search was carried out in reference lists of all previous published reviews on the topic. Finally, studies were retained if they were written in English and published in a peer-reviewed journal.

Study Selection and Data Extraction

The studies were selected following the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) Statement (18). Two authors examined the eligibility of relevant studies separately, based on the consecutive examination of the titles, abstracts, and full texts. The results were then discussed in committee, and disagreements were resolved by discussion. The following information was extracted from the selected studies: country, geographic region, design, recruitment setting, ID characteristics (i.e., sample size, sex ratio, age groups [children and/or adolescents], ID levels), TD comparison sample (i.e., yes-no, sample size), height and body weight measurement method (i.e., direct [by the research team or collected via measures taken by clinicians or teachers], or indirect), type of norm used to define overweight and obesity (e.g., International Obesity Task Force [IOTF], national norms, non-national norms) (see Table 1).

Quality Assessment of the Reviewed Studies

The quality of the reviewed studies was rated using criteria developed based on the recommendations of the STrengthening the Reporting of OBservational studies in Epidemiology statement (STROBE; Vandenbroucke et al., 19). These criteria covered four potential sources of bias in each study. The first criterion assessed the study population biases and more specifically whether the reviewed study: (a) was population-based; (b) reported the main demographic characteristics of the children and adolescents with ID (i.e., age, sex, and ID level); and (c) reported additional diagnoses of the children and adolescents with ID (e.g., Down syndrome, autism). The second criterion assessed outcome biases, more specifically whether the outcomes (weight and height) were measured directly (i.e., by the research team, clinicians or teachers). The third criterion assessed analysis biases, more specifically whether the reviewed studies reported subgroup (e.g., age, sex, ID levels, additional diagnoses) and/or interaction analyses. Finally, the last criterion assessed data presentation biases, more precisely whether the reviewed studies reported the frequency and prevalence estimates of overweight/obesity.

Statistical Analysis

Analyses were performed with the Comprehensive Meta-Analysis (20) software (version 2.2.064). Pooled estimates of overweight, overweight-obesity and obesity prevalence were generated using the random effects model, since the studies differed greatly regarding the participants' characteristics and the assessment methods. Forest plots for prevalence were generated using spreadsheets developed by Neyeloff, Fuchs, and Moreira (21). To compare the

risk of being overweight, overweight-obese or obese between children and adolescents with ID and their TD peers, odds ratios (OR) and 95% confidence intervals were calculated.

Potential sources of heterogeneity in prevalence estimates of overweight, overweight-obesity, and obesity were examined by performing a series of pre-specified subgroup (using a mixed effect model) analyses for the following variables: (a) sex; (b) geographic regions as defined by the World Health Organization (e.g., Europe, North America, South America, Western Pacific), except for the worldwide study of Lloyd et al. (22) in which geographic regions of specific subsamples were already defined; (c) recruitment settings (e.g., regular school, special school, Special Olympics); (d) ID levels (e.g., mild, mild to moderate, mild to profound, moderate to severe-profound); (e) type of norms used to define overweight or obesity (IOTF, national, non-national); (f) method used for measuring body height and weight (direct versus indirect); and (g) additional diagnoses (e.g., Down syndrome). No moderation analysis was performed when only one study was available in a pre-specified subgroup.

Heterogeneity of prevalence estimates within and between subgroups was assessed using the Q test (23) and the I^2 statistic (24). Finally, potential publication bias was assessed by examining the funnel plots [including results from the Duval and Tweedie's (25) "trim and fill" test], Begg and Mazumdar's (B-M) rank correlation test (26) and Egger's test of intercept (27).

Results

Study Selection

The search identified a total of 1 727 possibly eligible articles (see Figure 1). This number fell to 769 after duplicates were removed. Based on titles and abstracts, 711 studies were excluded for reasons detailed in Figure 1. The full texts of the remaining 58 articles were screened, and 16 studies (22,28-42) published between 1985 and 2015 met the inclusion criteria and were included in this meta-analysis (see Table 1).

Study Characteristics

Participant characteristics, study design and recruitment settings for the 16 retained studies are reported in Table 1. Studies were conducted mainly in Western Pacific (n = 4), Europe (n = 4), and North America (n = 4). Two of the 16 studies (13%) included a TD sample that could be used for comparative analyses. Overall, a total of 36 345 participants with ID were involved in these studies (M = 2 272; range = 25 to 20 031) and nearly half of the studies recruited their participants in regular and/or special schools (10/16 studies, 63%). Additionally, 10 of the 16 studies (63%) focused on children (≥4 – 11 years) and 14 of the 16 (88%) on adolescents (≥11 – 18 years). Additionally, participants were mostly boys (M = 61%, SD = 5%, range = 53% to 71%).

In the vast majority of the study, height and body weight were measured directly either by the research team or collected via measures taken by clinicians (e.g., nurses, doctors, dieticians) or teachers (N = 12; 75%). In the other studies, height and weight were reported by parents, career or schools without information on the method of measurement. Overweight, overweight-obesity and obesity status were determined using BMI in all studies, except for two (33, 41) using the WLI. The vast majority of the norms used in the reviewed studies were national (N = 8; 50%) or from the IOTF (N = 5; 31%). Only one used non-national norms and two do not mention the norms used.

In the reviewed studies using national and non-national norms, participants were considered as being (a) overweight if their age- and sex-specific BMI was ≥ 85th percentile and < 95th percentile or if their WLI was ≥ 110% and ≤119; (b) overweight-obese if their age- and sex-specific BMI was ≥ 85th percentile or if their WLI was ≥ 110%; and (c) obese if their age- and sex-specific BMI was ≥ 95th percentile or if their WLI was ≥ 120%.

In the studies using the IOTF norms (43), participants were considered as being (a) overweight if their age- and sex-specific BMI was equivalent to an adult BMI ≥ 25 kg/m² and < 30 kg/m²; (b) overweight-obese if their age- and sex-specific BMI was equivalent to an adult BMI ≥ 25 kg/m²; and (c) obese if their age- and sex-specific BMI was equivalent to an adult BMI ≥ 30 kg/m².

Prevalence Estimates of Overweight, Overweight-Obesity, and Obesity

Children. *Overweight* (Figure 2a) prevalence estimates of were reported in six studies from several countries (Brazil, France, South Korea, United States of America [USA], Worldwide). The pooled prevalence estimate was 15% (95%CI = 10%–20%), with a high level of heterogeneity ($Q_{(5)}$= 42, $p < .001$; $I^2 = 88$). The highest estimate was observed in the USA (25%) by Foley et al. (32), and the lowest in the USA (7%) and South Korea (8%) by Fox et al. (33) and Choi et al. (31), respectively. Finally, no evidence of publication bias was noted (Figure S1a, online supplements; B-M's test, $p = .50$; Egger's test, $p = .36$).

Prevalence estimates of *overweight-obesity* (Figure 3a) were reported in seven studies from several countries (Brazil, France, South Korea, USA, Worldwide). The pooled prevalence estimate was 30% (95%CI = 22%–39%), with a high level of heterogeneity ($Q_{(6)}$= 82, $p < .001$; $I^2 = 93$). The highest estimate was observed in the USA (45%) by Foley et al. (32) and the lowest in South Korea (14%) by Choi et al. (31). Finally, no evidence of publication bias was noted by the B-M rank correlation test ($p = .50$) and Egger's test of intercept ($p = .46$). The Duvall and Tweedie's trim and fill revealed that two studies were missing on the left of the funnel plot (Figure S1b, online supplements). When these two studies are imputed to obtain a symmetrical funnel plot, the pooled prevalence estimate becomes 27% (95%CI = 20%–35%).

Obesity prevalence estimates (Figure 4a) were reported in nine studies from several countries (Egypt, Brazil, France, Japan, South Korea, Taiwan, USA, Worldwide). The pooled prevalence estimate was 13% (95%CI = 10%–16%), with a high level of heterogeneity ($Q_{(8)}$ = 61, $p < .001$; $I^2 = 87$). The highest estimate was observed in the USA (21%) by Foley et al. (32) and Fox et al. (33), and the lowest in South Korea (6%) by Choi et al. (31). Finally, no evidence of publication bias was noted by the B-M rank correlation test ($p = .38$) and Egger's test of intercept ($p = .30$). The Duvall and Tweedie's trim and fill revealed that two studies were missing on the left of the funnel plot (Figure S1c, online supplements). When these two studies are imputed to obtain a symmetrical funnel plot, the pooled prevalence estimate becomes 11% (95%CI = 9%–14%).

Adolescents. *Overweight* (Figure 2b) prevalence estimates were reported in eight studies from several countries (Australia, France, South Korea, USA, Worldwide). The pooled prevalence estimate was 18% (95%CI = 16%–21%), with a high level of heterogeneity ($Q_{(7)}$= 55, $p < .001$; $I^2 = 87$). The highest prevalence estimate was observed in Australia (24%) and the USA (23%) by Krause et al. (34), and Foley et al. (32), respectively. Conversely, the lowest prevalence estimates were observed in France (13%) and South Korea (13%) by Mikulovic et al. (36) and Choi et al. (31), respectively. Finally, no evidence of publication bias was noted (Figure S2a, online supplements; B-M's test, $p = .19$; Egger's test, $p = .47$).

Prevalence estimates of *overweight-obesity* (Figure 3b) were reported in nine studies (Australia, France, South Korea, USA, Worldwide). The pooled prevalence estimate was 33% (95%CI = 27%–39%), with a high level of heterogeneity ($Q_{(8)}$ = 235, $p < .001$; $I^2 = 97$). The highest prevalence estimate was observed in the USA (51%) by Foley et al. (32) and the lowest in France (15%) by Mikulovic et al. (36). Finally, no evidence of publication bias was noted (Figure S2b, online supplements; B-M's test, $p = .46$; Egger's test, $p = .44$).

Obesity prevalence estimates (Figure 4b) were reported in 13 studies from several countries (Egypt, France, Indonesia, Japan, South Korea, Taiwan, USA, Worldwide). The pooled prevalence estimate was 15% (95%CI = 13%–18%) with a high level of heterogeneity ($Q_{(12)}$= 230, $p < .001$; $I^2 = 95$). The highest prevalence estimate was observed in Turkey (28%) and in the USA (28%) by Nogay (37) and Foley et al. (32), respectively. Inversely, the lowest prevalence estimate was observed in France (2%) by Mikulovic et al. (36). Finally, no evidence of publication bias was noted by the B-M rank correlation test ($p = .21$) and Egger's test of intercept ($p = .23$). The Duvall and Tweedie's trim and fill revealed that three studies were missing on the left of the funnel plot (Figure S2c, online supplements). When these three studies are imputed to obtain a symmetrical funnel plot, the pooled prevalence estimate was 13% (95%CI = 11%–16%).

Moderation Analyses

Results from the moderation analyses, as well as the references of the studies used for these analyses are detailed in Tables S1-S6 in the online supplements.

Children. Findings showed significant disparities in overweight-obesity and obesity pooled prevalence estimates by geographic region (Tables S4-S6). Pairwise comparisons (available upon request from the first author) showed that the risk of being overweight-obese was greater in children with ID from North America (39%) than in those living in South America (25%). North American children with ID were also more likely to be obese (23%) than those from Europe (9%), South America (11%), and Western Pacific (9%). Results also showed significant variations in the pooled prevalence of obesity by recruitment setting (Tables S5-S6). The pooled prevalence of obesity were significantly higher in children recruited via Special Olympics (17%) than via special schools (9%). No significant variations were found as a function of sex, ID level, additional diagnoses, body-height and body-weight measurement method or the norms used to define overweight, overweight-obesity or obesity (Tables S1-S6, online supplements).

Adolescents. Findings showed significant disparities in overweight, overweight-obesity and obesity pooled prevalence estimates by geographic region (Tables S1-S6). Adolescents with ID from North America (22% and 48%) were more likely to be overweight and overweight-obese than those from Europe (17% and 23%), and more likely to be obese (27%) than those living in Europe (8%), South East Asia (10%), and Western Pacific (16%). Results (Tables S4-S6) also showed that pooled prevalence of overweight-obesity and obesity were significantly higher in adolescents with Down syndrome (61% and 33%) than without Down syndrome (35% and 17%). Findings also revealed higher pooled prevalence of obesity among adolescents with ID in studies using national norms (19%) rather IOTF norms (10%). No significant variations were found as a function of sex, ID level, or body-height and body-weight measurement method (Tables S1-S6, online supplements).

Comparison of Risk with Typically Developing Peers

Children. None of the studies assessed the risk of being overweight, overweight-obese or obese in children with ID compared with their TD peers.

Adolescents. Only two studies provided data that can be used to compare the risk of overweight/obesity in adolescents with ID and their TD peers (34,39). Random effects models showed a statistically higher risk for overweight-obesity and obesity in adolescents with ID than in their TD peers, with a pooled OR of 1.54 (95%CI = 1.12–2.12, $p = 0.008$) and of 1.80 (95%CI = 1.30–2.49, $p < 0.001$); with a moderate level of heterogeneity ($Q_{(1)} = 1.3$, $p = 0.26$; $I^2 = 39$) and no observed heterogeneity ($Q_{(1)} = 0.11$, $p = 0.74$; $I^2 = 0$), respectively. Nevertheless, no significant differences were found in the risk of being overweight (OR = 1.15; 95%CI = 0.80–1.63; $p = 0.46$), with a very low level of heterogeneity ($Q_{(1)} = 1.1$, $p = 0.31$; $I^2 = 5$).

Quality Rating of the Reviewed Studies

Table 2 provides the quality ratings of the reviewed studies based on STROBE's criteria (19). The fact that only three studies (19%) used a population-based sampling raises concerns about the representativeness of the other samples and, consequently, about the generalizability of their results (Table 2), thus supporting the importance of the quantitative review process conducted here. Additionally, information regarding sample characteristics was often lacking, especially concerning sex ratios (5/16 studies, 31%), ID levels (12/16 studies, 75%), and additional diagnoses (7/16 studies, 44%). The majority of the studies (75%) have measured height and weight directly. Only one study did not report subgroup analyses, but only four (25%) performed interaction analyses. Finally, only three studies did not report both frequency and percentage of overweight or obese children and adolescents with ID (Table 2).

Discussion

Prevalence Estimates of Overweight, Overweight-Obesity, and Obesity

The first objective of this meta-analysis was to determine the pooled prevalence estimates of overweight/obesity among children and adolescents with ID. Among children, the results revealed pooled prevalence estimates of overweight, overweight-obesity, and obesity of 15% (7%–25%), 30% (14%–45%), and 13% (6%–21%), respectively. These pooled prevalence estimates are higher than those found in previous studies of TD children (44,45). In addition, these findings show that the highest and lowest prevalence estimates of overweight/obesity were observed in studies from the USA (32) and South Korea (31), respectively. Interestingly, findings from a French study (30) show that children with ID were two times more likely to be overweight (22%) than obese (10%), whereas in an American study (33) the children with ID were three times more likely to be obese (21%) than overweight (7%). However, in Brazil (29) and South Korea (31) prevalence estimates were nearly similar for overweight and obesity.

Among adolescents, the results revealed pooled prevalence estimates of overweight, overweight-obesity, and obesity of 18% (13%–24%), 33% (15%–51%), and 15% (2%–28%), respectively. These pooled prevalence estimates are higher than those found among TD adolescents (46). Additionally, these findings show that (a) the highest prevalence estimates of overweight were observed in studies from Australia (34) and the USA (32), and of obesity in studies from the USA (32) and Turkey (37); (b) the lowest prevalence estimates of overweight were observed in studies from France (36) and South Korea (31), and of obesity in studies from France (30,36). The highest prevalence estimates of overweight-obesity and obesity (> 20%) were found in three studies from the USA (32,38,39). Finally, two French studies (30,36) show that adolescents with ID were nearly three (19% vs. 7%) to seven (13% vs. 2%) times more likely to be overweight than obese. Inversely, studies from the USA (32,38,39) show that adolescents with ID were slightly more likely to be obese (20%-28%) than overweight (16%-23%). However, similar rates of overweight and obesity were observed in Australia (34) and South Korea (31).

Moderators

The second objective of this meta-analysis was to examine whether the heterogeneity of overweight/obesity prevalence estimates across studies could be attributed to various moderators, including the participants' characteristics (i.e., sex, geographic region, recruitment setting, ID level, and additional diagnoses) or the assessment method (i.e., type of norms used to define overweight or obesity, body-height and body-weight measurement method).

Participants' characteristics. The findings suggest that the risk of overweight was higher in adolescents with ID living in North America than in Europe. Additionally, findings show that children and adolescents with ID living in North America were significantly more overweight-obese than those living in South America and in Europe. Finally, children and

adolescents with ID living in North America were significantly more obese than those living in Europe, South America and in the Western Pacific. This finding suggests that the North-American environment may expose youth with ID to be at greater risk for weight gain when compared to other geographic areas. These results are consistent with those from recent reviews (44-46) and cross-national studies (47,48) conducted among TD youth. However, our findings should be interpreted with caution. Indeed, even within regions, most of the participants were from the same country (e.g., USA, France). Consequently, future research examining the prevalence of overweight/obesity among youth with ID should focus on more regions, as well as countries within regions.

Surprisingly, subsequent analyses suggest that children with ID recruited via Special Olympics were significantly more obese than those recruited in special schools. Higher prevalence estimates of obesity were also observed in adolescents recruited via Special Olympics compared to special schools, or regular and special schools, but the difference was non-significant. This result might be related to the fact that athletes with ID attending Special Olympics may have been misclassified as obese by reporting increased muscular mass, associated to a higher BMI. Further studies are required to determine the actuals reasons of these counter-intuitive results.

Additional findings suggest that adolescents with Down syndrome were significantly more overweight-obese and obese than those without Down syndrome. This result is consistent with findings from previous reviews (4,10,11,13), and may be explained by Must et al.'s (13) observation that adolescents with Down syndrome have "lower fat-free mass (González-Agüero et al., 2011) and lower resting metabolic rates than typically developing children (Hill et al. 2013; Luke et al., 1996)" (p. 158). Additionally, according to Reinehr et al. (4, p. 270), adolescents with Down syndrome "have a predisposition to overeat, since the cerebral regions that are responsible for weight regulation (hypothalamus) may be damaged (van Mil et al., 2001; Luke et al., 1996)." Nevertheless, since only two studies (34,39) were included in this subgroup analysis, these differences should be interpreted with caution and require additional scientific attention. Finally, no significant variations were found in the pooled prevalence estimates for other characteristics of participants with ID, including sex and ID level.

Assessment methods. These findings show that the norms used to define obesity significantly influenced prevalence estimates among adolescents with ID. Indeed, findings show that studies relying on national norms provided significantly higher pooled prevalence estimates of obesity than those using the IOTF norms, which is consistent with data obtained in TD youth (49). It is thus important that future studies systematically provided prevalence estimates of overweight/obesity among youth with ID using both norms (national and IOTF) in order to enable international and national comparisons. Finally, no significant variations were found in the pooled prevalence estimates for assessment methods, including body-height and body-weight measurement method.

Comparison with TD peers

The last objective of this meta-analysis was to examine whether children and adolescents with ID were at greater risk of overweight/obesity than their TD peers. The findings show that the risk of being overweight was nearly identical between adolescents with ID and their TD counterparts. However, additional findings indicate that adolescents with ID were nearly two times more at risk of being overweight-obese and obese than their TD peers. This result is consistent with findings from previous reviews (11,13). It shows that obesity represents an important health threat for this population that deserves more attention from practitioners and policy makers. Nevertheless, since only two studies (38,39) from the USA were included in these

analyses, these differences should be interpreted with caution and require future research.

Limitations and Directions for Future Studies

Although informative, the findings from this systematic review and meta-analysis should be interpreted with caution given the limitations of the reviewed studies. First, the reviewed studies were conducted mostly in Europe, North America, and Western Pacific regions. Moreover, only a few considered participants' characteristics (e.g., sex, age, ID level, living arrangements) and additional diagnoses (e.g., autism spectrum disorder, Down syndrome, Fragile X, Prader-Willi syndrome, physical disabilities) in subgroup analyses. Therefore, the moderating role of these variables should be more thoroughly examined in future studies.

Second, as already illustrated in previous reviews (8-11,13), most of the risk factors commonly associated with overweight/obesity in the general population (e.g., dietary intake, physical activity, sedentary behavior, socioeconomic status) were insufficiently controlled in the reviewed studies. Consequently, the role of these factors could not be examined in the present meta-analysis and should be examined in future studies.

Third, only a few of the reviewed studies compared the risk of overweight/obesity between children and adolescents with ID and their TD peers, and more specifically while controlling for key participant characteristics, such as sex and age. Consequently, it is unknown whether boys and girls or early and late children or adolescents with ID are at greater risk of overweight/obesity than their TD peers. Clearly, this issue should be examined in future studies.

Fourth, all the reviewed studies (except 28,34,36, 37) recruited participants in a single setting, and all used only one criterion (i.e., national norms or IOTF) to define overweight or obesity. Consequently, the role of these potential moderators in the prevalence estimates of overweight and obesity should be more thoroughly investigated in future studies.

Fifth, none of the reviewed studies (except 32) relied on a longitudinal design, precluding examination of longitudinal trajectories of overweight or obesity prevalence among youth with ID. Consequently, it is still unknown (a) whether overweight or obesity prevalence is plateauing or increasing with time, and (b) whether trajectories of overweight or obesity prevalence could differ according to the participants' characteristics (e.g., sex, age, ID level, additional diagnoses). A longitudinal design study is needed to provide clear answers to these questions.

Finally, the reviewed studies were generally poorly described and lacking in details on key variables, such as sex ratio, age or ID level. Last but not least, as regards descriptive epidemiology, only three studies were population-based, designed using a national survey database and/or a random-sampling method (34,35,38). This raises serious concerns about the representativeness of most of the samples, and thus the value of the reported prevalence rates.

Conclusion

This meta-analysis highlights that a large proportion of children and adolescents with ID are overweight and obese, and that they are significantly more obese than their TD peers. Unfortunately, many potentially important determinants of overweight and obesity (e.g., sex, age, ID level, living arrangements, additional diagnoses, dietary intake, physical activity) are clearly understudied in this population and deserve further investigation. Additionally, such a high prevalence among children and adolescents with ID is worrisome and problematic given their known higher risk of developing secondary health problems (52). A key policy priority should thus be to develop and test specific age subgroups lifestyle intervention for tackling or managing this serious public health issue in this vulnerable population (for systematic reviews see 53,54).

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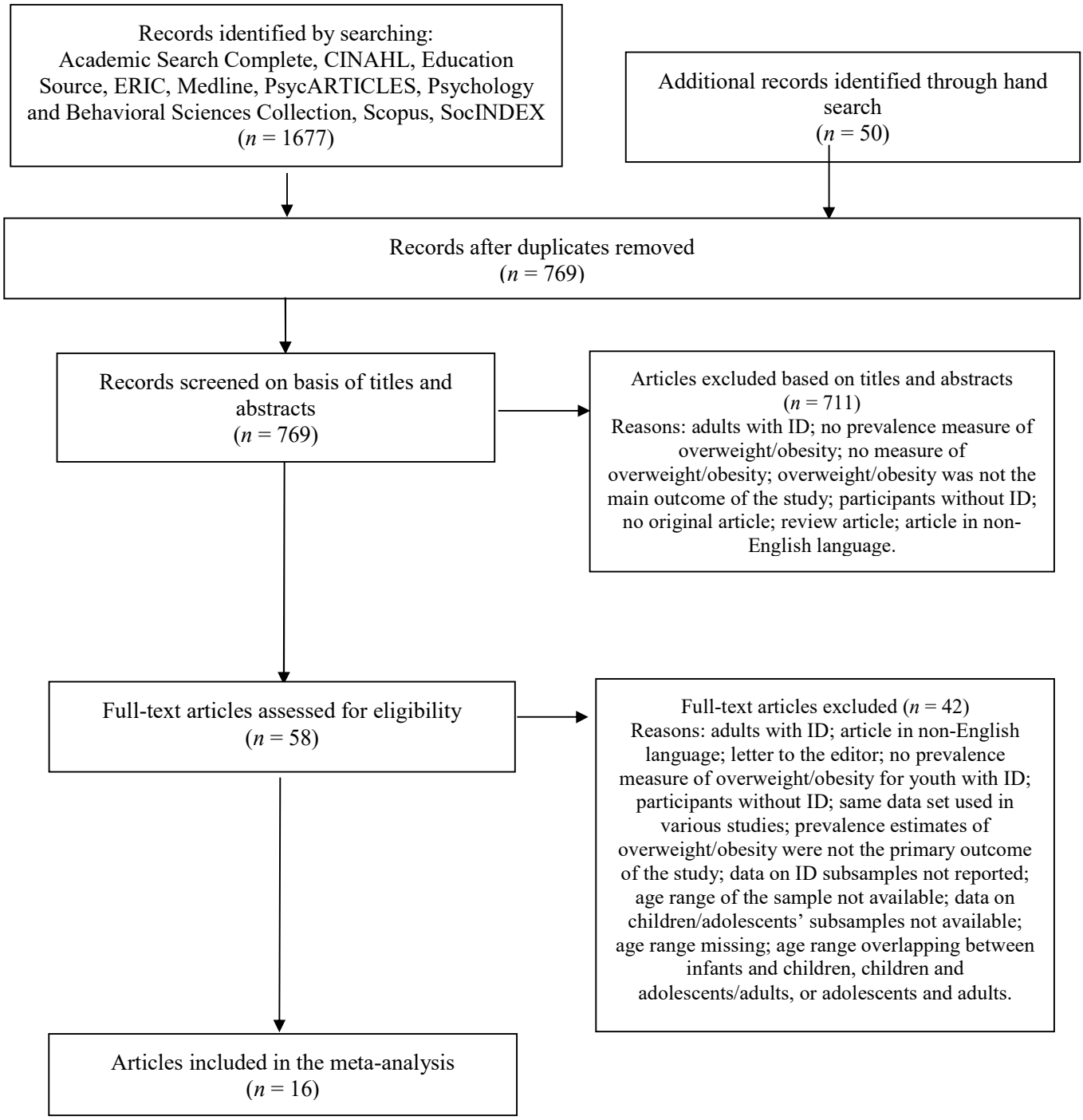
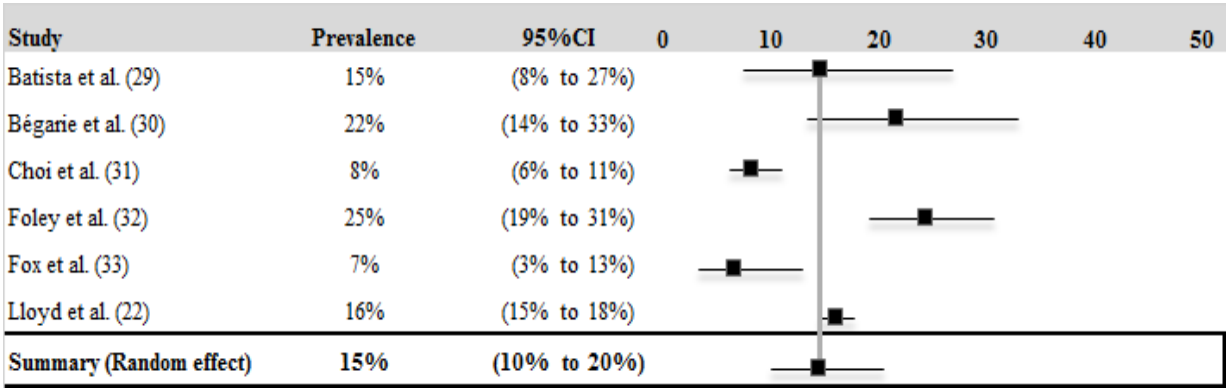


Figure 1. Results of Search Based on the PRISMA Statement (18)

(a)



(b)

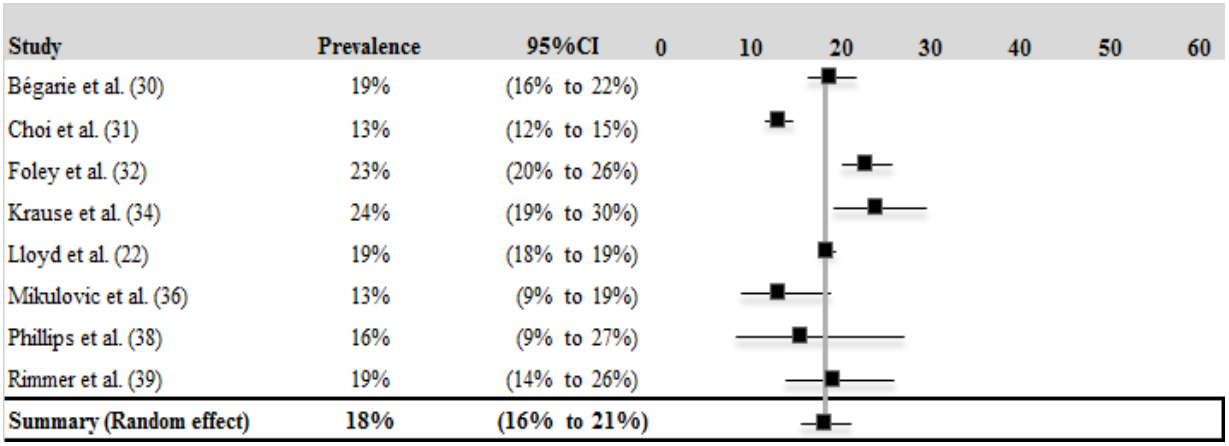
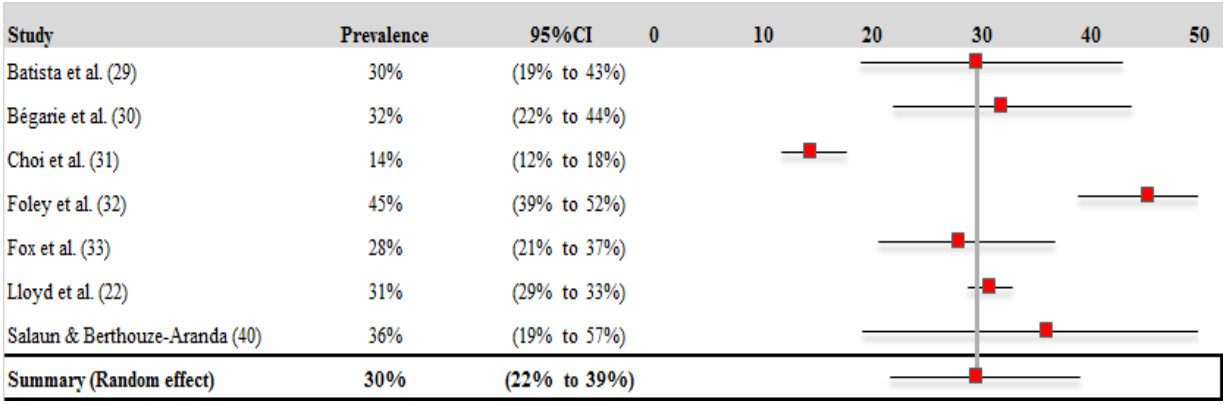


Figure 2. Forest Plot of Random-Effects Pooled Prevalence Estimates of *Overweight* among (a) Children and (b) Adolescents

(a)



(b)

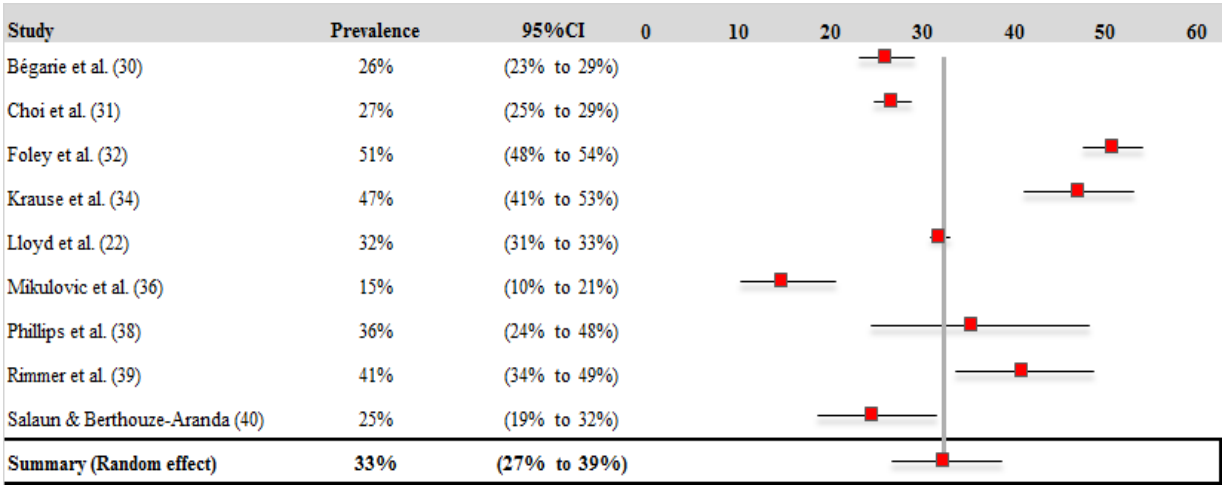
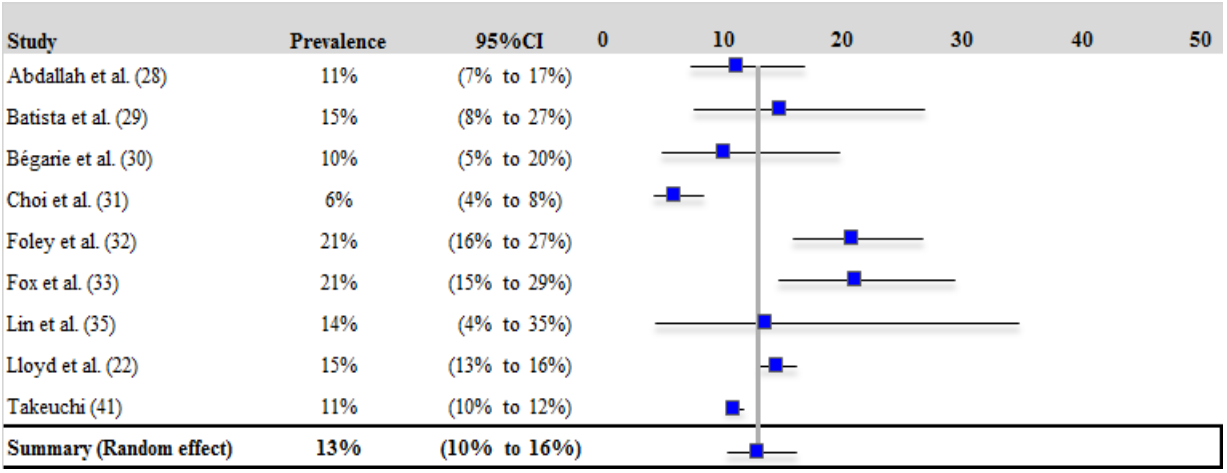


Figure 3. Forest Plot of Random-Effects Pooled Prevalence Estimates of *Overweight-Obesity* among (a) Children and (b) Adolescents

(a)



(b)

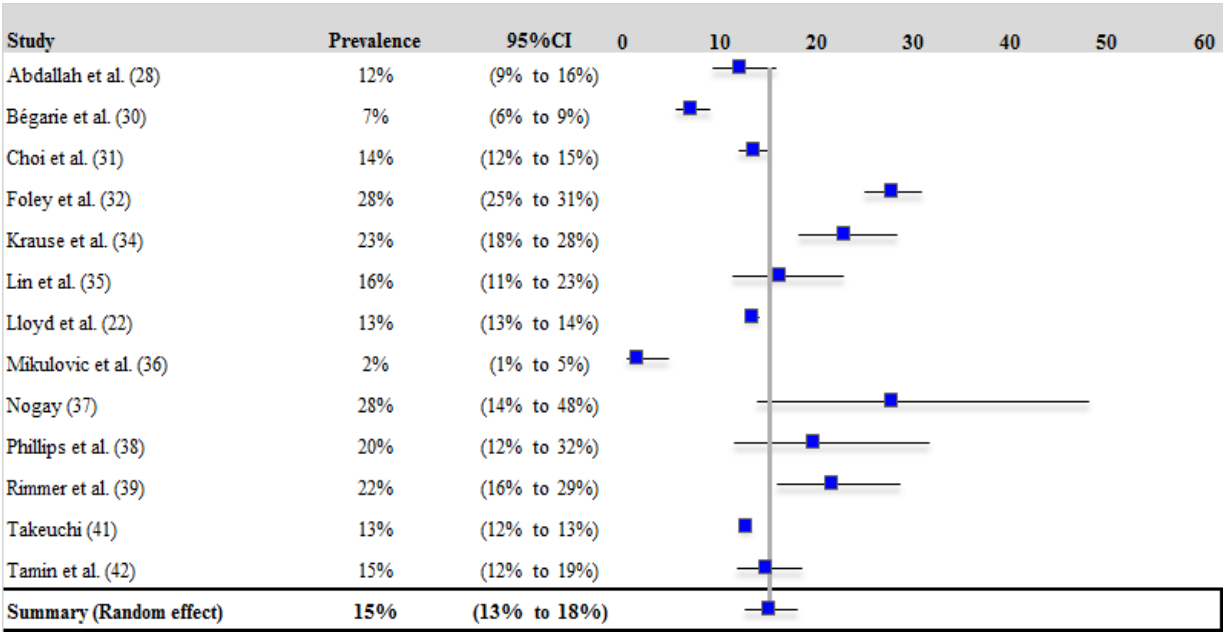


Figure 4. Forest Plot of Random-Effects Pooled Prevalence Estimates of *Obesity* among (a) Children and (b) Adolescents

Table 1

Main Characteristics of the Studies Included in the Meta-Analysis

Study	Country	Geographic Region	Design	Recruitment Setting	ID				TD		Measurement method	Norms used to define OW or OB	Outcome
					Sample size (*N*)	Sex (% of boys)	Age group (age range in years)	ID level	Yes-No	Sample size (*N*)			
Abdallah et al. (28)	Egypt	Eastern Mediterranean	CS	Regular and special schools	574	NA	Children (9-10) & Adolescents (11-14)	NA	O		Direct	NA	OB
Batista et al. (29)	Brazil	South America	CS	ID association	54	NA	Children (5-11)	NA	O		Direct	Non-national	OW, OW-OB, OB
Bégarie et al. (30)	France	Europe	CS	Special school	865	NA	Children (5-10) & Adolescents (11-18)	Mild to severe	O		Direct	IOTF	OW, OW-OB, OB
Choi et al. (31)	South Korea	Western Pacific	CS	Special school	2404	71	Children (7-10) & Adolescents (11-18)	NA	O		Direct	National	OW, OW-OB, OB
Foley et al. (32)	USA	North America	Cohort	Special Olympics	1122	61	Children (8-11) & Adolescents (12-18)	NA	O		Direct	National	OW, OW-OB, OB
Fox et al. (33)	USA	North America	CS	Regular school	118	53	Children (5.5-10.4)	Mild to profound	O		Direct	National	OW, OW-OB, OB
Krause et al. (34)	Australia	Western Pacific	CS	Regular and special schools	261	56	Adolescents (13-18)	NA	O		Direct	IOTF	OW, OW-OB, OB
Lin et al. (35)	Taiwan	Western Pacific	CS	National survey	187	64	Children (4-6) & Adolescents (13-18)	Mild to profound	O		Indirect	National	OB
Lloyd et al. (22)	Worldwide	North America, Africa-Eastern Mediterranean, South America, Europe, South-East Asia, Asia-Western Pacific	CS	Special Olympics	9678	63	Children (8-11) & Adolescents (12-18)	NA	O		Direct	IOTF	OW, OW-OB, OB
Mikulovic et al. (36)	France	Europe	CS	Regular and special schools	183	NA	Adolescents (11-14)	NA	O		Direct	IOTF	OW, OW-OB, OB
Nogay (37)	Turkey	Europe	CS	Regular and special schools	25	60	Adolescents (14-18)	Mild to severe	O		Direct	National	OB
Phillips et al. (38)	USA	North America	CC	National survey	60	59	Adolescents (12-17)	NA	●	8141	Indirect	National	OW, OW-OB, OB
Rimmer et al. (39)	USA	North America	CC	ID association	163	68	Adolescents (12-18)	NA	●	12973	Indirect	National	OW, OW-OB, OB
Salaun & Berthouze-Aranda (40)	France	Europe	CS	Special school	192	56	Children (6-11) & Adolescents (12-18)	Mild	O		Direct	IOTF	OW-OB
Takeuchi (41)	Japan	Western Pacific	CS	Special school	20031	65	Children (6-11) & Adolescents (12-17)	NA	O		Indirect	National	OB
Tamin et al. (42)	Indonesia	South-East Asia	CS	Special school	428	NA	Adolescents (14-16)	NA	O		Direct	NA	OB

Note. CC = case control; CS = cross-sectional; ID = intellectual disability; OB = obesity; OW = overweight; OW-OB = overweight including obesity; USA = United States of America; IOTF = International Obesity Task Force; ● = Yes; O = No; NA = not available; TD = typically developing.

Table 2

Quality Assessment of Studies

Study	Population bias			Outcome bias	Analysis bias		Data presentation bias
	Population-based	Main demographic characteristics reported	Additional diagnosis reported	Direct measurement of height and weight	Subgroup analyses reported	Interaction analyses reported	Frequency and prevalence of outcomes reported
Abdallah et al. (28)	○	○ (ID level)	○	●	● (age, SES, sex)	○	●
Batista et al. (29)	○	○ (sex, ID level)	○	●	● (age)	○	●
Bégarie et al. (30)	○	●	●	●	● (age, sex, comorbidity, ID level, etc.)	●	●
Choi et al. (31)	○	○ (ID level)	●	●	● (age, sex)	●	●
Foley et al. (32)	○	○ (sex, ID level)	○	●	● (age, sex)	○	○
Fox et al. (33)	○	●	●	●	● (age, sex, ID level, comorbidity, etc.)	●	●
Krause et al. (34)	●	○ (ID level)	●	●	● (age, sex, comorbidity, behaviour problems, mobility, medication, etc.)	●	●
Lin et al. (35)	●	○ (ID level)	●	○	● (age, sex)	○	●
Lloyd et al. (22)	○	○ (ID level)	○	●	● (age, sex)	○	○
Mikulovic et al. (36)	○	○ (ID level)	○	●	● (age, sex, school type)	○	○
Nogay (37)	○	●	○	●	● (age, sex)	○	●
Phillips et al. (38)	●	○ (sex, ID level)	●	○	○	○	●
Rimmer et al. (39)	○	○ (age, sex, ID level)	●	○	● (diagnosis)	○	●
Salaun & Berthouze-Aranda (40)	○	●	●	●	● (age, sex)	○	●
Takeuchi (41)	○	○ (ID level)	●	○	● (age, sex)	○	●
Tamin et al. (42)	○	○ (sex, ID level)	○	●	● (age)	○	●

Note. ● (reported characteristics) = Yes; ○ (missing characteristics) = No; ID = intellectual disability; SES = socioeconomic status

Online Supplemental Materials for:
Prevalence of Overweight and Obesity Among Children and Adolescents with Intellectual Disabilities: A Systematic Review and Meta-Analysis

This online supplement comprises nine sections including:

S1. References for Full-Text Articles Assessed for Eligibility but Excluded from the Meta-Analysis
Table S1. Subgroup Analyses of Prevalence Estimates of *Overweight* for Children and Adolescents
Table S2. Studies Included in the Subgroup Analyses of Prevalence Estimates of *Overweight* for Children and Adolescents
Table S3. Subgroup Analyses of Prevalence Estimates of *Overweight-Obesity* for Children and Adolescents
Table S4. Studies Included in the Subgroup Analyses of Prevalence Estimates of *Overweight-Obesity* for Children and Adolescents
Table S5. Subgroup Analyses of Prevalence Estimates of *Obesity* for Children and Adolescents
Table S6. Studies Included in the Subgroup Analyses of the Prevalence Estimates of *Obesity* for Children and Adolescents
Figure S1. Funnel Plot of Standard Error by Logit Event Rate of (a) Overweight, (b) Overweight-Obesity, and (c) Obesity among *Children*
Figure S2. Funnel Plot of Standard Error by Logit Event Rate of (a) Overweight, (b) Overweight-Obesity, and (c) Obesity among *Adolescents*

Section 1. References for Full-Text Articles Assessed for Eligibility but Excluded from the Meta-Analysis

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Table S1. Subgroup Analyses of Prevalence Estimates of *Overweight* for Children and Adolescents

Moderators	Samples	Subgroups	*N* studies	Random effects models		Tests for heterogeneity				Subgroup analyses - mixed effects		
				Prevalence	95%CI	*Q*	df	*p*	I^2 (%)	*Q*	df	*p*
Sex	Children	Boys	4	14%	(8% to 21%)	25	3	< 0.001	88	0.003	1	0.95
		Girls	4	14%	(8% to 22%)	15	3	0.002	79			
	Adolescents	Boys	4	18%	(14% to 22%)	34	3	< 0.001	91	0.9	1	0.36
		Girls	4	21%	(17% to 25%)	16	3	< 0.001	82			
Geographic region	Children	Europe	2	22%	(15% to 30%)	0	1	0.99	0	4.6	2	0.10
		North America	3	16%	(10% to 26%)	15	2	< 0.001	86			
		South America	2	14%	(12% to 17%)	0	1	0.94	0			
	Adolescents	Europe	3	17%	(15% to 20%)	4	2	0.16	45	12	2	< 0.001
		North America	4	22%	(21% to 24%)	3	3	0.45	0			
		Western Pacific	2	18%	(10% to 31%)	21	1	< 0.001	95			
Recruitment setting	Children	Special Olympics	2	20%	(13% to 29%)	10	1	< 0.001	90	0.6	1	0.45
		Special schools	2	13%	(5% to 31%)	11	1	< 0.001	91			
	Adolescents	Regular and special schools	2	18%	(10% to 32%)	8	1	< 0.001	87	1.6	2	0.45
		Special Olympics	2	21%	(17% to 25%)	10	1	< 0.001	90			
		Special schools	2	16%	(11% to 22%)	15	1	< 0.001	93			
ID Level	Children	-	-	-	- -	-	-	-	-	-	-	-
	Adolescents	-	-	-	- -	-	-	-	-	-	-	-
Norms used to define OW	Children	IOTF	2	17%	(14% to 21%)	1.5	1	0.22	32	0.7	1	0.40
		National	3	12%	(5% to 26%)	37	2	< 0.001	95			
	Adolescents	IOTF	4	19%	(17% to 22%)	9	3	0.03	66	0.1	1	0.71
		National	4	18%	(12% to 25%)	42	3	< 0.001	93			
Measurement of height and weight	Children	-	-	-	- -	-	-	-	-	-	-	-
	Adolescents	Direct	6	18%	(15% to 22%)	55	5	< 0.001	91	0.0004	1	0.98
		Indirect	2	18%	(14% to 24%)	0.4	1	0.54	0			
Additional diagnosis	Children	-	-	-	- -	-	-	-	-	-	-	-
	Adolescents	Down syndrome	2	27%	(19% to 37%)	1.3	1	0.26	21	1.9	1	0.17
		ID without Down syndrome	2	19%	(13% to 28%)	2	1	0.15	52			

Note. ID = intellectual disability; IOTF = International Obesity Task Force; OW = overweight.

Table S2. Studies Included in the Subgroup Analyses of Prevalence Estimates of *Overweight* for Children and Adolescents

Moderators	Samples	Subgroups	Studies
Sex	Children	Boys vs. Girls (n = 4)	Choi et al. (31); Foley et al. (32); Fox et al. (33); Lloyd et al. (22)
	Adolescents	Boys vs. Girls (n = 4)	Choi et al. (31); Foley et al. (32); Krause et al. (34); Lloyd et al. (22)
Geographic region	Children	Europe (n = 2)	Bégarie et al. (30); Lloyd et al. (22)
		North America (n = 3)	Foley et al. (32); Fox et al. (33); Lloyd et al. (22)
		South America (n = 2)	Batista et al. (29); Lloyd et al. (22)
	Adolescents	Europe (n = 3)	Bégarie et al. (30); Lloyd et al. (22); Mikulovic et al. (36)
		North America (n = 4)	Foley et al. (32); Lloyd et al. (22); Phillips et al. (38); Rimmer et al. (39)
		Western Pacific (n = 2)	Choi et al. (31); Krause et al. (34)
Recruitment setting	Children	Special Olympics (n = 2)	Foley et al. (32); Lloyd et al. (22)
		Special schools (n = 2)	Bégarie et al. (30); Choi et al. (31)
	Adolescents	Regular and special schools (n = 2)	Krause et al. (34); Mikulovic et al. (36)
		Special Olympics (n = 2)	Foley et al. (32); Lloyd et al. (22)
		Special schools (n = 2)	Bégarie et al. (30); Choi et al. (31)
ID level	Children	Not examined	Not examined
	Adolescents	Not examined	Not examined
Norms used to define OW	Children	IOTF (n = 2)	Bégarie et al. (30); Lloyd et al. (22)
		National (n = 3)	Choi et al. (31); Foley et al. (32); Fox et al. (33)
	Adolescents	IOTF (n = 4)	Bégarie et al. (30); Krause et al. (34); Lloyd et al. (22); Mikulovic et al. (36)
		National (n = 4)	Choi et al. (31); Foley et al. (32); Phillips et al. (38); Rimmer et al. (39)
Measurement of height and weight	Children	Not examined	Not examined
	Adolescents	Direct (n = 6)	Bégarie et al. (30); Choi et al. (31); Foley et al. (32); Krause et al. (34); Lloyd et al. (22); Mikulovic et al. (36)
		Indirect (n = 2)	Phillips et al. (38); Rimmer et al. (39)
Additional diagnosis	Children	No studies	No studies
	Adolescents	Down Syndrome (n = 2)	Krause et al. (34); Rimmer et al. (39)
		ID without Down syndrome (n = 2)	Krause et al. (34); Rimmer et al. (39)

Note. ID = intellectual disabilities; IOTF = International Obesity Task Force; OW = overweight

Table S3. Subgroup Analyses of Prevalence Estimates of *Overweight-Obesity* for Children and Adolescents

Moderators	Samples	Subgroups	*N* studies	Random effects models		Tests for heterogeneity				Subgroup analyses - mixed effects		
				Prevalence	95%CI	*Q*	df	*p*	I^2 (%)	*Q*	df	*p*
Sex	Children	Boys	5	29%	(19% to 41%)	55	4	< 0.001	93	0.005	1	0.95
		Girls	5	29%	(20% to 42%)	28	4	< 0.001	85			
	Adolescents	Boys	5	34%	(26% to 44%)	137	4	< 0.001	97	0.7	1	0.42
		Girls	5	39%	(32% to 47%)	51	4	< 0.001	92			
Geographic region	Children	Europe	3	32%	(25% to 40%)	0.3	2	0.87	0	13.7	2	0.001
		North America	3	39%	(31% to 48%)	10	2	0.01	81			
		South America	2	25%	(22% to 27%)	0.7	1	0.39	0			
	Adolescents	Europe	4	23%	(20% to 27%)	10	3	0.02	71	57.9	2	< 0.001
		North America	4	48%	(43% to 53%)	13	3	0.01	77			
		Western Pacific	2	36%	(19% to 58%)	44	1	< 0.001	98			
Recruitment setting	Children	Special Olympics	2	38%	(25% to 53%)	19	1	< 0.001	95	1.2	1	0.27
		Special schools	3	25%	(13% to 44%)	18	2	< 0.001	89			
	Adolescents	Regular and special schools	2	28%	(7% to 66%)	46	1	< 0.001	98	2.8	2	0.25
		Special Olympics	2	41%	(24% to 60%)	124	1	< 0.001	99			
		Special schools	3	27%	(25% to 28%)	0.4	2	0.80	0			
ID Level	Children	-	-	-	- -	-	-	-	-	-	-	-
	Adolescents	-	-	-	- -	-	-	-	-	-	-	-
Norms used to define OW-OB	Children	IOTF	3	31%	(29% to 33%)	0.3	2	0.86	0	0.1	1	0.76
		National	3	27%	(12% to 52%)	75	2	< 0.001	97			
	Adolescents	IOTF	5	28%	(22% to 36%)	65	4	< 0.001	94	1.4	1	0.24
		National	4	38%	(24% to 54%)	153	3	< 0.001	98			
Measurement of height and weight	Children	-	-	-	- -	-	-	-	-	-	-	-
	Adolescents	Direct	7	31%	(25% to 38%)	229	6	< 0.001	97	3.1	1	0.08
		Indirect	2	40%	(33% to 46%)	0.6	1	0.46	0			
Additional diagnosis	Children	-	-	-	- -	-	-	-	-	-	-	-
	Adolescents	Down syndrome	2	61%	(47% to 74%)	2	1	0.13	55	5.3	1	0.02
		ID without Down syndrome	2	35%	(22% to 52%)	6	1	0.01	84			

Note. ID = intellectual disability; IOTF = International Obesity Task Force; OW-OB = overweight-obesity.

Table S4. Studies Included in the Subgroup Analyses of Prevalence Estimates of *Overweight-Obesity* for Children and Adolescents

Moderators	Samples	Subgroups	Studies
Sex	Children	Boys vs. Girls (n = 5)	Choi et al. (31); Foley et al. (32); Fox et al. (33); Lloyd et al. (22); Salaun & Berthouze-Aranda (40)
	Adolescents	Boys vs. Girls (n = 5)	Choi et al. (31); Foley et al. (32); Krause et al. (34); Lloyd et al. (22); Salaun & Berthouze-Aranda (40)
Geographic region	Children	Europe (n = 3)	Bégarie et al. (30); Lloyd et al. (22); Salaun & Berthouze-Aranda (40)
		North America (n = 3)	Foley et al. (32); Fox et al. (33); Lloyd et al. (22)
		South America (n = 2)	Batista et al. (29); Lloyd et al. (22)
	Adolescents	Europe (n = 4)	Bégarie et al. (30); Lloyd et al. (22); Mikulovic et al. (36); Salaun & Berthouze-Aranda (40)
		North America (n = 4)	Foley et al. (32); Lloyd et al. (22); Phillips et al. (38); Rimmer et al. (39)
		Western Pacific (n = 2)	Choi et al. (31); Krause et al. (34)
Recruitment setting	Children	Special Olympics (n = 2)	Foley et al. (32); Lloyd et al. (22)
		Special schools (n = 3)	Bégarie et al. (30); Choi et al. (31); Salaun & Berthouze-Aranda (40)
	Adolescents	Regular and special schools (n = 2)	Krause et al. (34); Mikulovic et al. (36)
		Special Olympics (n = 2)	Foley et al. (32); Lloyd et al. (22)
		Special schools (n = 3)	Bégarie et al. (30); Choi et al. (31); Salaun & Berthouze-Aranda (40)
ID level	Children	Not examined	Not examined
	Adolescents	Not examined	Not examined
Norms used to define OW-OB	Children	IOTF (n = 3)	Bégarie et al. (30); Lloyd et al. (22); Salaun & Berthouze-Aranda (40)
		National (n = 3)	Choi et al. (31); Foley et al. (32); Fox et al. (33)
	Adolescents	IOTF (n = 5)	Bégarie et al. (30); Krause et al. (34); Lloyd et al. (22); Mikulovic et al. (36); Salaun & Berthouze-Aranda (40)
		National (n = 4)	Choi et al. (31); Foley et al. (32); Phillips et al. (38); Rimmer et al. (39)
Measurement of height and weight	Children	Not examined	Not examined
	Adolescents	Direct (n = 7)	Bégarie et al. (30); Choi et al. (31); Foley et al. (32); Krause et al. (34); Lloyd et al. (22); Mikulovic et al. (36); Salaun & Berthouze-Aranda (40)
		Indirect (n = 2)	Phillips et al. (38); Rimmer et al. (39)
Additional diagnosis	Children	No studies	No studies
	Adolescents	Down Syndrome (n = 2)	Krause et al. (34); Rimmer et al. (39)
		ID without Down syndrome (n = 2)	Krause et al. (34); Rimmer et al. (39)

Note. ID = intellectual disabilities; IOTF = International Obesity Task Force; OW = overweight

Table S5. Subgroup Analyses of Prevalence Estimates of *Obesity* for Children and Adolescents

Moderators	Samples	Subgroups	*N* studies	Random effects models		Tests for heterogeneity				Subgroup analyses - mixed effects		
				Prevalence	95%CI	*Q*	df	*p*	I^2 (%)	*Q*	df	*p*
Sex	Children	Boys	6	13%	(10% to 18%)	47	5	< 0.001	89	0.1	1	0.78
		Girls	6	14%	(11% to 18%)	17	5	< 0.001	71			
	Adolescents	Boys	6	16%	(12% to 21%)	131	5	< 0.001	96	1	1	0.31
		Girls	6	19%	(16% to 23%)	48	5	< 0.001	90			
Geographic region	Children	Europe	2	9%	(5% to 16%)	0.1	1	0.73	0	40.6	3	< 0.001
		North America	3	23%	(20% to 26%)	1.5	2	0.48	0			
		South America	2	11%	(8% to 14%)	1.3	1	0.26	23			
		Western Pacific	3	9%	(5% to 15%)	13	2	< 0.001	84			
	Adolescents	Europe	4	8%	(5% to 13%)	20	3	< 0.001	85	47.7	3	< 0.001
		North America	4	27%	(24% to 30%)	7	3	0.08	55			
		South East Asia	2	10%	(5% to 21%)	27	1	< 0.001	96			
		Western Pacific	4	16%	(13% to 19%)	24	3	< 0.001	87			
Recruitment setting	Children	Special Olympics	2	17%	(12% to 24%)	6	1	0.02	83	5.3	1	0.02
		Special schools	3	9%	(5% to 14%)	13	2	0.002	84			
	Adolescents	Regular and special schools	4	13%	(6% to 25%)	33	3	< 0.001	91	5.3	3	0.15
		National survey	2	17%	(13% to 23%)	0.4	1	0.55	0			
		Special Olympics	2	20%	(9% to 37%)	126	1	< 0.001	99			
		Special schools	4	12%	(10% to 14%)	25	3	< 0.001	88			
ID Level	Children	-	-	-	- -	-	-	-	-	-	-	-
	Adolescents	-	-	-	- -	-	-	-	-	-	-	-
Norms used to define OB	Children	IOTF	2	14%	(12% to 17%)	1.1	1	0.30	6	0.1	1	0.73
		National	5	13%	(9% to 20%)	45	4	< 0.001	91			
	Adolescents	IOTF	4	10%	(6% to 17%)	60	3	< 0.001	95	4.2	1	0.04
		National	7	19%	(14% to 25%)	165	6	< 0.001	96			
Measurement of height and weight	Children	Direct	7	13%	(10% to 18%)	42	6	< 0.001	86	1.3	1	0.26
		Indirect	2	11%	(10% to 12%)	0.2	1	0.70	0			
	Adolescents	Direct	9	14%	(11% to 19%)	200	8	< 0.001	96	0.6	1	0.43
		Indirect	4	17%	(12% to 23%)	15	3	< 0.001	80			
Additional diagnosis	Children	-	-	-	- -	-	-	-	-	-	-	-
	Adolescents	Down syndrome	2	33%	(25% to 42%)	0.3	1	0.61	0	6.1	1	0.01
		ID without Down syndrome	2	17%	(10% to 27%)	3	1	0.11	61			

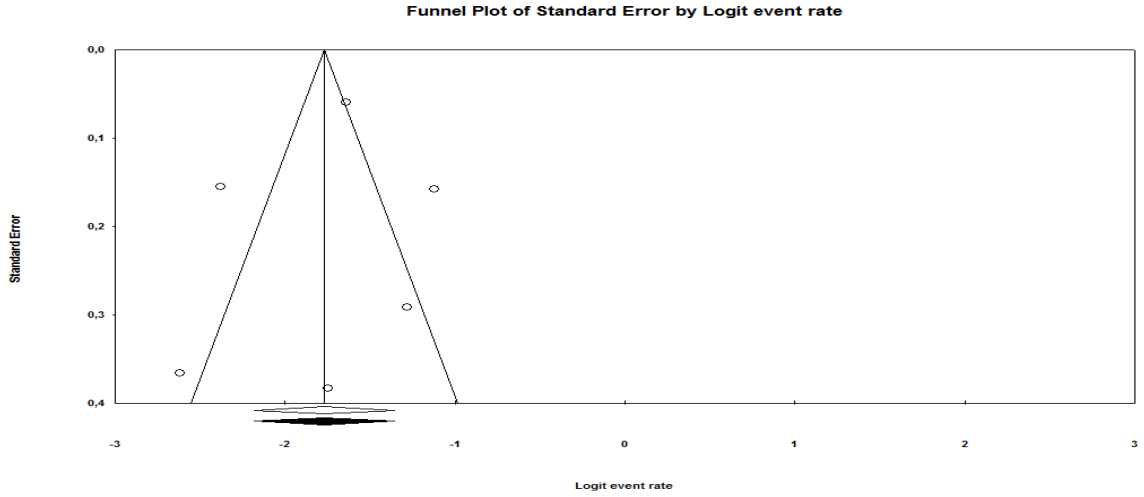
Note. ID = intellectual disability; IOTF = International Obesity Task Force; OB = obesity.

Table S6. Studies Included in the Subgroup Analyses of the Prevalence Estimates of *Obesity* for Children and Adolescents

Moderators	Samples	Subgroups	Studies
Sex	Children	Boys vs. Girls (n = 6)	Choi et al. (31); Foley et al. (32); Fox et al. (33); Lin et al. (35); Lloyd et al. (22); Takeuchi (41)
	Adolescents	Boys vs. Girls (n = 6)	Choi et al. (31); Foley et al. (32); Krause et al. (34); Lin et al. (35); Lloyd et al. (22); Takeuchi (41)
Geographic region	Children	Europe (n = 2)	Bégarie et al. (30); Lloyd et al. (22)
		North America (n = 3)	Foley et al. (32); Fox et al. (33); Lloyd et al. (22)
		South America (n = 2)	Batista et al. (29); Lloyd et al. (22)
		Western Pacific (n = 3)	Choi et al. (31); Lin et al. (35); Takeuchi (41)
	Adolescents	Europe (n = 4)	Bégarie et al. (30); Lloyd et al. (22); Mikulovic et al. (36); Nogay (37)
		North America (n = 4)	Foley et al. (32); Lloyd et al. (22); Phillips et al. (38); Rimmer et al. (39)
		South East Asia (n = 2)	Lloyd et al. (22); Tamin et al. (42)
		Western Pacific (n = 4)	Choi et al. (31); Krause et al. (34); Lin et al. (35); Takeuchi (41)
Recruitment setting	Children	Special Olympics (n = 2)	Foley et al. (32); Lloyd et al. (22)
		Special schools (n = 3)	Bégarie et al. (30); Choi et al. (31); Takeuchi (41)
	Adolescents	Regular and special schools (n = 4)	Abdallah et al. (28); Krause et al. (34); Mikulovic et al. (36); Nogay (37)
		National survey (n = 2)	Lin et al. (35); Phillips et al. (38)
		Special Olympics (n = 2)	Foley et al. (32); Lloyd et al. (22)
		Special schools (n = 4)	Bégarie et al. (30); Choi et al. (31); Takeuchi (41); Tamin et al. (42)
ID level	Children	Not examined	Not examined
	Adolescents	Not examined	Not examined
Norms used to define OB	Children	IOTF (n = 2)	Bégarie et al. (30); Lloyd et al. (22)
		National (n = 5)	Choi et al. (31); Foley et al. (32); Fox et al. (33); Lin et al. (35); Takeuchi (41)
	Adolescents	IOTF (n = 4)	Bégarie et al. (30); Krause et al. (34); Lloyd et al. (22); Mikulovic et al. (36)
		National (n = 7)	Choi et al. (31); Foley et al. (32); Lin et al. (35); Nogay (37); Phillips et al. (38); Rimmer et al. (39); Takeuchi (41)
Measurement of height and weight	Children	Direct (n = 7)	Abdallah et al. (28); Batista et al. (29); Bégarie et al. (30); Choi et al. (31); Foley et al. (32); Fox et al. (33); Lloyd et al. (22)
		Indirect (n = 2)	Lin et al. (35); Takeuchi (41)
	Adolescents	Direct (n = 9)	Abdallah et al. (28); Bégarie et al. (30); Choi et al. (31); Foley et al. (32); Krause et al. (34); Lloyd et al. (22); Mikulovic et al. (36); Nogay (37); Tamin et al. (42)
		Indirect (n = 4)	Lin et al. (35); Phillips et al. (38); Rimmer et al. (39); Takeuchi (41)
Additional diagnosis	Children	Not examined	Not examined
	Adolescents	Down Syndrome (n = 2)	Krause et al. (34); Rimmer et al. (39)
		ID without Down syndrome (n = 2)	Krause et al. (34); Rimmer et al. (39)

Note. ID = intellectual disabilities; IOTF = International Obesity Task Force; OW = overweight

(a)



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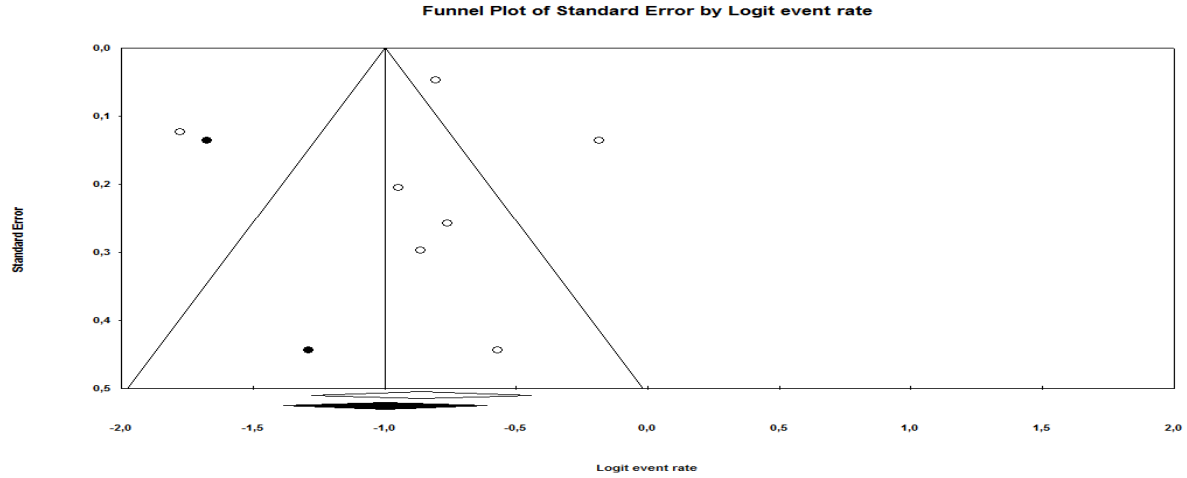

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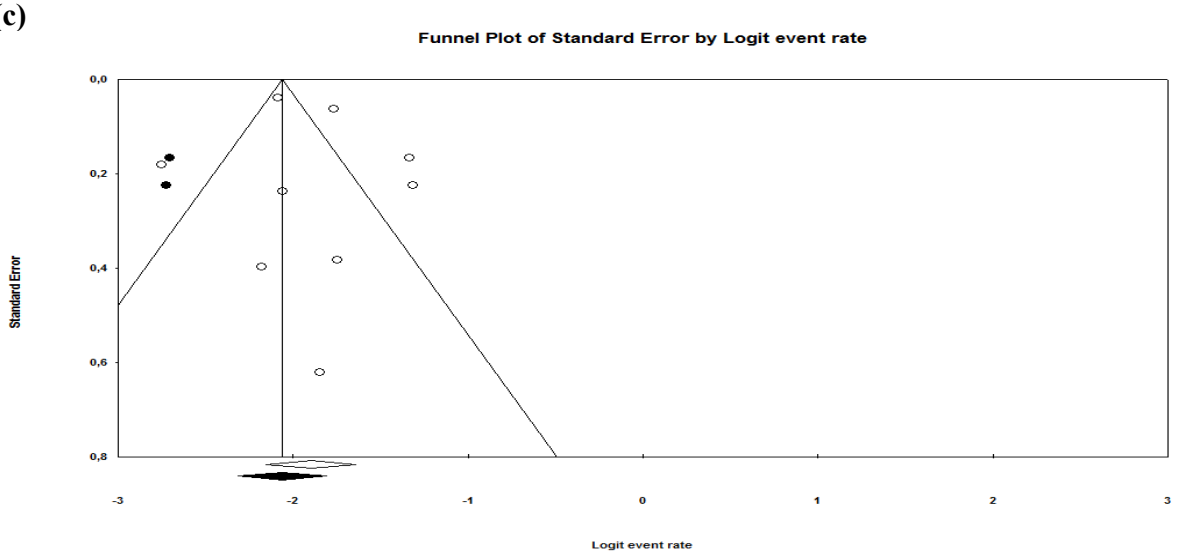
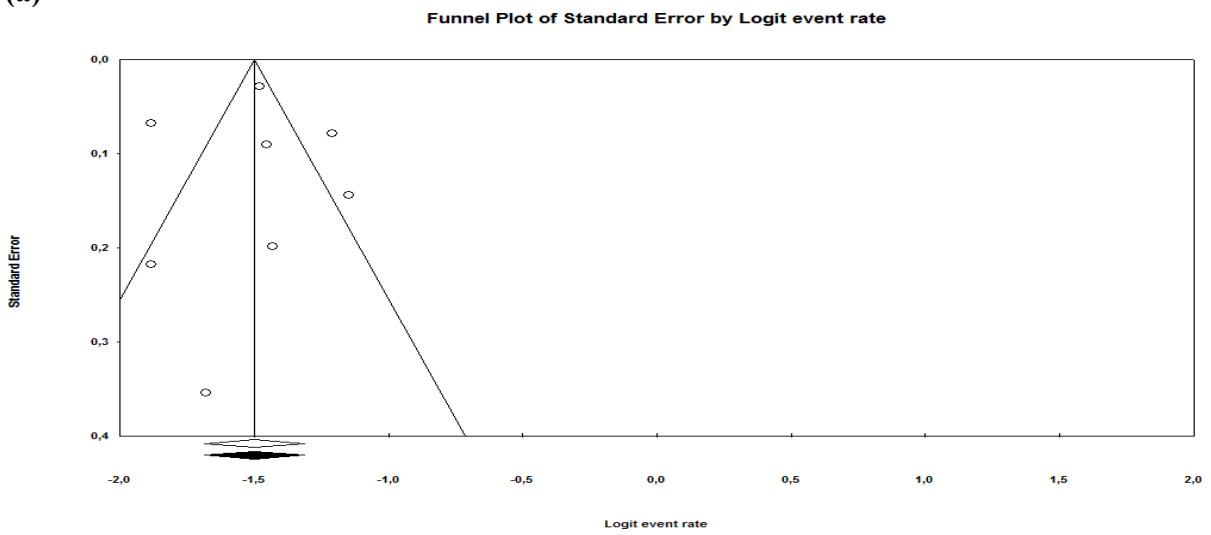


Figure S1. Funnel Plot of Standard Error by Logit Event Rate of (a) Overweight, (b) Overweight-Obesity, and (c) Obesity among *Children*

(a)



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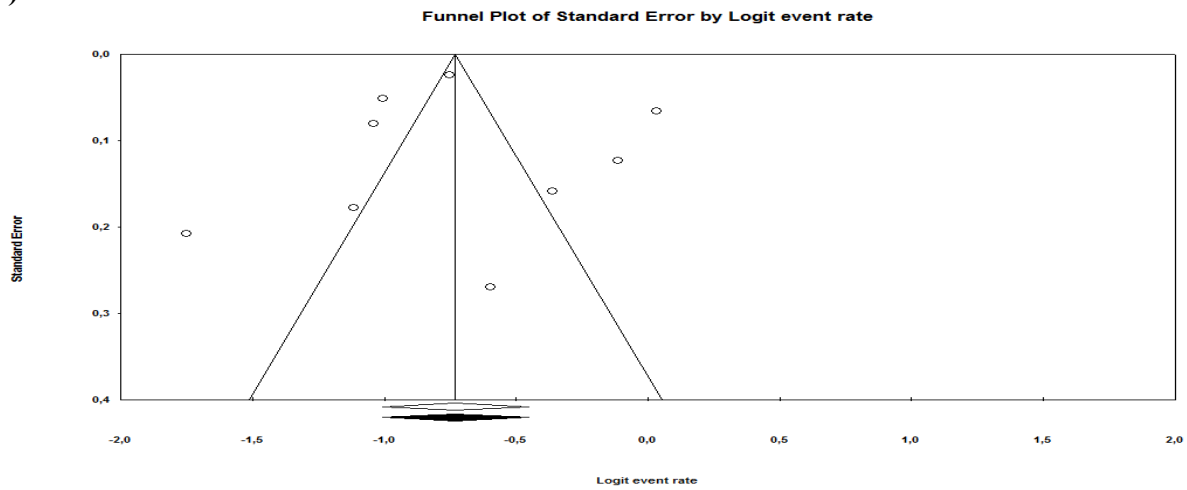

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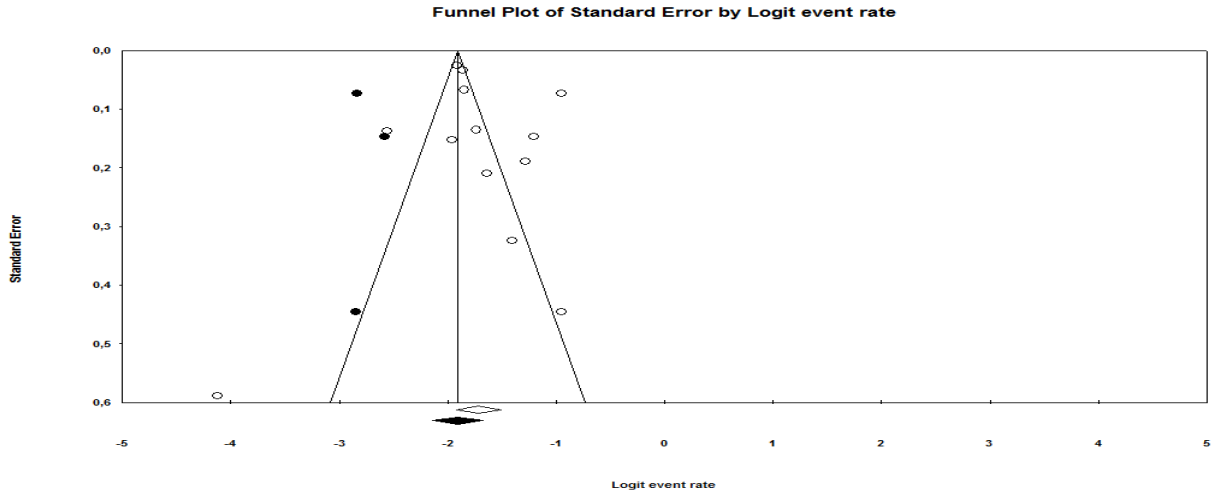

Figure S2. Funnel Plot of Standard Error by Logit Event Rate of (a) Overweight, (b) Overweight-Obesity, and (c) Obesity among *Adolescents*