A meta-analysis of children’s self-reports of dietary intake

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To cite this article: Brittany Merson, Kathy Pezdek & Karen Saywitz (2017) A meta-analysis of children’s self-reports of dietary intake, Psychology & Health, 32:2, 186-203, DOI: 10.1080/08870446.2016.1250274

To link to this article: http://dx.doi.org/10.1080/08870446.2016.1250274

Published online: 02 Nov 2016.

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A meta-analysis of children’s self-reports of dietary intake
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(Received 24 April 2016; accepted 14 October 2016)

Objective: Although research studies increasingly use children as primary reporters in dietary assessments, it is unclear how well children’s self-reported intake correlates with independently validated reports of their intake; this meta-analysis assesses that correlation.

Design: Moderators of the correlation between self-reported and independently validated intake were predicted \textit{a priori}: type of dietary intake assessment (24 h recall, food diary and food frequency questionnaires), validation measures, parental assistance and age. Online databases were searched for articles published from 1990 to 2014 that compared children’s self-reports of dietary intake to validated observations of food intake in children age 4–16.

Main outcome measures: Summary effect size Pearson $r$ between children’s self-reported dietary intake and independently validated dietary intake were calculated.

Results: In $k = 32$ samples from 23 studies, a statistically significant correlation ($r = .48$, $Z = 7.26$, $p < .001$) was found between children’s self-reported dietary intake and independently validated reports of dietary intake. Validation method ($Q = 17.49$, df $= 2$, $p < .001$) and parental assistance ($Z = 2.03$, $p = .042$) were significant moderators of this correlation. Self-report methodology ($Q = 3.95$, df $= 2$, $p = .139$) and age ($Q = .02$, $p = .879$) were not significant moderators of the distribution of effect sizes.

Conclusion: Together, these results provide baseline information about children’s recall in dietary intake assessments conducted with children as primary reporters.

Keywords: meta-analysis; dietary intake; children; self-reports; validation studies

Dietary intake behaviours directly impact children’s current health and influence future health outcomes such as chronic disease status and weight status (Joint WHO/FAO Expert Consultation, 2003; Strong, Mathers, Leeder, & Beaglehole, 2005). Many interventions are created each year to improve children’s dietary intake, but the efficacy of these interventions needs to be examined systematically to ensure that resources are allocated to the most useful interventions (Hoelscher, Kirk, Ritchie, & Cunningham-Sabo, 2013). Accurate information regarding the ways in which children’s self-reports of dietary intake differ from externally validated reports of dietary intake would enable researchers to better understand the validity of data in their interventions and ensure that

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consequent research and policy recommendations are effective. This meta-analysis examines the correlation between self-reports and independent reports of dietary intake in dietary validation studies with children as the primary reporters.

Although many past studies depended on reports from adult informants to estimate children’s dietary intake, researchers are now more likely to design studies that collect information directly from children (Docherty & Sandelowski, 1999). This methodological shift is due to a change in beliefs about children’s abilities to report their own behaviours, and the recognition that children can provide information about their behaviour that may be inaccessible to adults (Clavering & McLaughlin, 2010; Docherty & Sandelowski, 1999). However, there is reason to be cautious when translating self-report techniques developed for adults to work with children. Although research examining the cognitive processes involved in recall of dietary intake has improved the validity of dietary assessment interviews in adult populations (Krall, Dwyer, & Coleman, 1988; Smith, 1991), evidence from applied research domains indicates that interview techniques that work well with adults are not always effective with children (Blandon-Gitlin & Pezdek, 2009; Saywitz, Camparo, & Romanoff, 2010). Children and adults have numerous cognitive developmental differences that likely affect the accuracy of both self-reported dietary intake and the efficacy of these methodologies for obtaining self-reports of dietary intake. These cognitive differences include basic memory, language and social skills (Farrar & Goodman, 1992; Hudson & Nelson, 1986; Rumelhart & Ortoney, 1977), as well as differences in representations of meals that are essential to accurate memory of dietary intake (Baranowski & Domel, 1994).

Despite the many cognitive differences between children and adults that may affect memory and reporting of dietary intake, similar self-report methodologies are used for assessing food intake in both children and adults. These self-report methodologies often belong to one of three general categories: structured food recall interviews, food diaries and food frequency questionnaires (FFQs). Structured food recall interviews require recall of specific food intake in a specified reference period, often the 24 h prior to the interview or the previous day (Collins, Watson, & Burrows, 2010; Thompson, Subar, Loria, Reedy, & Baranowski, 2010). Multiple types of 24 h recall interviews have been developed to address problems with reporting dietary intake, especially underreporting (Bliss, 2004; Conway, Ingwersen, Vinyard, & Moshfegh, 2003; Steinfeldt, Anand, & Murayi, 2013; Tran, Johnson, Soutlanakis, & Matthews, 2000; University of Minnesota, 2014). Food diaries require respondents to recall and record dietary intake in a specified reference period (Thompson et al., 2010). Food diaries include both qualitative and quantitative information about dietary intake. However, food diaries are vulnerable to social reactivity and under-reporting (Collins et al., 2010; Thompson et al., 2010). FFQs require respondents to use a close-ended response format to indicate the number of times they consumed a listed food in a specified reference period. This reference period is often long (Thompson et al., 2010). FFQs are relatively easy to administer, but are often formatted such that children can find them burdensome to complete as correct responses depend on memory for patterns of food intake over an extended time period. Furthermore, FFQs may provide less detailed information to researchers and can be difficult to analyse (Collins et al., 2010). Overall, food recall interviews, food diaries and FFQs offer distinct advantages and disadvantages. Furthermore, because these three
self-report methodologies have distinct response formats, they require different cognitive skills to complete correctly.

Of these three self-report methodologies that measure dietary intake, 24 h food recall interviews are the most commonly used for both children and adults (Baxter et al., 2009). Systematic reviews focusing on interviewing children have reported that the format of the interview used limits the accuracy and content of self-reports of dietary intake (Johnson, Driscoll, & Goran, 1996; Livingstone & Robson, 2000; McPherson, Hoelscher, Alexander, Scanlon, & Serdula, 2000). A recent systematic review (Sharman, Skouteris, Powell, & Watson, 2016) examined the accuracy of children’s self-reported dietary intake using studies that reported correspondence, intrusion, and omission rate in dietary recall interviews. After examining interview conditions, interview techniques, environmental factors and person level variables, they concluded that (a) a longer retention interval between food intake and the interview and (b) more meals included in the interview had the largest negative impact children’s self-report accuracy.

Although Sharman et al.’s extensive systematic review (2016) focusing on dietary intake interviews contributes important information that can improve dietary intake data from children, it does not provide a standardised effect size measure of the magnitude and direction of misreporting in children’s self-reports of dietary intake. Other systematic reviews examining the difference between children’s self-reported intake in interviews, food diaries, and FFQs have also used children’s under-reporting or over-reporting to summarise smaller sets of dietary intake studies (Burrows, Martin, & Collins, 2010; Livingstone & Robson, 2000; McPherson et al., 2000). Establishing a standardised effect size measure of the relationship between children’s self-reported intake and independent validation would (a) provide researchers with a quantitative measure of the strength of the relationship that could be easily compared between studies and (b) ensure clear communication of this relationship to researchers in multiple subject areas (Hedges, 2008).

The current study

This meta-analysis assessed the correlation between children’s self-reports of dietary intake and independently validated measures of their dietary intake. Using the meta-analytic approach suggested by Rosenthal (1995) and Borenstein, Hedges, Higgins, and Rothstein (2009), Pearson r correlation was used as the effect size measure between dietary intake reported by children and dietary intake measured by independently validated observations. Moderator analyses were conducted for four methodological and demographic moderators predicted a priori: self-report method, validation method, parental assistance and age. Self-report method was selected as a moderator of interest due to the differences in cognitive skills required to report an accurate account of dietary intake for each methodology. Validation measure was selected as a moderator due to differences in data collection errors inherent in each measure. Parental assistance was measured as a moderator based on multiple reports of changes in children’s reporting when parents are present. Age was used as a moderator based on cognitive differences associated with the capacity to convey accurate reports of behaviour that are present between age groups. Finally, agreement statistics were conducted for type of dietary variable reported.
Method

Sources

Literature searches were conducted in 2014 using broad search terms (‘children’ and ‘questioning’) on multiple electronic databases, including PsycInfo, JStor and Google scholar. These databases and the Dietary Assessment Calibration/Validation (DACV) Register (National Cancer Institute, 2013) were also searched using more specific search terms (‘children’, ‘adolescents’, ‘diet’, ‘food’, ‘recall’, ‘observation’, ‘record’ and ‘validation’). Hand searches were also conducted and authors were contacted if a study was not available online.

![Flow chart of literature search and article selection for meta-analysis of children’s self-reports of eating behaviour compared with independent validation methodology.](image)

Figure 1. Flow chart of literature search and article selection for meta-analysis of children’s self-reports of eating behaviour compared with independent validation methodology.
**Study selection**

Studies were examined using the inclusion criteria outlined in Figure 1. At Step 1, an initial set of 4152 articles included articles that contained the search terms in either the abstract or the article body. Articles included in this meta-analysis were published dietary validation studies with school-aged children (4–16 years old) from the US and other countries in which children’s self-reported dietary intake was compared to an independent validation measure of intake. All studies reported either the Pearson correlation between the self-report and the validation measure or statistics that could be converted to calculate the effect size.

Studies were included in this meta-analysis if they were conducted using self-report methodologies, included at least one independent validation methodology, and children acted as the primary reporter of their own dietary intake. Self-report methodologies included (a) 24 h recall interviews, (b) food diaries and (c) FFQs. Independent validation methodologies included (a) direct observations of food intake measured by trained researchers, (b) weighed plate studies and (c) biological markers of dietary intake (biomarkers). We reported only one self-report/validation comparison for each sample of children. If multiple self-report and validation methodologies were compared in separate samples of children within a study, we reported both comparisons. If a sample of children in a study completed multiple types of self-reports or if their intake was validated with multiple validation methodologies, the methodology selected for inclusion in the meta-analysis was chosen if it was (a) more similar to validated measures published in research studies and (b) more independent of parental input.

At Step 2, initial studies selected for inclusion were coded to determine whether they met all inclusion criteria. Statistical information needed to calculate Pearson r, such as descriptive statistics, paired t-tests, or simple F-tests were coded for each study. These data, as well as sample size (n) for each study were recorded. A total of 25 articles eligible for the meta-analysis at the abstract screening step were screened out at Step 3 either because exclusion criteria were reported in the article body or the data collected did not meet statistical requirements to be analysed using Pearson r. Studies excluded based on their statistical reporting included four articles reporting Spearman’s $r$ (unweighted average Spearman’s $r = .54$) and articles reporting percent matches, percent intrusions and percent omissions.

The Pearson correlation coefficient $r$ between self-reported intake and independent validation was recorded directly from studies that reported the statistic. If alternate statistical test data or descriptive data (mean, standard deviation and sample size) were reported, the Pearson $r$ was calculated and reported in Table 1. Further information about each study including self-report methodology and independent validation methodology used was also included in Table 1.

**Results**

The total sample for the meta-analysis included 23 articles with 33 different samples ($N = 2232$ children). Pearson $r$ correlation coefficients were either recorded from the article or calculated from the statistical test results reported in the articles that did not report an effect size (Borenstein et al., 2009). Fisher’s $Zr$ correction was applied to all correlation coefficients for statistical calculations, and the final reported effect size was
Table 1. Summary data for studies that examined the correlation between children’s self-reported intake and independently validated intake.

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Self-report methodology</th>
<th>Parental assistance</th>
<th>Target period</th>
<th>Validation methodology</th>
<th>Age</th>
<th>Observation location</th>
<th>Sample size (n)</th>
<th>Self-reported intake</th>
<th>Independently validated intake</th>
<th>Difference (Self-reported intake - validated intake)</th>
<th>( r )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>24 h recall interviews</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reynolds et al. (1990)</td>
<td>Cued recall, temporal order</td>
<td>No</td>
<td>Previous day</td>
<td>Observed intake</td>
<td>7–8</td>
<td>Summer camp</td>
<td>18</td>
<td>2336 kcal</td>
<td>2979 kcal</td>
<td>-643 kcal</td>
<td>.66**</td>
</tr>
<tr>
<td>Lytle et al. (1993)</td>
<td>24-hour recall</td>
<td>No</td>
<td>Previous day</td>
<td>Observed intake</td>
<td>Third grade</td>
<td>School, home</td>
<td>49</td>
<td>1822.5 kcal</td>
<td>1649.8 kcal</td>
<td>172.7 kcal</td>
<td>.59**</td>
</tr>
<tr>
<td>Johnson et al. (1996)</td>
<td>USDA based 3 pass MPR</td>
<td>Yes</td>
<td>Previous 24 h</td>
<td>Biomarkers (TEE)</td>
<td>4–7</td>
<td></td>
<td>24</td>
<td>1553 kcal</td>
<td>1607 kcal</td>
<td>-54 kcal</td>
<td>.25</td>
</tr>
<tr>
<td>Wyon et al. (1997)</td>
<td>24 h MPR, on telephone</td>
<td>No</td>
<td>Same day breakfast</td>
<td>Weighed plate</td>
<td>M = 10</td>
<td>N/A</td>
<td>166</td>
<td>315.2 kcal</td>
<td>N/A</td>
<td>-</td>
<td>.89**</td>
</tr>
<tr>
<td>Lytle et al. (1998)</td>
<td>NDS_R based, Diary assisted</td>
<td>No</td>
<td>Next day</td>
<td>Observed intake</td>
<td>Fourth Grade</td>
<td>School lunch</td>
<td>78</td>
<td>58 kcal</td>
<td>N/A</td>
<td>-124.6 kcal</td>
<td>.41**</td>
</tr>
<tr>
<td><strong>NDS_R based, Diary assisted multiple 24-hour recall interviews</strong></td>
<td></td>
<td>No</td>
<td>Previous 24 h</td>
<td>Observed intake</td>
<td>Biomarkers</td>
<td>6.5–11.5</td>
<td>M = 9.5</td>
<td>30</td>
<td>N/A</td>
<td>.04 KJ</td>
<td>.32</td>
</tr>
<tr>
<td>Baranowski et al. (2002)</td>
<td>In person, NDS_R based</td>
<td>No</td>
<td>Previous 24 h</td>
<td>Observed intake</td>
<td>Observed intake</td>
<td>8–10</td>
<td>M = 9.6</td>
<td>138</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>Weber et al. (2004)</td>
<td>NDS_R, diet-record assisted</td>
<td>No</td>
<td>Previous 24 h</td>
<td>Observed intake</td>
<td>Observed intake</td>
<td>M = 10</td>
<td>School lunch</td>
<td>62</td>
<td>5.26 items</td>
<td>7.81 items</td>
<td>-2.55 items</td>
</tr>
<tr>
<td>Baxter et al. (2009)</td>
<td>NDS_R based</td>
<td>No</td>
<td>Prior 24 h morning</td>
<td>Observed intake</td>
<td></td>
<td>School</td>
<td>62</td>
<td>6.05 items</td>
<td>7.98 items</td>
<td>-1.93 items</td>
<td>.59**</td>
</tr>
<tr>
<td>NDS_R based</td>
<td>No</td>
<td>Prior 24 h afternoon</td>
<td>Observed intake</td>
<td></td>
<td>School</td>
<td>62</td>
<td>6.40 items</td>
<td>7.82 items</td>
<td>-1.42 items</td>
<td>.18</td>
<td></td>
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<tr>
<td>NDS_R based</td>
<td>No</td>
<td>Prior 24 h evening</td>
<td>Observed intake</td>
<td></td>
<td>School</td>
<td>62</td>
<td>5.65 items</td>
<td>8.03 items</td>
<td>-2.38 items</td>
<td>.39**</td>
<td></td>
</tr>
<tr>
<td>NDS_R based</td>
<td>No</td>
<td>Previous day morning</td>
<td>Observed intake</td>
<td></td>
<td>School</td>
<td>62</td>
<td>5.48 items</td>
<td>7.56 items</td>
<td>-2.08 items</td>
<td>.29*</td>
<td></td>
</tr>
<tr>
<td>NDS_R based</td>
<td>No</td>
<td>Previous day afternoon</td>
<td>Observed intake</td>
<td></td>
<td>School</td>
<td>64</td>
<td>6.48 items</td>
<td>7.66 items</td>
<td>-1.18 items</td>
<td>.36**</td>
<td></td>
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</table>

(Continued)
<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Self-report methodology</th>
<th>Parental assistance</th>
<th>Target period</th>
<th>Validation methodology</th>
<th>Age</th>
<th>Observation location</th>
<th>Sample size (n)</th>
<th>Self-reported intake</th>
<th>Independently validated intake</th>
<th>Difference (Self-reported intake - validated intake)</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bokhof et al. (2011)</td>
<td>In person, computer assisted (EPIC-SOFT)</td>
<td>No</td>
<td>Previous day</td>
<td>Biomarkers (urine sample)</td>
<td>43</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.30*</td>
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<td>Rothausen et al. (2012)</td>
<td>In person, computer assisted (EPIC-SOFT)</td>
<td>No</td>
<td>Previous day</td>
<td>Biomarkers (Acti Reg TEE)</td>
<td>67</td>
<td>900 KJ</td>
<td>870 KJ</td>
<td>30 KJ</td>
<td></td>
<td></td>
<td>.29**</td>
</tr>
<tr>
<td>Vandevijvere et al. (2013)</td>
<td>HELENA-Dietary Assessment tool</td>
<td>No</td>
<td>Same day</td>
<td>Biomarkers</td>
<td>64</td>
<td>990 KJ</td>
<td>1100 KJ</td>
<td>-110 KJ</td>
<td></td>
<td></td>
<td>.51**</td>
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<tr>
<td></td>
<td>HELENA-Dietary Assessment tool</td>
<td>No</td>
<td>Same day</td>
<td>Biomarkers</td>
<td>163</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.09</td>
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<tr>
<td>Hunsberger et al. (2013)</td>
<td>Computer based, original protocol (SACINA)</td>
<td>No</td>
<td>21–24 h after intake</td>
<td>Weighed plate</td>
<td>25</td>
<td>320 g</td>
<td>313 g</td>
<td>7 g</td>
<td></td>
<td></td>
<td>.92**</td>
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<tr>
<td>Dome et al. (1994)</td>
<td>daily</td>
<td>No</td>
<td>Observed intake</td>
<td>Food diaries</td>
<td>10–11</td>
<td>School</td>
<td>67</td>
<td></td>
<td></td>
<td></td>
<td>.62**</td>
</tr>
<tr>
<td>Bandini, Schoeller, Cyr, and Dietz (1990)</td>
<td>2-week food record</td>
<td>No</td>
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<td></td>
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<tr>
<td>O’Connor et al. (2001)</td>
<td>dietary intake record</td>
<td>Yes</td>
<td>Biomarkers</td>
<td>47</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Andersen et al. (2005)</td>
<td>4-day food record precede diary</td>
<td>No</td>
<td>Biomarkers</td>
<td>41</td>
<td>7514 KJ</td>
<td>7396 KJ</td>
<td>118 KJ</td>
<td></td>
<td></td>
<td>.47**</td>
<td></td>
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<tr>
<td></td>
<td>7-day food record computer assisted, temporal based with eating occasion</td>
<td>No</td>
<td>Biomarkers (TEE)</td>
<td>31</td>
<td>780 kcal</td>
<td>1190 kcal</td>
<td>-410 kcal</td>
<td></td>
<td></td>
<td>.74**</td>
<td></td>
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<tr>
<td>Biltoft-Jensen et al. (2013)</td>
<td>Computer assisted, temporal based with eating occasion</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Sjöberg et al. (2003)</td>
<td>FFQ</td>
<td>Yes</td>
<td>Biomarkers</td>
<td>35</td>
<td>1100 KJ</td>
<td>1140 KJ</td>
<td>-40 KJ</td>
<td></td>
<td></td>
<td>.14†</td>
<td></td>
</tr>
<tr>
<td>Bertók et al. (2005)</td>
<td>FFQ</td>
<td>No</td>
<td>7 day weighed plate</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.60*</td>
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<tr>
<td>Di Noia and Contento (2009)</td>
<td>5 A Day FFQ</td>
<td>No</td>
<td>3-day observed intake</td>
<td>Biomarkers (TEE)</td>
<td>156</td>
<td>6.69 servings</td>
<td>5.44 servings</td>
<td>1.25 servings</td>
<td></td>
<td></td>
<td>.39*</td>
</tr>
<tr>
<td>ACAES FFQ</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.03</td>
</tr>
</tbody>
</table>
converted back to Pearson $r$ (Rosenthal, 1984). Variation in the distribution of effect sizes was examined using two indicators of heterogeneity of variance, $I^2$ and $Q$.

**Overall effect size estimates**

The overall effect size (Pearson $r$), 95% CI and statistical significance, $p$, were calculated using a random effects model. The analysis showed a significant summary effect size of the correlation between self-reported dietary intake and independent observations of intake ($r = .48$, 95% CI [.36, .58], $Z = 7.26$, $p < .001$). This significant effect size represents a medium-large positive correlation between self-reported dietary intake and independently observed intake using general guidelines for cut-offs in social science research (Rosenthal, 1995). Rosenthal’s file drawer analysis was conducted on the overall summary effect size to assess publication bias. A total of 1372 nonsignificant unretrieved studies would be necessary to shift the overall summary effect size to nonsignificance. This result is well above the tolerance level of 155 studies calculated using Rosenthal’s recommended tolerance formula (Rosenthal, 1984). Bland–Altman statistical analyses were also conducted to examine how well self-reported intake and independent validations of intake agreed in their estimation of true dietary intake.

**Pearson correlation coefficient $r$ moderation analyses**

A high heterogeneity of the distribution of effect size was found in the analysis ($Q = 324.80$, $df = 32$, $p < .001$; $I^2 = 90.15\%$) indicating that significant moderators of effect size were present among studies (Hedges & Olkin, 1985; Huedo-Medina, Sanchez-Mecha, Marin-Martinez, & Botella, 2006). Significant moderators and moderators with significant heterogeneity were further examined post hoc. Table 2 summarises the effect sizes in the moderation analyses.

**Self-report type**

The moderation effect of the three self-report types (24 h recall interviews $k = 21$, Food Diaries $k = 7$, FFQs $k = 5$) on the correlation between self-report and independently validated report of children’s dietary intake was analysed. Self-report type was not a significant moderator of the effect size of the correlation ($Q = 3.95$, $df = 2$, $p = .139$).

Although the correlation between children’s self-report of dietary intake and independent validation of children’s dietary intake did not vary significantly between self-report types, the type of error (i.e. under- or over-estimation of intake) affecting this correlation did vary among self-report types (see Table 1 for error types and Figure 2 for a graphic representation of effect sizes).

**Validation methodology**

The validation methodology used was assessed as a moderator of the effect size of the correlation between self-reported intake and independently validated intake: weighed plate dietary intake ($k = 3$), observations ($k = 14$) and biomarker validation ($k = 16$). Each validation methodology was used to validate at least one study of each type of assessment ensuring that the moderator was not confounded with self-report type.
Validation methodology was a significant moderator of the correlation between self-reported dietary intake and independently validated intake ($Q = 15.15$, $df = 2$, $p = .001$) with this correlation highest in weighed plate intake ($r = .85$, 95% CI [.70, .93]), next highest in observations ($r = .47$, 95% CI [.36, .57]) and the lowest in biomarker validation studies ($r = .39$, 95% CI [.27, .50]). The correlation between self-reported intake and independently validated intake was significantly higher in weighed intake studies than in studies using other validation methodologies (weighed plate vs. biomarkers, $Z = 3.89$, $p < .001$; weighed plate vs. observations, $Z = 3.43$, $p < .001$). Biomarker and observation studies did not significantly differ from each other ($Z = 1.04$, $p = .29$).

**Parental assistance**

The studies that allowed for parental assistance of their children ($k = 5$) had a lower correlation between self-report and independent intake ($r = .15$, 95% CI [.00, .30]) than the studies completed without parental assistance ($k = 28$, $r = .53$, 95% CI [.41, .63]). This difference in effect sizes was significant ($Z = 4.00$, $p < .001$).

**Age**

Studies were grouped into one of three categories based on average age of participant, or age ranges included if average age was not reported. Studies in this meta-analysis included children aged 4–16 years; however, individual study samples often included only a small age range. The three categories used for the moderation analysis were 4–8 years ($k = 6$, 8.92% of sample), 8–12 years ($k = 19$, 63.48% of sample) and 12–16 years ($k = 8$, 27.60% of sample). Age was not a significant moderator of the correlation between self-report and independently validated report of dietary intake ($Q = .23$, $df = 2$, $p = .892$).

---

### Table 2. Results of moderator analyses.

<table>
<thead>
<tr>
<th>Moderator</th>
<th>k</th>
<th>Pearson Correlation $r$</th>
<th>95% CI [LL, UL]</th>
<th>$Q$ ($df &gt; 1$) or $Z$ ($df = 1$)</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interview type</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 h recall Interview</td>
<td>21</td>
<td>.49</td>
<td>[.33, .62]</td>
<td>265.34</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Food Diary/Record</td>
<td>7</td>
<td>.57</td>
<td>[.36, .70]</td>
<td>27.37</td>
<td>.001</td>
</tr>
<tr>
<td>FFQ</td>
<td>5</td>
<td>.27</td>
<td>[.01, .49]</td>
<td>13.73</td>
<td>.008</td>
</tr>
<tr>
<td>Overall Moderation ($df = 2$)</td>
<td></td>
<td></td>
<td></td>
<td>$Q = 3.96$</td>
<td>.139</td>
</tr>
<tr>
<td><strong>Validation measure</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weighed Plate</td>
<td>3</td>
<td>.86</td>
<td>[.70, .93]</td>
<td>8.32</td>
<td>.016</td>
</tr>
<tr>
<td>Observation</td>
<td>14</td>
<td>.47</td>
<td>[.36, .57]</td>
<td>56.97</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Biomarkers</td>
<td>16</td>
<td>.39</td>
<td>[.27, .50]</td>
<td>51.73</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Overall Moderation ($df = 2$)</td>
<td></td>
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<td></td>
<td>$Q = 15.15$</td>
<td>&lt;.001</td>
</tr>
<tr>
<td><strong>Parental assistance</strong></td>
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<td></td>
<td></td>
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<tr>
<td>No Parental Assistance</td>
<td>28</td>
<td>.53</td>
<td>[.40, .63]</td>
<td>282.12</td>
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</tr>
<tr>
<td>Parental Assistance Allowed</td>
<td>5</td>
<td>.15</td>
<td>[.00, .29]</td>
<td>5.57</td>
<td>.233</td>
</tr>
<tr>
<td>Overall Moderation ($df = 1$)</td>
<td></td>
<td></td>
<td></td>
<td>$Z = 4.00$</td>
<td>.001</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4–8 years</td>
<td>6</td>
<td>.54</td>
<td>[.18, .77]</td>
<td>38.71</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>8–12 years</td>
<td>19</td>
<td>.46</td>
<td>[.30, .59]</td>
<td>214.25</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>12–16 years</td>
<td>8</td>
<td>.48</td>
<td>[.28, .64]</td>
<td>47.24</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Overall Moderation ($df = 2$)</td>
<td></td>
<td></td>
<td></td>
<td>$Q = .23$</td>
<td>.892</td>
</tr>
</tbody>
</table>

Notes: Table reports the effect size and 95% CI for groups of moderators, as well as the significance of the heterogeneity of effect sizes. Effect sizes, 95% CI, $Q$ and $p$-value calculated with a random effects model.
Agreement statistics

Bland–Altman statistical analyses were conducted to examine agreement in the estimation of true dietary intake between self-reported intake and independent validations of intake (Bland & Altman, 2010) for three types of dependent variables reported in studies: servings/number of food items, energy expenditure (kilojoules) and kilocalories. Limits of agreement were set at two standard deviations from the mean difference between self-reported and independently validated intake for each group of studies using the dependent variables specified.

For studies examining the difference between self-reported intake and independently validated intake using servings/numbers of food items, all samples were within the
limits of agreement (1.13 servings ± 1.55 servings), indicating that there is acceptable agreement between self-report and validation methodologies (see Figure 3a). Studies examining the difference between self-reported intake and independently validated intake using kilojoules had all samples within the limits of agreement (−30.28 KJ ± 93.64 KJ), indicating that there is acceptable agreement between self-report and validation methodologies (see Figure 3b). For studies examining the difference between

![Figure 3. Bland–Altman plots of agreement between self-reported dietary intake and independently validated dietary intake. Difference between self and independent validation is plotted on the y-axis. Average intake in each study is plotted on the x-axis. Red line represents the mean difference between self-reported and independently validated intake; black lines represent mean difference ±/−2 SD. Studies reporting only a mean difference are not shown in these graphs.]
self-reported intake and independently validated intake using kilocalories, most but not all samples were within the limits of agreement (−322.9 kcal ± 545.06 kcal), indicating that there is disagreement between dietary intake measures (see Figure 3c).

Discussion
Summary of findings
This meta-analysis provides evidence for a statistically significant correlation between children’s self-reports of dietary intake and independently validated reports of dietary intake (overall effect size \( r = .48 \)). According to accepted effect size cut-offs in social sciences, this result reflects a medium-large effect size for the relationship between children’s self-reported dietary intake and independently validated reports of their dietary intake (Cohen, 1992). However, given the important relationship between nutrition and health outcomes, this correlation would need to be much larger to justify depending solely on children’s self-report to represent actual dietary intake (Macdiarmid & Blundell, 1998).

Interpretations of moderation effects
Moderation analyses of self-report methodology, independent validation measure, parental assistance and age of participants were conducted to examine the source of the heterogeneity of the effect size dispersion among studies in the meta-analysis. The correlation between self-report and independent report of dietary intake did not differ significantly among the three self-report methodologies. This nonsignificant heterogeneity is somewhat surprising, given that the self-report types differ in the cognitive skills required by each method. However, the types of errors contributing to the size of the correlation differed across self-report types. A large percentage of the 24 h recall assessments (71%, \( k = 15/21 \)) found that children under-reported their intake, while food diary assessments (50%, \( k = 3/6 \)) showed a mixture of under- and over-reporting and FFQ studies reported that children over-reported their dietary intake compared to independent observations (80%, \( k = 4/5 \)). Future studies comparing self-report with two or more methodologies could provide a better understanding of how the specific cognitive skills required to complete these reports affect under- and over-reporting.

Validation methodology was a significant moderator of the correlation between children’s self-reported dietary intake and independent validation. Weighed plate studies had a significantly higher correlation between self-reported intake and validation than both observation and biomarker studies, and the correlation did not significantly differ between these latter two categories. It is unclear why children’s self-reported intake was most highly correlated with weighed plate validation methodology, as each type of validation methodology is prone to error and none are completely accurate representations of dietary intake. A potential explanation is that weighed plate study methodologies changed the reporting of the children by either presenting food in a way that enabled children to more accurately estimate intake or by changing how children attended to their intake. Another explanation may be that weighed plate study methodologies created reactivity in children in a different way than other validation methodologies. Future research should examine the ways in which weighed plate validations change reporting
of dietary intake to examine if some aspects of this design affect the ways that children encode, store, or recall information about dietary intake.

Parental assistance significantly moderated the effect size of the correlation between children’s self-reports and independently validated reports of dietary intake. Children’s self-reported dietary intake without parental assistance was more highly correlated with the independent validation method than children’s self-reported intake with parental assistance. These results may be due to parental biases; previous research indicates that parents systematically under- and over-estimate children’s intake (Sobo & Rock, 2001), and that children completing an assessment with a guardian present are more likely to exhibit social desirability biases (Sobo, Rock, Neuhouser, Maciel, & Neumark-Sztainer, 2000). The smaller correlation between reported and validated dietary intake when parents were present suggests that researchers should carefully weigh the decision to include parents in a dietary intake assessment. In addition to providing a larger correlation between children’s reports of intake and independently validated intake, studies using only children’s own self reports have the advantage of providing a clearer picture of how children remember and report dietary intake.

Age was not a significant moderator in this study. This is somewhat surprising given that younger children are reported to have less accurate recall of dietary intake than older children (Burrows et al., 2010). However, these nonsignificant results are consistent with the review of children’s reporting of dietary intake by Sharman et al. (2016); they reported only five studies (11% of their sample) with a significant age effect. The current results may provide evidence that the cognitive skills required to report dietary intake are developed adequately at a younger age than researchers have previously assumed. A more likely explanation is that the small number of studies examining self-reports of dietary intake from children younger than 8 years of age (5.67% of studies included in this meta-analysis) may be confounded with parental assistance effects. Finally, age may be a nonsignificant moderator because older children and adolescents have a wider range of dietary intake and more control over timing and quantity of intake than younger children; this greater variation may require more resources to recall and have a greater impact on reporting than age-related cognitive differences.

**Interpretations of agreement statistics**

Bland–Altman agreement statistics (Altman & Bland, 1983; Bland & Altman, 2010) were calculated for a subset of studies reporting servings/number of food items, energy expenditure and kilocalories. Studies reporting intake in servings/food items and energy expenditure were within the limits of agreement set at two standard deviations from the mean difference between self-reported and independently validated intake. Studies reporting kilocalories had samples outside the limits of agreement. Overall, the Bland–Altman analyses suggest that children’s self-reports of dietary intake generally agree with independent validations of intake, although variations in study design affect that agreement.

**Limitations**

One limitation in this study was the high number of articles removed during the screening process due to variations in the quality of statistical data reported (raw data,
statistical test data or effect sizes). Other studies were excluded due to our selection of Pearson $r$ correlation as the effect size measure. Those excluded studies compared the number and type of errors children make when reporting intake to an independent validation method, thereby reporting data that could not be used to compute Pearson $r$ correlations.

**Implications for future research**

Self-report methodology and age are highly related to cognitive skills but were not found to be significant moderators of the correlation between self-reported intake and independently validated intake in this study. However, to create better primary interventions, it is important to understand what children at younger ages are eating. More studies examining self-reported intake with young children between four and seven years of age would allow researchers to understand the development of the cognitive skills most important for reporting accurate dietary intake, and provide more information helpful for planning interventions with young children.

**Conclusion**

This meta-analysis provides a better understanding of how the relationship between children’s dietary intake as measured by self-report and independently validated dietary intake. Specifically, this meta-analysis provides researchers with an overall effect size; this significant positive effect size ($r = .48, p < .001$) suggests that children are able to report their own eating behaviours. However, it is important to note that although this correlation is considered medium-large in some social science settings, it is not sufficiently large to justify using children’s report as a sole measure of dietary intake in research studies (Schoeller et al., 2013). Given that many health behaviour and health behaviour change models are based on perceptions of current health behaviours (Champion & Skinner, 2008), self-reports of dietary intake may be a useful dependent variable when designing interventions and testing theories. However, when the goal of a research project is to inform policies, self-report data alone is not a sufficient measure of dietary intake.

Children’s dietary intake affects both their current health and future health outcomes. One of the first steps to creating more efficacious obesity prevention policies and programmes involves a clear understanding of children’s current dietary intake. This meta-analysis provides information about how children’s self-reports of dietary intake correlate with validated reports of intake, an important baseline when interpreting results of interventions attempting to create dietary behaviour change across research designs and paradigms. This meta-analysis also provides more information about how changes in data collection methodologies affect the way children represent and recall dietary behaviours. Future research that examines children’s knowledge and recall of dietary behaviours will further improve the reporting of data in observational and experimental studies, and facilitate researchers interested in improving dietary intake.

**Disclosure statement**

No potential conflict of interest was reported by the authors.
Notes
1. Although differences were not statistically significant, the correlation between self-reported intake and independent validation was lowest with the FFQ ($r = .27$), greater in 24 h recall ($r = .48$), and highest in food diaries ($r = .57$). See Table 2 for more detail.
2. Although differences between age groups were not statistically significant, the correlation between self-reported intake and independent validation was lowest with 8–12 years of children ($r = .46$), greater in 12–16 years of children ($r = .48$) and highest in 4–8 years of children ($r = .54$). See Table 2 for more detail.

References
*References marked with an asterisk indicate studies included in the meta-analysis.


