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REVIEW

Dietary diversity score and obesity: a systematic review and meta-analysis of observational studies

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BACKGROUND/OBJECTIVES: Studies examining the association between dietary diversity score (DDS) and obesity have led to inconsistent findings. Therefore, the purpose of this review is to summarize and elucidate the source of heterogeneous results reported in different studies.

METHODS: PubMed, ISI Web of Science, Scopus and Google Scholar were searched through December 2013 to identify all relevant articles. Sixteen publications met the inclusion criteria for the systematic review and 10 articles were entered into the meta-analysis. Eight studies had data on the odds ratio (OR) for overweight/obesity and eight compared the mean body mass index (BMI) among subjects with highest versus the lowest DDS.

RESULTS: A meta-analysis on eligible studies failed to show a significant association on either overweight/obesity OR (OR: 0.72; 95% confidence interval (CI): 0.45–1.16; $P = 0.174$) or mean differences (MD) in BMI (MD: 0.22; 95% CI: −0.70–1.14; $P = 0.643$) comparing the highest and lowest diverse diets. Between-study heterogeneity was high, and subgroup analysis failed to identify the source of heterogeneity.

CONCLUSIONS: Our systematic review and meta-analysis showed that there was no significant association between DDS and BMI status, which may be due to use of different methods for assessing dietary intake and determination of DDS. Thus, well-designed prospective studies with similar approaches to assess DDS are highly recommended.

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INTRODUCTION

Obesity is a public health concern affecting all age groups in many parts of the world.[1] Globally, at least 35% of adults are overweight or obese.[1] Recent research has shown a dramatic increase in the rates of obesity. For example, prevalence of overweight among Chinese adolescents increased from 7.5% in 2004 to 12.6% in 2009.[2] In addition, obesity is a major risk factor for chronic diseases such as type 2 diabetes,[3–5] cardiovascular disease,[6,7] metabolic syndrome[8,9] and some types of cancers.[10–13]

Shifts in dietary patterns have been considered a major risk factor for overweight and obesity.[14,15] In recent years, it has become increasingly common to evaluate dietary patterns according to nutrients, food or food groups.[16] Furthermore, it is more important to examine indices that show the overall characteristics of the diet in relation to the risk of chronic diseases.[17] The dietary diversity score (DDS) is one of the *a priori* defined diet quality indices used to assess nutrient adequacy as well as overall diet quality. Dietary diversity has been known as a key index of high diet quality in various populations.[18–20] DDS evaluates the diversity within food groups that are often chosen based on healthy dietary guidelines.[21,22] The higher diversity in healthy food groups like vegetables and fruits could increase DDS but would not add substantial energy to the overall calorie content of the diet.

Studies have linked DDS to adverse health such as cardiovascular disease,[23] metabolic syndrome,[24] cancer[25] and obesity;[26,27] however, the association between DDS and obesity have not been fully elucidated. Although some studies have reported inverse associations between DDS and obesity,[21,22,28] others have failed to show this link[29,30] or found positive associations.[23,27,31] Although higher DDS may be linked to lower body mass index (BMI) due to higher intakes of fiber, vitamin C and calcium, which are inversely associated with obesity,[26] higher DDS may contribute to increased energy consumption and, therefore, higher body fat and BMI.[27] The majority of research on the association between DDS and obesity are cross-sectional or based on data from cohort studies.[22,23,29]

To our knowledge, no review has examined research to date studying the association between DDS and obesity. Therefore, the present study provides a systematic review and meta-analysis with the aim of quantifying published evidence about the association between DDS and overweight or obesity and identifying possible sources of heterogeneity among studies.

METHODS

Search strategy

PubMed, ISI Web of Science, Scopus and Google Scholar were searched up to December 2013 using key words selected from Medical Subject Headings (MeSH) and other related keywords including 'dietary diversity score', 'diversity score', 'DDS', 'diet diversity', 'diversity', 'dietary pattern' and 'diet quality' in combination with 'body mass index', 'BMI', 'obesity', 'obesity, abdominal', 'obese', 'overweight', 'waist circumference', 'waist',

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'body size', 'body weight', 'weights and measures', 'weight', 'body fat distribution', 'fat', 'intra-abdominal' and 'lean'.

Inclusion criteria

Observational studies examining the association between DDS and overweight or obesity in human adults included cross-sectional, case–control or cohort studies were included in our systematic review. To be included in the meta-analysis, the study must have reported the mean ± standard deviation (s.d.) of BMI in subjects with the highest DDS compared with the lowest DDS, an odds ratio (OR), relative risk or prevalence of overweight and/or obesity in subjects with highest DDS compared with lowest as the reference group.

Exclusion criteria

Studies which were carried out on the same populations were excluded for analysis and only publications with large samples or with several variables for controlling the DDS–obesity association were entered in the systematic review and meta-analysis. Savy *et al.*[32–34] reported the association between DDS and BMI or obesity in three publications in the same sample; therefore, the study with the largest sample size was included for analysis.[32] Azadbakht *et al.*[26, 28] performed two studies in university students and two in Tehrani adults.[23,24] Because the sample sizes were the same, we chose the study that focused on the DDS–BMI association and provided data in quartiles rather than tertiles to categorize DDS.[26] All retrieved articles were separately screened based on the title and abstract by two authors (FA and ASA), and relevant papers were screened based on their full texts. Discrepancies were discussed with the principal investigator (LA) to achieve consensus before data extraction.

Data extraction

First author's last name, publication year, sample size, participants' age, country and city where study was accomplished, participants' mean ± s.d. of BMI based on DDS subgroups and number of participants in each group or maximally adjusted OR for obesity regarding DDS, or prevalence of overweight and/or obesity in each DDS subgroups, and variables adjusted in models were extracted from each relevant study.

Statistical analysis

The ORs and their 95% confidence intervals (CI) for comparing prevalence of overweight and/or obesity between groups with highest and lowest DDS were used to calculate logOR and its standard error (s.e.) as the effect size for the meta-analysis.[35] We calculated OR and its 95% CI if a study reported the number of participants based on food and/or beverage consumption strata.[22,23,29,32,36] Eight studies also compared mean ± s.d. of BMI in cases with the highest and lowest DDS, which were used to calculate unstandardized mean differences as the effect size were included in a separate meta-analysis.[22,23,26,27,29,30,32,37]

The overall effect was derived by using random effects model that takes between-study variation into account.[35] Subgroup analysis was performed to identify possible sources of heterogeneity, if required. Between-study heterogeneity was assessed using Cochran's Q test and I squared.[38] Sensitivity analysis was used to explore the extent to which inferences might depend on a particular study or a number of publications. Publication bias was evaluated by examining Begg's funnel plots.[39] Formal statistical assessment of funnel plot asymmetry was assessed by Egger's regression asymmetry test and Begg's adjusted rank correlation test. The data were analysed using STATA version 11.2 (STATA Corp, College Station, TX, USA), and *P*-values less than 0.05 were considered statistically significant.

RESULTS

Description of studies

After screening the title/abstract of 8580 articles, 57 studies were included for full-text review. Among these, 16 articles were eligible to be included in the systematic review after screening the full text[21–23,26,27,29–32,36,37,40–44] (Figure 1). All of the included studies used a cross-sectional study design. Six studies were conducted in Asia, five in Africa, three in North America and two in South America. The sample size of included studies ranged from 172[31] to 10424.[43] Out of 16 eligible studies, 10 articles reported required data (OR for overweight/obesity and/or mean of BMI across DDS categories) for the meta-analysis. Among studies included in the meta-analysis, eight articles reported an OR for obesity/overweight in participants with the highest DDS compared with individuals with lowest DDS.[22,23,26,29,32,36,37,41] Other papers reported mean and s.d. of BMI across DDS categories (for example, quartiles of DDS).[22,23,26,27,29,30,32,37]

Dietary diversity scoring methods used by included studies

Kant *et al.*[21, 43] used five main food groups including fruit, vegetable, meat, dairy and grain according to the USDA food guide pyramid to calculate DDS (Table 1). Four articles[23,26,29,42] used a modified version of the method introduced by Kant;[43] three articles developed the five main food groups of the food pyramid into 23 subgroups;[23,26,29] and one study used six food groups including a fat/oil group as an additional group.[42] Two studies applied nine food groups (including cereals/roots/tubers, pulses/nuts, vitamin-A-rich fruits/vegetables, other vegetables, other fruits, meat/poultry/fish, eggs, milk/dairy products and oils/fats) derived according to a method that was proposed at a workshop on dietary diversity in Rome in 2004 based on FAO guidelines;[22,37] one of these studies reported two types of DDS and introduced a new scoring pattern of 22 food groups.[37] Mayega *et al.*[41] applied approximately the same food groups in nine categories for scoring the dietary diversity. Ajani *et al.*[36] used 14 food groups based on 2007 FAO guidelines. In a study by Savy *et al.*,[32] food items were aggregated into 14 groups by following the FAO guidelines. One study applied seven food groups by modifying the scoring method that was used by Savy *et al.*[31] Furthermore, four studies applied 11, 12, 23 and 24 food groups based on national guidelines and local dietary habits.[27,30,40,44] For almost all of the studies, the maximum score was the total number of food groups. The rationale behind scoring dietary diversity was the use of a dummy variable which means that if each food group had been consumed by a subject, a maximum of 1 point would be allocated to that food group, and when it had not been consumed, it would receive a point of 0. However, several studies gave a maximum score of 1 and 2 points to each food subgroup and main group, respectively, resulting in a maximum DDS of 10.[23,26,29] One study used weighted scores based on the nutritional value of each food group, hence, seven food groups had a maximum score of 18.[31]

Findings from the systematic review

The characteristics of the 16 studies included in the systematic review are summarized in Table 1. The study by Kant *et al.*[43] analyzed the association by gender. Eight studies failed to identify a significant association between DDS and BMI;[29,30,32,36,37,41–43] however, the study by Mageya *et al.*[41] observed that participants with a moderate DDS had a significantly lower odds of being overweight compared with those with a low score; however, the same association was not found when individuals with the highest DDS were compared. Three studies showed that the probability of being obese[23,44] or overweight[31] significantly increased with higher DDS. Two studies reported that increased DDS was significantly associated with increased mean BMI.[23,27] Moreover, two studies reported a positive association between DDS and BMI,[27,40] whereas four studies showed a significant inverse association between DDS and BMI or obesity.[21,22,26,43]

Findings from the meta-analysis on odds ratios

Among the 16 articles investigating the DDS–BMI association, 3 of them reported OR for being overweight or obese in the highest DDS subgroup in comparison with individuals with the lowest DDS[26,37,41] and five studies reported the number of overweight and/or obese participants across DDS categories.[22,23,29,32,36] Our meta-analysis based on eight papers with a total of 6091 subjects aged ⩾ 18 years failed to reach a significant association (OR = 0.72; 95% CI: 0.45–1.16; $P = 0.174$); however, a significant between-study heterogeneity was observed (Cochrane Q test, $P < 0.001$, $I^2 = 80.9\%$, $\tau^2 = 0.322$) (Figure 2).

To explore the possible sources of heterogeneity, we performed a subgroup analysis based on the number of participants (using cutoff point of 1000 participants). The subgroup analysis revealed a marginally significant inverse relationship between higher DDS and reduced risk of overweight/obesity among studies with larger sample size (OR = 0.75; 95% CI: 0.54–1.04; $P = 0.084$) without between-study heterogeneity (Cochrane Q test, $P = 0.684$, $I^2 = 0.0\%$, $\tau^2 < 0.001$), whereas the analysis on studies with lower sample size did not show a significant association (OR = 0.73; 95% CI: 0.37–1.44; $P = 0.366$) with a high between-study heterogeneity (Cochrane Q test, $P < 0.001$, $I^2 = 84.9\%$, $\tau^2 = 0.352$). Exclusion of two studies[22,26] from the analysis resulted in the absence of heterogeneity in this subgroup of studies (Q test, $P = 0.971$, $I^2 = 0.0\%$, $\tau^2 < 0.001$) (data are not shown).[22,26]

Meta-regression and subgroup analysis based on study location, adjusted variables, dietary assessment method, scoring methods for DDS, number of participants and age were evaluated to explain their contribution to between-study heterogeneity, however, none of the foregoing subgroup analyses could explain the source of heterogeneity.

Findings from meta-analysis on BMI means across DDS categories

There were eight articles which reported the means for BMI across DDS categories.[22,23,26,27,29,30,32,37] One of the studies reported the association based on two ethnic groups.[30] Therefore, nine effect sizes from eight studies with 3684 adults were included in the meta-analysis. Our meta-analysis did not find a significant difference in BMI between highest and lowest DDS categories (mean difference = 0.22; 95% CI: − 0.70–1.14; $P = 0.643$), while between-study heterogeneity was high (Cochrane Q test, $P < 0.001$, $I^2 = 87.3\%$, $\tau^2 = 1.587$) (Figure 3). Meta-regression and subgroup analysis based on study location, use of adjustments, dietary assessment methods used by each study, scoring methods for DDS, number of participants and their age could not explain the source of heterogeneity.

Sensitivity analysis and publication bias

Applying sensitivity analysis showed that none of the studies could considerably alter the summary effect. In spite of slight

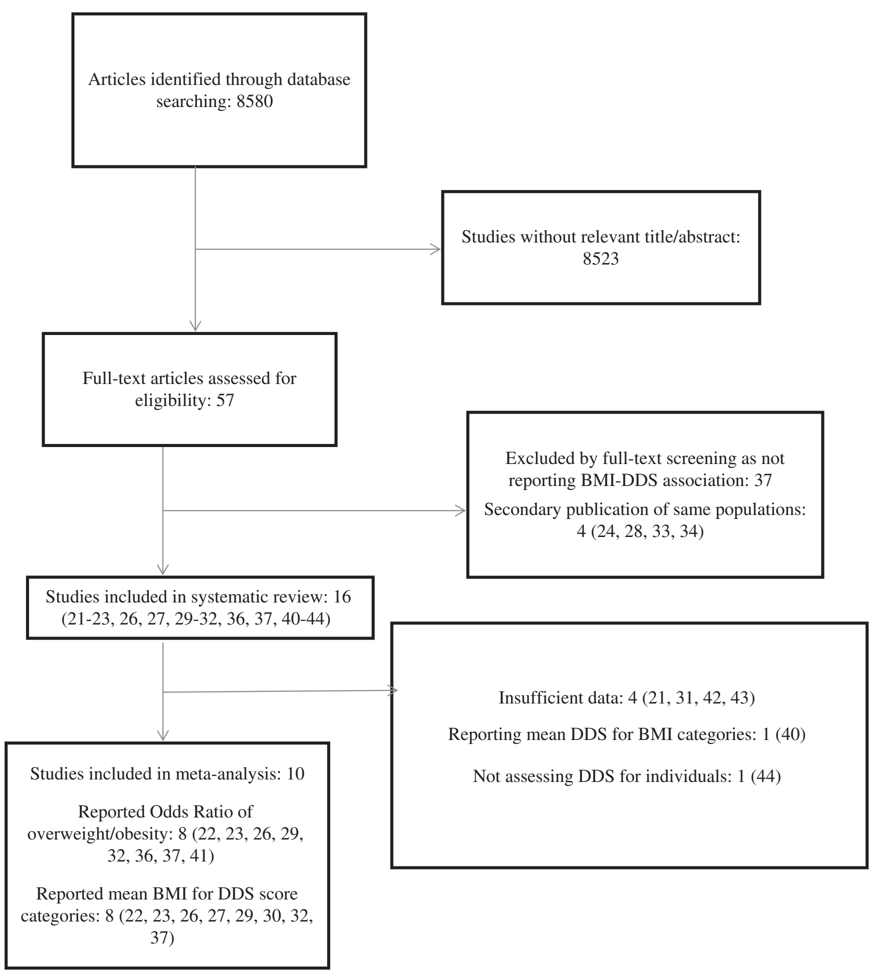

Figure 1. Flow diagram of study screening and selection process.

Table 1. Characteristics of studies included in the systematic review owing to reporting DDS–BMI association

First author (Ref.)	*Gender (Sample size)*	*Age range (years)*	*Country*	*Number of food groups applied for dietary scoring*	*Dietary intake assessment method*	*Result*	*Adjusted variable*
Oldewage -Theron and Egal[22]	F (722)	>19	South Africa	9	FFQ	There was a significant inverse association between mean of BMI in participants with higher DDS compared with participants with lowest DDS	—
Mayega *et al.*[41]	F and M (1656)	35–60	Uganda	9	Recall (7d)	There was no significant association between OR for being overweight/obese in participants with higher DDS compared with participants with lowest DDS	Sex, age, residence, SES quintile, family history of diabetes, blood pressure level, level of physical activity, knowledge about lifestyle diseases, tobacco use, alcohol use
Ajani[36]	F (1472)	Adults	Nigeria	14	24-h recall	There was no significant association between OR for being overweight/obese in participants with higher DDS compared with participants with lowest DDS	—
Hasan-Ghomi *et al.*[29]	F and M (199)	>40	Iran	5 main and 23 subgroups	FFQ	There was no significant association between OR for being overweight/obese and mean of BMI in participants with higher DDS compared with participants with lowest DDS	—
Azadbakht *et al.*[26]	F (289)	18–28	Iran	5 main and 23 subgroups	FFQ	There was a significant inverse association between OR for being overweight/obese and mean of BMI in participants with higher DDS compared with participants with lowest DDS	Age, physical activity and total energy intake
Savy *et al.*[37]	F (481)	20–59	Burkina Faso	22	24-h recall	There was no significant association between OR for being overweight/obese and mean of BMI in participants with higher DDS compared with participants with lowest DDS	Age and education of the women, economic and hygiene index of the household, care for women index
Azadbakht *et al.*[23]	F and M (581)	$\geqslant 18$	Iran	5 main and 23 subgroups	FFQ	There was a significant direct association between OR for being overweight/obese and mean of BMI in participants with higher DDS compared with participants with lowest DDS	—
Savy *et al.*[32]	F (691)	17–51	Burkina Faso	14	24-h recall	There was no significant association between OR for being overweight/obese and mean of BMI in participants with higher DDS compared with participants with lowest DDS	Age and height, food variety score, underlying variables,[a] basic variables[a]
Jayawardena *et al.*[27]	F and M (481)	>18	Sri Lanka	12	24-h recall	There was a significant direct association between mean of BMI in participants with higher DDS compared with participants with lowest DDS	—
Kimura *et al.*[30]	F and M (240)	$\geqslant 60$	China	11	11-item Food Diversity Score Kyoto (FDSK11)	Han ($n=176$): There was no significant association between mean of BMI in participants with higher DDS compared with participants with lowest DDS. Tibetan ($n=64$): There was no significant association between mean of BMI in participants with higher DDS compared with participants with lowest DDS	—
Lee *et al.*[42]	F and M (1743)	$\geqslant 65$	Taiwan	6	24-h recall	There was no significant association between mean of BMI in participants with higher DDS compared with participants with lowest DDS	—

Table 1. (Continued)

First author (Ref.)	*Gender (Sample size)*	*Age range (years)*	*Country*	*Number of food groups applied for dietary scoring*	*Dietary intake assessment method*	*Result*	*Adjusted variable*
Bezerra *et al.*[44]	PSUs[b] (3393)	20–65	Brazil	23	Record	There was a significant direct association between mean of BMI in PSUs with higher DDS compared with PSUs with lowest DDS	
Benefice *et al.*[31]	F (172)	Adults	Bolivia	7	24-h recall	There was a significant direct association between BMI in participants with higher DDS compared with participants with lowest DDS	Age
Ponce *et al.*[40]	M (325)	35–65	Mexico	24	2 nonconsecutive 24-h recalls	There was a significant direct association between mean of DDS in obese participants compared with participants with normal BMI	—
Kant *et al.*[21]	F and M (8719)	⩾20	USA	5	24-h recall	There was a significant inverse association between mean of BMI in participants with higher DDS compared with participants with lowest DDS	Age, race/ethnicity, education, smoking, alcohol use, activity, energy intake, trying to lose weight status
Kant *et al.*[43]	F (6264)/M (4160)	25–74	USA	5	24-h recall	Women: There was a significant inverse association between mean of BMI in participants with higher DDS compared with participants with lowest DDS. Men: There was no significant association between mean of BMI in participants with higher DDS compared with participants with lowest DDS	Age

Abbreviations: BMI, body mass index; DDS, dietary diversity score; F, female; FFQ, food frequency questionnaire; M, male; OR, odds ratio; PSU, primary sample units; SES, socioeconomic status. [a]Underlying variables: Size of compounds in individuals, Care of women, Hygiene of household; Basic variables: Secondary activity of the HH, Agricultural production tools, Woman's ethnic group. [b]analysis were based on PSUs; the mean number of households in the PSUs was 10.

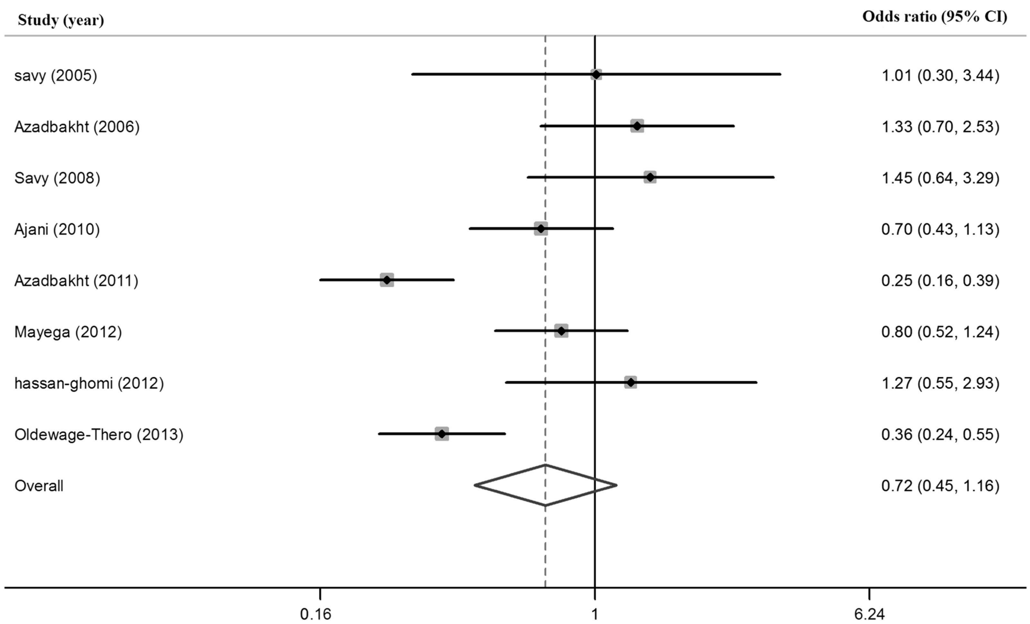

Figure 2. Forest plot illustrating overall overweight/obesity OR among participants with highest versus lowest DDS.

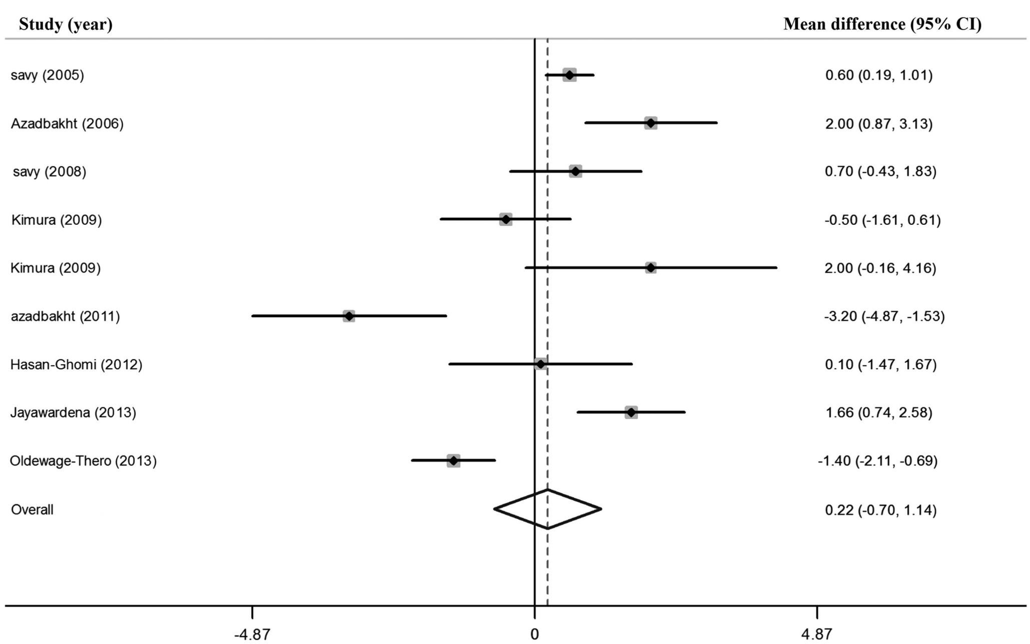

Figure 3. Forest plot illustrating weighted mean difference in BMI among participants with highest versus lowest DDS.

asymmetry in Begg's funnel plot, no evidence of significant publication bias was found (Begg's test: $P = 1.0$ and $P = 0.835$; Egger's test: $P = 0.850$ and 0.819 for odds of overweight/obesity and mean difference in BMI, respectively) (Figure 4).

DISCUSSION

Our meta-analysis of cross-sectional studies examining the association between DDS and overweight/obesity and BMI failed to show a significant association. To explore the source of heterogeneity, subgroup analyses based on sample size, study location, random selection of subjects, using adjustment, dietary questionnaire, scoring pattern for DDS could not explain the heterogeneity. Subgroup analyses according to sample size in studies reporting ORs of overweight/obesity resulted in a complete absence of heterogeneity only in studies with larger sample sizes.[36,41] Furthermore, studies with 1472 and 1656 participants[36,41] showed an inverse relationship between BMI and DDS (marginally significant).

Although not included in the meta-analysis, the study by Kant *et al.*[21,43] may have affected the overall effect size due to the large sample size. Despite using 24-h dietary recalls to evaluate DDS, a significant inverse association was found between BMI and DDS.[21,43] An inverse relationship among women but not men was found in 10 242 adults.[43] In 2005, among 8719 adults and notwithstanding adjustment for age, race/ethnicity, education,

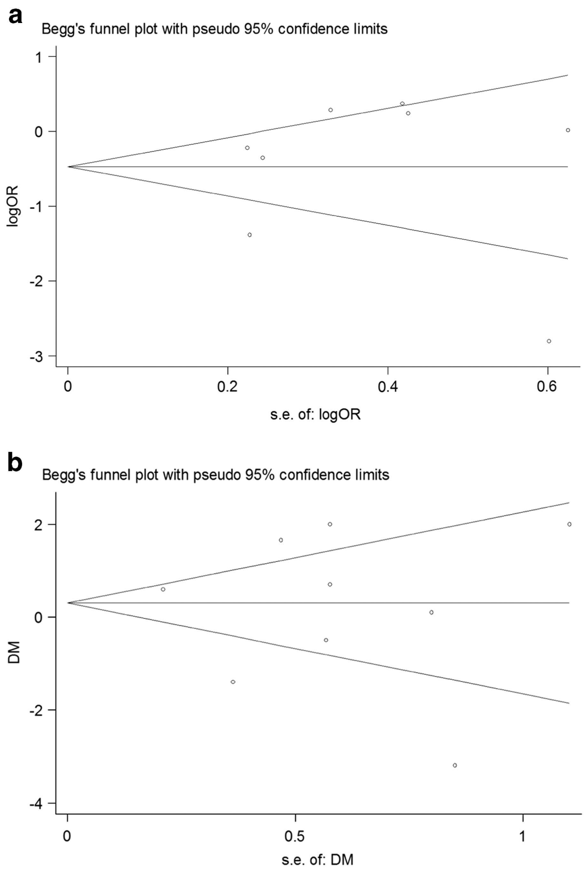

Figure 4. Begg's funnel plot (with pseudo 95% CIs) (**a**) of the ORs versus the s.e. of the ORs in studies that investigated overweight/obesity OR among participants with highest versus lowest DDS. The horizontal line shows the pooled relative risks calculated with the DerSimonian and Laird random-effects model, and (**b**) of the difference in means (DMs) versus the s.e. of the MDs (mean differences) of BMI for studies that evaluated the mean BMI of subjects with lowest and highest DDS. The horizontal line shows the pooled DMs calculated with the DerSimonian and Laird random-effects model.

smoking, alcohol use, activity, energy intake and trying to lose weight, there was a higher BMI in subjects consuming the lowest diverse diets compared with individuals with highest DDS.[21] Another study[42] in 1743 elderly subjects, representing a mean of BMIs across DDS, showed that underweight and obese subjects were more likely to have low DDS, while a high proportion of individuals with a BMI of 18.5–23.9 and 24–26.9 kg/m^2 were in the highest DDS compared with the lowest, that is, 47.4 vs 42.5 and 30.5 vs 30.0 kg/m^2, respectively. The two other articles excluded from the meta-analysis owing to insufficient information were performed in 2006 and 2007 on 325 men and 172 women, respectively. Both studies showed a direct association between dietary diversity and BMI.[31,40] The first study showed that obese participants had higher diverse diets than normal subjects.[40] Despite the large sample size in the study by Bezerra *et al.*,[44] its exclusion from the meta-analysis was not only owing to calculating DDS based on purchased food items instead of dietary questionnaires but also owing to reporting DDS of several households as primary sample units rather than individuals.

Several aspects of the two studies that resulted in heterogeneity in the analysis on overweight/obesity ORs require further discussion (that is, those performed by Azadbakht *et al.*[26] and Oldewage-Theron *et al.*[22]). First, the subjects were selected from specific populations. Second, participants were female students from Isfahan University of Medical Sciences or black women of low income peri-urban areas of the Vaal Region of South Africa, respectively. Furthermore, the low prevalence of obesity in students and normal BMI in black women included in these studies might result in lower between-subject variation in BMI and consequently weak estimates of ORs.

Several limitations require further discussion. First, there were no studies assessing the DDS–BMI relationship in a prospective design; therefore, any casual associations between DDS and BMI status cannot be inferred from the current systematic review and meta-analysis. Although some studies had cohort designs, the main dependent variable was mortality and the DDS–BMI association was only reported at baseline.[42,43] Unfortunately, we were unable to extract to what extent the DDS contributed to individual foods or food groups because different food groups were used by researchers to determine the DDS (Table 1). Furthermore, some studies did not report the contribution of food groups to DDS and various foods were correlated with DDS in different surveys. Most of the included studies did not adjust for two important variables: energy intake and socioeconomic status. However, the studies by Azadbakht *et al.*[26] and Kant *et al.*[21] adjusted for energy intake. From these two studies, only the study by Azadbakht *et al.* had sufficient data to be included in the meta-analysis. Furthermore only two studies adjusted socioeconomic status,[37,41] which resulted in a non-significant DDS–BMI association when analyzed separately. Adjustment for energy intake and socioeconomic status in future studies is highly recommended. However, over-adjustment may mask the association between DDS and obesity.[32] Finally, the instrument used for assessing dietary diversity may have a key role in determining the relationship with obesity risk. Usual intake is important for assessing dietary diversity. In addition, examining the disease–diet association over the long-term is merited. Taken together, it appears that the use of a food frequency questionnaire is the most appropriate tool for assessing long-term diet diversity. Nevertheless, most of the studies[21,27,30–32,36,37,40–43] used 24-h dietary recalls rather than the food frequency questionnaire[22,23,26,29] to assess nutritional diversity. In one study, the use of a 3-day food record compared with a 1-day record resulted in a significant mean difference in DDS of 4.4 and 3.5, respectively.[33] Various methods to assess DDS might explain the high heterogeneity seen among studies. A review of DDS measurement approaches concluded that dietary diversity was a promising measurement research tool; however, considerable research on how to best measure DDS and the context for it use is needed.[45] It should be considered that we could not include six studies in the meta-analysis owing to lack of data.[21,31,40,42–44] Moreover, studies used a range of defined food groups to score diversity and most studies used dietary recall rather than a food frequency questionnaire to examine diversity of the diet. In the current study, we compared obesity and mean BMI between participants with highest and lowest DDS to evaluate the linear association between DDS and BMI; however, the association may be curvilinear (U-shaped).

It has been suggested that higher dietary diversity is associated with higher intakes of total energy from fat, saturated fat and linked to obesity.[40] However, some studies attributed higher dietary diversity to higher intake of low-energy-dense items such as fruits and vegetables and consequently diversity was linked to lower the risk for obesity.[26] Correspondingly, studies assessing diversity scores exclusively for fruits and vegetables showed that despite increasing energy intake across tertiles of the diversity of fruits and vegetables, mean BMI decreased.[46] On the other hand, Savy *et al.*[37] showed that higher diversity was not only associated with both higher intakes of sugar and fat but also related to increased consumption of micronutrients, fish, vitamin-A-rich fruits and vegetables.

We propose a new method to capture DDS. First, the use of a food frequency questionnaire to evaluate usual intakes compared with food records, recalls and histories based on a few days may be better for capturing DDS. Second, we suggest calculating all six main food groups (including cereals, vegetables, fruits, meats, dairy foods and fats) for assessing DDS, because most published studies did not account fat intake.[21,23,24,26–31,43] Recent studies show that healthy fats from vegetable sources and nuts are beneficial for human health; therefore, we propose adding a fat group (2 subgroups) to the other five main food groups (23 subgroups) used in previous papers.[23,24,26,28,29] Hence, food groups including grains, vegetables, fruits, meats, dairy and fats could be divided into 25 subgroups; the grain including 7 subgroups (refined bread, biscuits, macaroni, whole grain bread, corn flakes, rice and refined flour), fruits consisting of 2 subgroups (fruit and fruit juice, berries and citrus), vegetables including 7 subgroups (vegetables, potato, tomato, other starchy vegetables, legumes, yellow vegetables and green vegetables), meats consisting of 3 subgroups (red meat, poultry, fish and eggs), dairy (milk, yoghurt and cheese) and finally fat including two subgroups (vegetable oils and nuts). Furthermore, to be considered a 'consumer' for any of the food groups, a participant should consume at least 0.5 of the serving in a day as defined by dietary guidelines. Finally, the total DDS might be determined as the sum of the scores from the six main groups with a score between 0 and 12.

In conclusion, our systematic review and meta-analysis showed that there was no significant association between DDS and BMI status perhaps owing to various methods used to capture dietary intake as well as different methods for assessing DDS. Reassessing the overall utility of DDS as a measure of quality of diet and developing new validated DDS tools to be used worldwide are highly desirable. In addition, well-designed prospective studies using similar approaches to assess DDS are merited.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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