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Assessing the efficacy and external validity of interventions promoting calcium or dairy intake in young adults: a systematic review with meta-analysis

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Abstract

Calcium and dairy products have a role in the prevention of chronic diseases and attainment of peak bone mass, during adolescence to young adulthood. However, intakes are often suboptimal and interventions to improve consumption of food sources are needed. This systematic review aimed to investigate the efficacy and external validity of interventions promoting calcium or dairy foods among young adults. Eight databases were searched from inception to identify relevant studies. Inclusion criteria included those aged 18 to 35 years in an intervention promoting calcium or dairy food intake. The mean age of the participants was 19.9±1.4 years. Of the 16 studies that met the selection criteria, five studies were included in the meta-analyses for calcium (pooled effect size 0.35, 95% CI 0.04 to 0.67) and three studies for dairy (pooled effect

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size 0.31, 95% CI 0.11 to 0.50). The quality of the body of evidence was determined using the GRADE system, and was of overall low quality with high risk of bias. Our review suggests young adults respond favourably to interventions but the effect size is small.

Keywords

calcium, dairy, young adults, interventions, behavior change

Introduction

Dairy foods provide the major source of calcium in the Australian diet along with other essential micronutrients including protein, vitamins (A, B12 and riboflavin) and minerals (P, Mg, K and Zn) (Weaver, 2009; Yantcheva et al., 2016). Calcium and dairy products have a role in the maintenance of good health and prevention of chronic disease (Larson et al., 2009), and are recommended in the dietary guidelines in many countries (Ebeling Peter, 2013; National Health and Medical Research Council, 2013; Nations, 2016; U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015).

There is a growing body of evidence connecting dairy foods consumption with improved health outcomes, through improved weight control (Doidge and Segal, 2012; Dougkas et al., 2011). Two or more servings of dairy foods consumption per day was associated with reduced risk of ischemic heart disease and myocardial infarction (Elwood et al., 2008; Elwood et al., 2004; National Health and Medical Research Council, 2011), and associated with reduced risk of stroke (Alvarez-Leon et al., 2006; de Goede et al., 2016; National Health and Medical Research Council, 2011). Three servings of low fat dairy products are associated with reduced risk of hypertension (McGrane et al., 2011; National Health and Medical Research Council, 2011). Increased dairy foods consumption may also be inversely associated with insulin resistance syndrome, also known as metabolic syndrome or syndrome X (Martins et al., 2015; Pereira et al., 2002), and reducing type two diabetes (Elwood et al., 2008; National Health and Medical Research Council, 2011; Pereira et al., 2002; Pittas et al., 2007).

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Despite the established benefits of dairy products and alternatives for chronic disease prevention, it still remains a reluctant choice among adults. In the latest survey results in Australia, 90% of the Australian population (aged two years and over) do not consume enough dairy foods (Australian Bureau of Statistics, 2016). They are commonly consumed by children (Australian Bureau of Statistics, 2012), but statistics suggest that the intake of dairy products and alternatives decrease during adolescence (Baird et al., 2012; Parker et al., 2012). From the latest Australian Nutrition and Physical Activity Survey (NNPAS) 2011-12, almost 45% of males and 70% of females aged 19 to 30 years have inadequate calcium intakes (Australian Bureau of Statistics, 2015). This raises some concern as sufficient intake of calcium is necessary, particularly during adolescence and young adulthood, to maximise peak bone mass (Matkovic, 1992), and increasing dairy intake may displace the consumption of energy-dense, high-fat foods and soft drinks (Rampersaud et al.; Rangan et al., 2012; Vartanian et al., 2007).

The transition to adulthood is a period often associated with developing more autonomy over dietary choices (Allman-Farinelli et al., 2016). Young adulthood is a vulnerable time, as they are entering new environments (i.e. moving out of home, starting college or university) and gaining independence from their parents (Deshpande et al., 2009). These changes may lead to engagement in risky behaviors and reduced concern about their future well-being (Harhay and King, 2012). Consequently, they are vulnerable to developing lifelong unhealthy behaviors (Ha et al., 2009). This is concerning, given that the habits formed can have a substantial effect in later life but also for future generations (Gore et al., 2011). Therefore, it is important that this group be targeted separately to instil healthy behaviors (National Health and Medical Research Council, 2015; Nour et al., 2016).

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Previous systematic reviews have focused on interventions on dairy foods and calcium consumption in children and adolescents (Hendrie et al., 2013; Marquez et al., 2015), or in elderly adults at risk of developing osteoporosis (Kastner and Straus, 2008; Little and Eccles, 2010; Lock et al., 2006). There has been little research on effective lifestyle programmes in the young adult age group (Hebden et al., 2012; National Health and Medical Research Council, 2015). In the recent years, there has been a shift towards electronic interventions due to rising use of technology to promote better health (Kohl et al., 2013). To date, there is no published review investigating the effectiveness of calcium and dairy interventions in young adults. In order to translate interventions into the broader young adult population, it is essential to examine the external validity which is considered as important as efficacy (Steckler and McLeroy, 2008). Therefore, the aim of this review was to examine the efficacy of dairy and calcium interventions targeting young adults and assess the quality of the studies and external validity components reported.

Methods

Protocol and Registration

The review has been registered with Prospero (Registration number: CRD42016035908). The PRISMA guidelines were used in the synthesis of the review (Moher et al., 2009).

Eligibility Criteria

Criteria for inclusion included young adults, defined as those aged 18 to 35 years, as this is considered the acceptable range based on the National Institute of Health cut-offs (National

Institutes of Health, 2010) in an intervention that promoted calcium or dairy intake, with or without a comparison group. The outcome of measure was change in calcium or dairy intake at baseline and post-intervention. The outcome could be reported in servings or frequencies. Randomised controlled trials (RCTs), quasi-experimental design and before and after studies with a primary or secondary aim to increase calcium or dairy intake were included. Comparison was made between baseline and follow-up, as well as between intervention and control group. Control group may be no intervention or minimal contact.

Information Sources

A systematic search was conducted using the following academic databases: Cinahl, Embase, Global Health, Medline, Pre-Medline, PsycINFO, Scopus and The Cochrane Library. These databases were searched from inception to 22nd May 2017 to select relevant articles. A search strategy for Medline was developed first and revised appropriately for each database. A combination of subject and keyword search was used to retrieve more relevant papers. For subject searching, relevant terms were searched on all databases and subject headings were chosen (where relevant). For example, ‘telemedicine’ was found on Medline thesaurus Medical Subject Headings (MESH) which encompasses the terms ‘mHealth’, ‘eHealth’, ‘telehealth’ and ‘mobile Health’. The keyword search terms for interventions were broad, including electronic (‘email’, ‘texting’, ‘mobile phones’, ‘smartphones’) and non-electronic interventions (‘nutrition intervention’, ‘health education’, ‘nutrition education’, ‘dietary records’).

No restriction limit was used on databases except for language (English) and studies involving ‘humans’ (where applicable). The complete search strategy in the electronic database Medline is presented in Table 1 (refer to supplementary tables for full search strategy). Additional studies were retrieved by hand searching the reference list of relevant studies.

Study Selection

Titles and abstracts of all retrieved studies were downloaded onto EndNote X7 citation management software (Thomson Reuters, Philadelphia, PA, USA). After removal of duplicates, two authors (AR and AG) independently assessed all records for eligibility criteria. If a decision could not be made based on abstract text, the full text was retrieved. Any disagreements were resolved by discussion and a third reviewer consulted if necessary (MAF).

Data Collection Process and Data Items

A data collection form was developed to extract the following details: author, year and country, target population, inclusion criteria, recruitment methods, study population, study design, and baseline characteristics; description of intervention including focus, setting, theoretical construct, study arms, delivery method and personnel, duration; and changes in intake from baseline to post-intervention, attrition rate, comparison of drop-outs, follow-up intervention and sustainability of program. In addition, the name of the tool used for assessment of dairy or calcium was extracted and additional questions were included to conduct a dietary tool quality assessment based on that used in a previous review with no modifications necessary as it is appropriate for dietary assessment of all age groups (Burrows et al., 2012).

Some additional data were extracted for quality assessment (i.e. method of randomization, allocation concealment, blinding and reporting bias) (Higgins et al., 2011). A pilot data extraction was carried out before entering data and changes were made appropriately. The primary author extracted the full text of selected studies with 20% additionally extracted by a second author.

Summary Measures and Synthesis of Results

Standardized Mean Difference (SMD) was used as the summary measure which was deemed to be a suitable measure as the same outcome measure was measured in different ways (i.e. servings of food, mg or amount in grams and it standardizes the results before they are combined in a meta-analysis (Cochrane Handbook for Systematic Reviews of Interventions, 2011b). The outcome of interest was the change in dairy or calcium intake post-intervention. Where possible, information pertaining to intake was recorded (frequency or as servings, mg, cups etc.) pre and post-intervention. The changes in mean and standard deviation, standard error and any associated P values overtime were documented. If standard error was reported, it was converted to standard deviation (Cochrane Handbook for Systematic Reviews of Interventions, 2011a). For randomised controlled trials, the magnitude of the intervention outcomes were converted to SMD, using Lipsey and Wilson's web-based calculator (Lipsey and Wilson, 2001; Wilson, 2001). The magnitude of effect was assessed according to the categories, whereby an effect <0.2 is negligible, between 0.2-0.49 is small, 0.5-0.8 is medium and >0.8 is large (Cohen, 1992).

To pool the outcomes for the meta-analysis, dairy and calcium effect sizes were grouped separately, when sufficient data were available i.e. mean, standard deviation and sample size of treatment and control groups. The analyses were conducted based on a random effects model using the metan command on STATA version 13.1 (StataCorp LP). Heterogeneity between studies was assessed using the I^2 statistic, which examines the percentage of variability between studies that cannot be attributed to sampling variations or chance alone.

Risk of Bias Assessment

For all randomised controlled trials, the risk of bias was assessed by two review authors using the Cochrane risk of bias assessment tool (Higgins J, 2011). Five domains were assessed for each study: random sequence generation (selection bias), concealment of allocation methods (selection bias), incomplete outcome data (attrition bias), blinding (performance bias and detection bias) and risk of selective outcome reporting (reporting bias). This was completed as described in the Cochrane Handbook for Systematic Reviews of Intervention Version 5.1.0 (Higgins J, 2011).

For non-randomised trials, the articles were assessed using the Evidence Analysis Manual developed by the Academy of Nutrition and Dietetics (American Dietetics Association, 2005). The tool encompasses 10 validity questions which included the assessment of (i) the clarity of the research question; (ii) whether selection bias was apparent; (iii) whether the study groups were comparable and confounders controlled for; (iv) whether withdrawals were handled adequately; (v) blinding of subjects and investigators; (vi) whether the study protocol was described in sufficient detail; (vii) validity and reliability of measurements to measure outcomes; (viii) whether appropriate statistical analysis was conducted; (ix) whether the conclusion accounts for limitations and biases; and (x) declaration of conflict of interest and funding sources.

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The study was rated as low risk of bias if six or more of the validity questions were met (including questions ii, iii, vi and vii). If the study did not meet one or two of the validity questions (ii, iii, vi and vii) but met all others, it would be considered as moderate risk of bias. The study was rated as poor quality if the answer was no to six or more questions (out of 10). Any disagreements of quality rating between the review authors were resolved by discussion. A third researcher opinion was sought, where necessary.

GRADE Assessment

The grading of recommendation, assessment, development and evaluation (GRADE) system was applied to evaluate the overall quality of the body of evidence (Atkins et al., 2004). Five domains were assessed for each study to ascribe a quality rating: limitations in study designs; consistency of results; directness of the evidence comparing it to the study populations, intervention design and outcomes; precision of outcomes; and publication bias.

Studies without a control group were not included for GRADE assessment as it was not possible to calculate the effect sizes without a control group. Instead, we assessed whether the trial was successful in changing dietary behavior of calcium or dairy and if it included any external validity components.

Rating External Validity

The external validity of included studies was conducted based on the criteria for rating external validity designed by Green and colleagues (Green and Glasgow, 2006). The assessment encompasses: reach and representativeness of participants; intervention implementation and adoption; and program maintenance and institutionalization.

Quality and Validity of Dietary Assessment Tools

The Australian Child and Adolescent Obesity Research Network (ACAORN) scoring method was used to assess the quality and validity of the dietary assessment tool of the included studies (Burrows et al., 2012). The ACAORN tool is applicable to all age groups as it is about the quality of dietary assessment tools, not children specifically.

Results

Study Selection

As shown in Figure 1, the searches identified 5217 records after duplicates were removed. After the titles and abstracts were screened for relevance, 99 studies were identified for full text examination. From these, 83 were excluded from this review because they did not meet the inclusion criteria. Reasons for exclusion of these studies are provided in Supporting Information 2. A total of 16 studies were included in this review and summarised in Table 2-4. The studies were classified as RCT's (n = 8), non-randomised controlled trials (n = 2) and before and after study design (n = 6).

Study Reach and Representativeness of Participants

As shown in Table 2, all studies were conducted between 1990 and 2015. Over half of the studies were conducted in the United States (n = 10), two studies in Japan, and one study each in Canada, Korea, Italy and Malaysia. The total number of participants included in this review was

2434 with a mean of 152 participants per study (range: 7 to 417). The mean participation rate was 11.9% (range: 0.6% to 29.5%). The study population tended to be of higher education, female (81.1%) and Caucasian background which limited the representativeness of the population; the mean age was 19.9 years (range: 18.4 to 22.3 years). For studies that reported ethnicity (n = 9), the populations with the highest representation included White or Caucasian (n = 6) and a minority included African American, Hispanic or Latino (n = 3). A majority of the studies described their target audience as ‘college or university students’ (n = 9), one of which specifically targeted university sports scholar students, and only a few studies targeted the general population (n = 3).

Intervention Implementation and Adaption

Eleven studies focused on improving dairy or calcium as their primary focus and the remaining studies targeted multiple food groups or nutrients. Ten studies promoted calcium, six targeted dairy and four measured both (Bohaty et al., 2008; Ehlert, 2010; Ha et al., 2009; Shahril et al., 2013).

As shown in Table 3, the majority of the studies were conducted in a university setting (n = 15), with one study conducted in the community (Bohaty et al., 2008). The majority of the studies provided face-to-face delivery of information (n = 12). This included lecture style delivery (n = 5) (Bohaty et al., 2008; Ha et al., 2009; Jung et al., 2011; Shahril et al., 2013), tape or video presentation (Koszewski et al., 1990; Sueta, 2000; Sueta and Fukuda, 1995). Four studies reported including a discussion or interactive activity component (Ehlert, 2010; Ha et al., 2009; Koszewski et al., 1990; Martinelli, 2013). Three studies reported on providing pamphlet, brochures or handouts (Gerend and Shepherd, 2013; Jung et al., 2011; Shahril et al., 2013). One study provided a nutrition course in a class setting (Kwon and Chang, 2000), and one study provided education in small groups (Peterson et al., 2000). One study used phone calls as part of their intervention (Bohaty et al., 2008), and one study used text messaging (Shahril et al., 2013). Two studies used group emails and one study used mail-delivery to communicate information.

Six studies delivered a single one-off session with some follow-up contact through mail or telephone, which may be considered as lower intensity intervention (Gerend and Shepherd, 2013; Jung et al., 2011; Koszewski et al., 1990; Peterson et al., 2010; Sueta, 2000; Sueta and Fukuda, 1995). Six studies provided multiple sessions over the course of the intervention. Four studies provided contact on a weekly or daily basis which was classed as higher intensity (Ha et al., 2009; Poddar et al., 2012; Poddar et al., 2010; Shahril et al., 2013). Psychological theory-based constructs were used in 6 studies and included: Social Cognitive Theory (SCT) (Ehlert, 2010; Poddar et al., 2010), Health Belief Model (HBM) (Jung et al., 2011; Poddar et al., 2012), or a combination of Transtheoretical or Stage of Change and Theory of Reasoned Action (Talpade and Caddell, 2015). Four studies incorporated goal-setting as part of their intervention (Ehlert, 2010; Poddar et al., 2012; Sueta, 2000; Sueta and Fukuda, 1995), one of which provided feedback to participants.

The mean length of intervention was 18.25±18.0 weeks (range: 3 weeks to 1 year). Over half of the studies had a duration of less than six months (n = 12). Three studies had duration of one month or less (Gerend and Shepherd, 2013; Koszewski et al., 1990; Peterson et al., 2010). Four studies had a duration of one year or more (Jung et al., 2011; Sueta, 2000; Sueta and Fukuda, 1995). Few studies did not clearly specify the duration; the length of intervention was estimated from the details, where possible.

Study Maintenance and Institutionalisation

Most studies reported on intake at baseline and post-intervention in sufficient detail (Table 4). Calcium intake was measured in mg or calcium-rich servings and dairy amount was reported in servings and frequencies. Of 10 studies with a control group, six studies reported a significant difference between intervention and control group (Ehlert, 2010; Jung et al., 2011; Peterson et al., 2000; Poddar et al., 2012; Shahril et al., 2013; Sueta and Fukuda, 1995). For studies without a control group, two studies reported no significant difference before and after intervention (Bohaty et al., 2008; Martinelli, 2013). Three studies reported a significant difference (Ha et al., 2009; Kwon and Chang, 2000; Peterson et al., 2010), two of which were in females only (Ha et al., 2009; Kwon and Chang, 2000).

Attrition was reported in 10 studies; the mean attrition rate was 21.3%, and ranged from 1% to 64%, see Table 4. A majority of the studies did not provide any information comparing drop-out characteristics to completers (n = 13). Five studies included follow-up of dietary intake after the intervention (Bohaty et al., 2008; Gerend and Shepherd, 2013; Peterson et al., 2000; Sueta, 2000; Sueta and Fukuda, 1995), while one included continued support via meetings, phone calls or mail-delivered material during the follow-up period (Jung et al., 2011). No studies reported any detail of program sustainability after the intervention research.

Risk of Bias

The Cochrane risk of bias assessment is presented in Table S4. A total of eight studies were included for Cochrane assessment, all of which were RCT's. For the overall judgement, four studies rated as unclear, three as high and one was low risk. The majority of the studies rated as unclear for selection bias did not describe the method of randomisation or concealment of allocation. A majority of the studies rated as low risk had low or no attrition; only two studies were found to have a high attrition rate (>20%) (Jung et al., 2011; Peterson et al., 2000). For performance and detection bias, most studies were rated as low risk as they provided description on blinding or reported an objective measure of outcome. All studies reported pre-specified outcomes; however, one study was rated as unclear or high as there were large baseline differences between intervention and control group for dairy intake (Ehlert, 2010).

Results for all non-randomised controlled trials and before and after studies assessed using the American Dietetic Association or ADA tool (n = 8) are presented in Table S5. Six studies were deemed to have a moderate risk of bias and two as high risk. None of the studies blinded the research team or data collectors for assessment of outcomes. Three studies did not conduct appropriate statistical analysis (Kwon and Chang, 2000; Martinelli, 2013; Talpade and Caddell, 2015). One study did not use valid and reliable instruments to measure outcomes (Talpade and Caddell, 2015).

GRADE Quality Rating

Study Limitations

Of six studies included in the meta-analysis, the majority of the studies rated were as high risk of bias (n = 3).-Two studies described the method for providing randomised sequence generation

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(Poddar et al., 2012; Shahril et al., 2013). One study adequately concealed intervention and control groups (Poddar et al., 2012). One study could anticipate allocation as it was explained to participants (Peterson et al., 2000). Three studies described the method of blinding which involved blinding of the principal investigator or research assistants (Ehlert, 2010; Jung et al., 2011; Shahril et al., 2013). Three studies performed a completer's analysis (Jung et al., 2011; Poddar et al., 2012; Shahril et al., 2013) and one study performed an intention to treat analysis (Peterson et al., 2000). All but one study reported pre-specified outcomes.

Consistency

The effect size for change in calcium intake yielded an I^2 statistic of 75.1% (P value for heterogeneity = 0.003) and I^2 statistic of 53.4% (P value for heterogeneity = 0.092) for change in dairy intake. Both of these results indicate moderate heterogeneity (Figure 2 and 3).

Directness

There are variations between study design, population and outcome measures which made it difficult to compare between studies. The majority of population included in our study were college students, and only two interventions recruited beyond the university or college setting (Jung et al., 2011; Koszewski et al., 1990).

Precision

Only three studies reported conducting sample power calculations; however, these were mainly based on Bone Mineral Density (BMD) outcomes rather than calcium or dairy intake. One study calculated power to examine bone density (Jung et al., 2011). The sample size of the population included in the GRADE body of evidence yielded 1091 participants (range 78 to 380), which is considered insufficient.

Publication Bias

Whilst an extensive search strategy was conducted to minimise the risk of publication bias, this cannot be ruled out as unpublished or negative finding studies may have been missed. Funnel plot and statistical tests of publication bias were not reported as they are not recommended for meta-analyses less than 10 studies due to the inability to detect true symmetry with fewer studies (Higgins J, 2011). As shown in Table 5, overall body of evidence was rated as low due to the study limitations, heterogeneity and small sample size in the included studies. Out of six studies included in the meta-analysis, one scored low risk of bias, three as unclear and two were high risk, which indicates serious limitations.

Efficacy of Interventions

Of the 16 reviewed studies, 10 studies provided results for calcium and eight studies provided results on dairy intake. Four studies included results for both calcium and dairy intake. Studies targeting calcium intake appear to be slightly more successful than dairy intake. For calcium, five studies were included in the meta-analysis; six of which reported positive effects (SMD 0.05-0.79, four were statistically significant). The pooled effect size was 0.35 (95% CI 0.04 to 0.67); all studies contributed similar weighting (ranged from 17.85% to 24.65%).

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For dairy, three studies were included in the meta-analysis; all of which reported positive effects (SMD 0.04-0.50, two were statistically significant). The pooled effect size was 0.31 (95% CI 0.11 to 0.50). Contributing weighting of studies ranged from 13.62 to 31.76%).

Quality and Validity of Dietary Assessment Tools

As shown in Table 6, over half of the studies scored as acceptable/ reasonable (n = 9). Five studies were rated as poor and two studies rated good. The mean score was 2.5, and ranged from 1 to 4.

Of the reviewed studies, the most common method of assessing intake was food record (n = 8) and three studies used a dietary recall. Five used tools that were specific to the study such as questionnaires, FFQs (Food Frequency Questionnaire) and capturing photos of meals. Three studies used a FFQ, one of which had been validated previously in a similar population (Gerend and Shepherd, 2013), and one conducted a test-retest of the instrument (Peterson et al., 2010). A majority of the studies did not acknowledge appropriate validation studies in relation to the use of their tool; (Hertzler and Frary, 1994; Ilich et al., 1998; Thompson and Byers, 1994) and only three studies provided details of a validation study in sufficient detail (Gerend and Shepherd, 2013; Jung et al., 2011; Peterson et al., 2000).

Discussion

To our knowledge, this is the first systematic review of interventions of calcium or dairy intake among young adults. Our findings suggest that calcium or dairy interventions may have a small effect on increasing intake, as indicated by the meta-analyses. However, findings must be

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interpreted with caution, due to the presence of heterogeneity and poor quality of the intervention studies.

Education was reported as the most widely used technique to change behavior. It was previously suggested in the literature that knowledge of calcium was related to intake of dairy foods (Nicklas, 2003). While knowledge is important, it is apparent that knowledge on its own is not sufficient for a behavior change to take place (Brug et al., 2005; Jepson et al., 2010). Participants must be taught the ‘how to’ aspect of behavior change (Worsley, 2002). Research has established the importance of incorporating a behavior change theory in the intervention (Brug et al., 2005). Half of the studies included a theoretical construct or a behavior change technique in their intervention, but of these only four of seven had positive outcomes. Self-efficacy is often thought to be the best predictor of engagement in a particular behavior (Hackman and Knowlden, 2014), but it is reported that there are two phases of self-efficacy motivational and volitional in healthy eating and both need to be high for behavior change (Ochsner et al., 2013). This may be why only three of five studies addressing self-efficacy were successful. A meta-regression examining successful behavior change techniques for adopting healthy eating and physical activity in adults revealed that self-monitoring combined with at least one other technique from control theory such as goal-setting and feedback was more effective (Michie et al., 2009). Four studies used goal-setting and two of these resulted in positive behavior changes, one of which also used self-monitoring.

Among the studies that improved dairy or calcium intake, only small changes were observed. Several studies reported the increase being significant but still inadequate compared to dietary guidelines. The benefits resulting from behavioral modification to improve calcium intake may only be evident over time, however the long term effectiveness of the interventions in the current review cannot be determined since only seven studies included a follow-up. They will only reap the benefits if the behavior modifications are sustained and a longer follow-up is required to determine this. It is necessary to address any barriers, as well as beliefs and myths concerning dairy foods consumption. Future studies may benefit from addressing barriers to dairy consumption in order to address long-term behavior change, as stated in a recent review (Hendrie et al., 2013).

From our assessment of dietary tools, it is evident that some uncertainty remains in the quality of the tools used. In order to assess shortfalls in a population, an accurate measurement is required. An earlier review by Magarey et al emphasized the need to develop better quality tools to assess calcium and dairy foods intake (Magarey et al., 2014); our findings from this review are in agreement. The studies included in this review are of uncertain quality as a majority of the papers did not conduct blinding of investigators and participants or ensure random allocations or concealment or blinding of assessors. However, two studies rated scored as high quality, both of which were effective.

The degree to which the interventions can be translated to the broader young population is poor, as a majority of our studies recruited from a university or college setting. Most of the studies were conducted in western countries and used convenience sampling. Even though the latest statistics show a greater proportion of young adults entering tertiary education (OECD, 2015), young people in lower socioeconomic status remain underrepresented (Centre for the Study of

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Higher Education, 2008). This gap could be addressed by recruiting outside the tertiary sector in the community at large.

None of our studies provided information of sustainability or costs; therefore, the external validity remains unclear. Numerous systematic studies have emphasised the lack of external validity in the field of public health research (Blackman et al., 2013; Klesges et al., 2008; Laws et al., 2012; Nour et al., 2016; Partridge et al., 2015). In order to upscale interventions and translate into the wider community, studies need to report on external validity components, particularly program sustainability and cost-effectiveness.

Interventions which were of higher intensity (i.e. provided weekly or daily contact) did not perform any better compared to interventions that were of low intensity (only one point of contact) or moderate intensity. This is consistent with a recent review (Racey et al., 2016), which included children from 9 to 18 years in a school setting. Face-to-face contact was the most widely used method for delivery of the interventions, however, with increasing use of technology; a small number of interventions incorporated an electronic component. Recent reviews on e-health or m-health interventions for other dietary behaviors have shown promising results (Free et al., 2013; Nour et al., 2016; Webb et al., 2010). A recent review targeting dairy food intake in adolescents found that interventions were successful without providing an individual contact (Marquez et al., 2015). This is an important consideration as it means group delivery of an intervention may be sufficient when targeting this age group, resulting in lower costs. Earlier reviews have pointed out the lack of electronic interventions in this field of research (Marquez et al., 2015; Ryan et al., 2013). There is the potential to explore the use of

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electronic technologies in interventions to improve intake of dairy products, as they are a convenient and possibly cost-effective alternative to traditional modes (Steinhubl et al., 2015).

Three studies in our review included a form of electronic technology, two of which were successful and incorporated face-to-face contact, which indicated that some human contact may be important. It may be worth focusing on a discrete nutritional behavior rather than trying to change numerous behaviors (Hendrie et al., 2013; Jung et al., 2016; Sweet and Fortier, 2010).Targeting one nutrition behavior may be more manageable for the participants as they are likely to view it as seemingly minor and manageable compared to a global change in diet (Jung et al., 2016)

Future studies could consider online-technology based interventions because they can double the number of users as opposed to an average public health campaign (10% vs. 5% respectively) (Cugelman, 2013). With the rise of the internet as a source of nutritional and medical information and high ownership of smartphone in young adults, these may be appropriate channels to deliver health promotion (Kite et al., 2016; Pollard et al., 2015). Furthermore, smartphones are becoming very popular, young adults having the highest smartphone ownership and a recent US survey has revealed that 85% young adults are smartphone user and almost three-quarters have used their smartphone to look up health information (Pew Research Center, 2015). There have already been a number of successful interventions addressing other nutritional behaviors using this media to promote nutritional behavior (Allman-Farinelli et al., 2016; Coughlin et al., 2015; Nour et al., 2017; Olson, 2016).

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This review has several strengths which include a comprehensive search strategy, adherence to PRISMA protocol for selection of studies (Moher et al., 2009), and a meta-analysis for dairy foods and calcium intake. In addition, two reviewers conducted a risk of bias and GRADE assessment to assess the overall body of evidence. The limitations of the included studies are the dietary tools used to measure dietary intake and overall poor quality of studies. The limitations of the search strategy include filtering studies that were only published in English and those indexed in major databases. While attempts were made to search grey literature, the possibility of publication bias cannot be ruled out. Finally, the considerable differences in the intensity of the interventions made it difficult to make direct comparisons between the studies.

In conclusion, our review revealed some evidence demonstrating that calcium and dairy interventions are effective; however, poor quality of studies and moderate heterogeneity remain a limitation. Future interventions could include a form of electronic technology, self-monitoring, goal-setting and social support for increasing intake. Greater rigour is needed in terms of reporting external validity components and improving quality of interventions in order to confidently determine their effectiveness and cost-effectiveness for dissemination to the population-at-large. The findings of this review may be used to inform the development of future interventions targeting young adults for increased calcium and dairy intake to optimal levels.

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Table 1 Electronic database search: Medline

Search ID number	Search terms	Results
1	Young Adult/	473361
2	Students/	40762
3	Youth* .tw	41829
4	(Young* adj2 (adult* or person* or people)).tw.	89813
5	College student*.tw.	12779
6	University student*.tw.	7540
7	or/1-6	2009668
8	exp Dairy Products/	79847
9	Calcium, Dietary/	12999
10	or/8-9	91783
11	Telemedicine/	13171
12	Electronic Mail/	2075
13	exp Internet/	57138
14	Mobile Applications/	819
15	exp Cell Phones/	6658
16	Telephone/	9838
17	Reminder Systems/	2550
18	Social Networking/	1337
19	Information Dissemination/	11843
20	Computer Systems/	11937
21	Ehealth*.tw.	762
22	Mhealth*.tw.	342
23	E-health*.tw.	1132
24	M-health*.tw.	108
25	Mobile health.tw.	592
26	Telehealth.tw.	1668
27	Text*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]	78307
28	SMS.tw.	3117
29	Health messag*.tw.	1392
30	Social media.tw.	1784
31	Electronic health.tw.	5165
32	Telecommunication.tw.	1013
33	Computer based.tw.	10083
34	Electronic Communication.tw.	561
35	Smartphone*.tw.	1397
36	Diet/	126793

37	Mobile app*.tw.	396
38	Diet Records/	4359
39	Education, Distance/	2903
40	Food Preferences/	10770
41	Social Control, Informal/	3542
42	Social Support/	55800
43	Nutritional Sciences/	10778
44	Food Habits/	24013
45	Health Promotion/	58486
46	Education/	18872
47	Health Communication/	918
48	Health Literacy/	2445
49	Consumer Health Information/	2322
50	Health knowledge, attitudes, practice/	81149
51	Individual session*.tw.	540
52	Group session*.tw.	2242
53	Phone call*.tw.	1711
54	Dietary intervention*.tw.	4298
55	Dietary program*.tw.	144
56	Nutrition intervention*.tw.	1341
57	Nutrition program*.tw.	1636
58	Nutrition education*.tw.	2920
59	Education program*.tw.	19706
60	or/11-59	577665
61	7 and 10 and 60	1469
62	limit 63 to english language	1378

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Table 2 Reach and representativeness of participants

Author, year, country, citation	Target population	Inclusion criteria	Recruitment methods	Participation	Study design and study arms (n)	Baseline demographics (mean±SD)
(Bohaty et al., 2008), USA	Young females	Aged 19-30 years, not currently pregnant or breastfeeding and able to speak, read and write English	Information flyers posted at hairdressing school, a fitness centre and a day care centre.	NR	B&A	Age: 22.3±3.1
					I: 80	Sex: all females
					No control group	Ethnicity: 98% Caucasian
						Other: 74% freshmen
(Ehlert, 2010), USA	College students	Part of the Education Opportunities Fund (EOF) program at University	Email sent to EOF students	NR	RCT	Age: 18 years: 81%
					I: 40	Sex: 64% females
					C: 38	Ethnicity: I: 50% Black or AA
						C: 50% Hispanic or Latino
(Gerend and Shepherd, 2013), USA	College women	Undergraduate women	From on campus laboratory	NR	Non-RCT	Age: 18.45±0.86
					141 (group numbers not provided)	Sex: all females
						Ethnicity: 82% White
(Ha et al., 2009), USA	College students	Healthy, 18-24 years and enrolled in basic nutrition class	Sophomore level nutrition class	NR	B&A	Age: 20.15±1.38
					I: 90	Sex: 88% females
					No control group	Ethnicity: 90% White
						BMI: 26.3±5.63
(Jung et al., 2011), Canada	College women	Female, less than 19 years of age, living in university residence and consuming less than DRI for calcium (as reported in a FFQ)	Conducted during a campus club fair at McMaster University	290 women met criteria	RCT	Age: I: 18.4±0.66
					I: 67	C: 18.6±0.55
					C: 66	Sex: all females
(Koszewski et al., 1990), USA	College women	Female undergraduate students	Notice posted in school newspapers and newsletters and personal student contacts in sororities, dormitories and classes.	PP: 22,000	RCT	Age: 20±3
				PR: 0.6%	I: 68	Sex: all females
				5000 contacted	C: 62	Other: 32% freshmen
(Kwon and Chang, 2000), Korea	College students	Students enrolled in a basic nutrition course	Participants of a basic nutrition course	NR	B&A	Age: 20.0±2.3
					I: 187	Sex: 79% females
					No control group	BMI: 20.2±2.3
(Martinelli, 2013), Italy	College sports students	University scholarship athletes	From a pool of recipients of a university scholarship	PP: 105	B&A	Age: 21.6±2.4
				PR: 6.7%	I: 7	Sex: 57% females
					No control group	BMI: 25.4±2.3
(Peterson et al., 2000), USA	Young females	Aged 18-30 years with low baseline calcium intake (<700 mg/day)	Television and newspaper advertisements/flyers distributed at the local businesses and Psychology Department	255 responded to recruitment	RCT	Age:
					I: 62	I: 21.6±3.8
					C: 60	C: 21.1±2.9
						Sex: all females
						Ethnicity: 33% minority
(Peterson et al., 2010), USA	College students	18-23 years, have a meal plan with residence hall	Surveys distributed in person during lunch and dinner and person entering	PP: 19,878	B&A	Age: 19.58±1.365
				PR: 1.4%	I: 288	Sex: 36% females
					No control	Ethnicity: 61%

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		dining and eat at least 3 meals at the dining hall weekly	the cafeteria were invited.		group	White/ Caucasian 27% AA
(Poddar et al., 2010), USA	College students	No exclusion criteria	Recruited from an undergraduate elective personal health course	PP: 997 PR: 29.5%	RCT I: 148 C: 146	Age: I: 20.2±1.3 C: 20.2±1.5 Sex: 55% females Ethnicity: 82% White 11% Asian/ Pacific Islander
(Poddar et al., 2012), USA	College students	Enrolled in health-related classes, 980 eligible to participate, no exclusion criteria	Recruitment announcement on course website, descriptive flyer emailed to students and direct recruitment during lectures	PP: 980 PR: 21.5%	RCT I: 107 C: 104	Age: 20.2±0.1 Sex: 57% females Ethnicity: 73% White
(Shahril et al., 2013), Malaysia	College students	18-24 years, actively using mobile phone, first or second year diploma or degree from management studies, healthy and able to read, write and understand Malay or English	Students recruited from class lists based on eligibility criteria	NR	RCT I: 205 C: 212	Age: I: 19.2±1.1 C: 19.0±1.2 Sex: 81% females
(Sueta and Fukuda, 1995), Japan	College women	Students taking a dietitian course	Students taking a dietitian course	NR	Non-RCT I: 54 C: 54	Age: 18 or 19 Sex: all females
(Sueta, 2000), Japan	College women	Students taking a dietitian course	Students taking a dietitian course	NR	Non-RCT I: 54 C: 54	Age: 18-19 Sex: all females
(Talpade and Caddell, 2015), USA	College students	African American students	Enrolled in a research class	NR	B&A I: 40 No control group	Age: 18-26 Sex: 80% females Ethnicity: all AA BMI: 25.71

NR= not reported

B&A= before and after study design

I= intervention

BMI= body mass index;

PP= population pool

PR= participant rate

RCT= randomised controlled trial

C= Control

AA= African American

DRI= dietary reference intake

FFQ= food frequency questionnaire

Non-RCT= Non-randomised controlled trial

BMD= bone mineral density

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Table 3 Intervention implementation and adoption

Author, year, citation	Intervention								
	Mode of contact	Frequency of contact	Setting	Dietary focus	Description	Theoretical construct	Study arms	Personnel	Duration (including follow-up)
(Bohaty et al., 2008), USA	Face-to-face	10 sessions	Community	Calcium and dairy only	45-min slide show presentation followed by group discussion, follow-up phone call and handouts;	SCT	I: educational intervention to increase calcium, vitamin D and dairy	Nurses	>8 wks (NR)
		1 f/u call at 8 wks post-intervention					No control group		
(Ehlert, 2010), USA	Face-to-face	4 sessions held every 3 wks	University	Calcium, dairy and other	Four sessions delivered in 1.5 hour segments; face-to-face session followed by discussion, questionnaire	SCT	I: SNAAKS curriculum	Questionnaire reviewed by nutrition and curriculum experts	14 wks
							C: non-nutrition curriculum		
(Gerend and Shepherd, 2013), USA	Face-to-face, handouts	One-off session	University	Calcium only	Participants were given 6 mins to read a pamphlet and received handouts to take home	Gain and loss framed messaging	I_1: gain-framed pamphlet	NR	~1 mo (NR)
		1 f/u at 1 mo post-intervention					I_2: loss-framed pamphlet		

(Ha et al., 2009), USA	Face-to-face	3 times per week	University	Dairy and calcium only	Traditional lecture with interactive activities. Participants met 3 times a week for 50 mins and completed a "Happy Body Log" to encourage behavior changes	NR	I: class-based nutrition intervention No control group	NR	Spring Semester, ~15-16 weeks (NR)
(Jung et al., 2011), Canada	Face-to-face	One-off session, f/u by mail 7 and 24 wks post-intervention	University	Calcium only	45 min seminar followed by second mail-delivered intervention: OSC's 'Speaking of Bones' presentation and two pamphlets	HBM	I: 20 gain-framed messages C: 11 loss-framed messages	Registered dietitian presented the seminar	52 wks
(Koszewski et al., 1990), USA	Face-to-face	One-off session, food intake recorded 4 wks post-intervention	University	Calcium and other	15 min slide-tape presentation with Q&A session at the end	NR	I: slide-presentation C: no presentation	Data collection by trained graduate and undergraduate students	1 mo
(Kwon and Chang, 2000), Korea	Face-to-face	NR	University	Dairy and other	Basic level nutrition course at the university	NR	I: nutrition course No control group	NR	Questionnaire collection for ≥2 wks (NR)

(Martinelli, 2013), Italy	Face-to-face, email	6 sessions over 5 mo	University	Calcium and other	Six sessions with interactive workshops on topics relevant to sports nutrition. Group emails sent for meeting times and other program details	NR	I: nutrition education programme	Qualified sports nutrition professional and performance nutritionist	5 mo
							No control group		
(Peterson et al., 2000), USA	Face-to-face	3 sessions, f/u lab visit at 3 and 6 mo + call reminder before an appointment	University	Calcium only	Three calcium intervention sessions in small groups, explaining osteoporosis, sources of calcium and assessing change in intake	NR	I: behavioral/ nutrition intervention	NR	6 mo
							C: no intervention		

(Peterson et al., 2010), USA	Paper	3 reminder emails sent out to record food intake	University	Dairy and other	A logo “The Right Stuff!” was created at point-of-selection to promote healthy foods. Card showing healthy choices and flyers/ signs distributed in the area.	NR	I: point-of-selection intervention No control group	Content validity by registered dietitians	3 wks
(Poddar et al., 2010), USA	Electronic, online and email	Daily emails for the first 3 wks, then once every wk for the final 2 wks	University	Dairy only	Online course; posted information, behavior checklists and tailored feedback.	SCT	I: web based nutrition education C: no intervention	Doctoral student in nutrition and 3 registered dietitians	5 wks
(Poddar et al., 2012), USA	Electronic/ online + face-to-face (optional)	Weekly- one module/ per wk. Social event held fortnightly (optional)	University	Dairy only	Online course management system (specifically developed for the study). Participants asked to complete weekly behavior checklists and social events providing nutrition education.	HBM	I: dairy intervention based on SCT	A registered dietitian attended social events session to provide education and practical tips on increasing dairy	8 wks

							C: stress management intervention		
(Shahril et al., 2013), Malaysia	Face-to-face, electronic/ text messaging	A total of 13 text messages sent every 5 days	University	Calcium, dairy and other	Multimodal intervention: conventional lectures, brochures and text messaging used	NR	I: multimodal intervention	Nutrition and public health s developed key messages, diet history and data analysis performed by a nutritionist	10 wks
							C: no intervention		
(Sueta and Fukuda, 1995), Japan	Face-to-face	One-off session, food intake recorded 1 wk and 1 yr post-intervention	University	Calcium only	National survey results shown, participants learnt to self-evaluate their eating pattern and set goals, 40 min videotape on why calcium is necessary and taught how to eat enough in their diet (Basic Foods List)	NR	I: calcium education	Basic Foods List developed by dietitians	12 mo
							C: no intervention		

(Sueta, 2000), Japan	Face-to-face	One-off session, food intake recorded 1 wk and 1 yr post-intervention	University	Calcium only	National survey 1991 results shown, participants learnt to self-evaluate their eating pattern and set goals. Education videotape on calcium intake screened and taught how to eat enough calcium in diet (Basic Foods List)	NR	I: calcium education C: no intervention	Video shown developed by a group of dietitians	12 mo
(Talpade and Caddell, 2015), USA	Face-to-face	Weekly sessions held over 2 wks, food intake recorded 3 mo post-intervention	University	Dairy and other	Two 50-min information sessions over two weeks;	Trans-theoretical stages of change model + theory of reasoned action	I: HEALTH intervention No control group	NR	4 mo

F/u= follow-up

SCT= Social Cognitive Theory

I= intervention

Wks= weeks

NR= not reported

MI- motivational interviewing

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C= Control

Yrs= years

SNAAKS= Student Nutrition Action, Attitude, Knowledge and Skills

OSC= Osteoporosis Society of Canada

HBM= Health Belief Model

Q&A= Question and answer

GBTL= game based team learning

CDAS= cloud diet assessment system

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Table 4 Study results and maintenance

Author, year, citation	Baseline to post-intervention		Effect size (Cohen's d)	Attrition	Compared drop outs	Follow-up
(Bohaty et al., 2008), USA	Calcium: mg Pre: 961.3±477 Post: 905.0±510 P= 0.38 (NS)	Dairy: cups Pre: 0.7278±0.82 Post: 0.8608±0.88 P: 0.14 (NS)	NA, no control group	NR	NR	Yes, at wk 2 (phone call) wk 8 (dietary intake).
(Ehlert, 2010), USA	Calcium: Calcium-rich food servings Pre: I: 2.35±1.18 C: 2.42±1.44 Post: I: 2.42±1.45 C: 2.47±1.24 P: 0.020	Dairy: frequency/day Pre: I: 0.765 ±1.84 C: 1.54 ±4.13 Post: I: 1.51 ±2.77 C: 0.901 ±1.66 P: 0.800 (NS)	Calcium: -0.037 Dairy: 0.265	Nil	NR	NR
(Gerend and Shepherd, 2013), USA	B= 0.29 No further information provided		No control vs. intervention mean and SE/SD for calculation	11% (n=15)	Yes, non-completers were similar to completers for all demographics	Yes, participants returned one month after intervention to provide intake data.
(Ha et al., 2009), USA	Calcium: mg Pre: 813.18±501.48 Post: 858.21±373.11	Total milk: fl.oz Pre: 5.40±9.57 Post: 6.43±11.27 P: 0.433 (NS) Milk: S, NR (females only)	No control vs. intervention mean and SE/SD for calculation	11% (n=10) No control group	NR	NR
(Jung et al., 2011), Canada	Calcium intake (mg): Pre: I: 927±369 C: 891±286 Post: I: 1144±514 C: 813±286 P: <0.01		Calcium: 0.787	I: 24% (n=16) C: 29% (n=19)	NR	Yes, at week 8 (mail-delivered intervention), week 25 (mail-delivered intervention) and week 52 (diet assessment).
(Koszewski et al., 1990), USA	Calcium: mg Pre: I: 93±62 C: 116±73 Post: I: 99±71 C: 96±56 P> 0.05 (NS)		Calcium: 0.047	NR	NR	NR
(Kwon and Chang, 2000), Korea		Milk and dairy foods: mg Pre: Males: 484.9±232.5 Females: 405.0±233.3 Post: Increase in females, amount, NR Milk & dairy: S, NR (females only)	No control vs. intervention mean and SE/SD for calculation	NR	NR	NR
(Martinelli,	Calcium: mg		No control vs.	Nil	NR	NR

2013), Italy	Pre: 924.9±365.1 Post: 1112.5±826.2 P: 0.510 (NS)		intervention mean and SE/SD for calculation			
(Peterson et al., 2000), USA	Dietary calcium intake: Pre: I: 418.17±136.94 C: 470.15±155.81 Post: I: 725.82±334.28 C: 634.16±302.44 Follow-up I: 755.28±305.25 C: 676.96±315.00 P: <0.001		Calcium: 0.253	34% (n=42)	Yes, drop-outs had a significantly lower baseline calcium intake compared to those who completed the study	Yes, at 3 and 6 mo for diet assessment.
(Peterson et al., 2010), USA		Cottage cheese: P= 0.001 (correlation significant at the p≤0.01 level) Skim milk P: NR, NS	Calcium:	I: 64% (n=184) No control group	NR	NR
(Poddar et al., 2010), USA		Dairy: total dairy (servings/ day) Pre: I: 1.5±1.16 C: 1.4±1.17 Post: NR P: NR, NS	No control vs. intervention mean and SE/SD for calculation	I: 9% (n=13) C: 7% (n=10)	NR	NR
(Poddar et al., 2012), USA		Dairy: Pre: servings/day I: 1.37±0.95 C: 1.97±0.94 Post: adjusted I: 0.17±7.78 C: -0.13±7.45 P: 0.01	Dairy: 0.039	I: 16% (n=17) C: 14% (n=15)	NR	NR
Shahril et al 2013 (Malaysia)	Calcium: Pre: I: 312.6±100.1 C: 331.4±103.8 Post: I: 376.5±125.4 C: 300.6±116.5 P: <0.001	Dairy products: Pre: I: 0.11±0.27 C: 0.05±0.14 Post: I: 0.13±0.27 C: 0.06±0.14 P: 0.005 Milk: Pre: I: 0.08±0.27 C: 0.09±0.28 Post: I: 0.26±0.40 C: 0.09±0.28 P: <0.001	Calcium: 0.629 Dairy: 0.332 Milk: 0.498	I: 13% (n=27) C: 5% (n=10)	Higher dropout rate in males (16%) vs females (8%)	NR
(Sueta and Fukuda, 1995),	Calcium (mg): Pre:		No SD or SE reported for	Nil	NA	Yes, at one year to collect dietary

Japan	I: 474 C: 494 Post: I: 516 C: 491 P: <0.05		calculation			intake.
(Sueta, 2000), Japan	Calcium (mg): Pre: I: 474.4 C: 494.2 Post: I: 418.8 C: 409.7 P>0.05 (NS)		No SD or SE reported for calculation	I: 1% (n=1) C: 0	Only one person dropped out	Yes, at one year to collect dietary intake
(Talpade and Caddell, 2015), USA	Inter-item correlation matrix for dairy: 1.000 No further information reported		No SD or SE reported for calculation	33% (n=13)	NR	NR

Pre= prior to receiving intervention

Post= post-intervention

NS= not significant

NA= not applicable

NR= not reported

Wks= weeks

I= intervention

C= control

S= significant

Yrs= years

Table 5. Overall assessment of quality in 6 studies (1091 participants) of promotion of calcium or dairy intake using Grading of Recommendations Assessment, Development and Evaluation (GRADE) system (Atkins et al., 2004)

Category	Rating with reasoning
Limitations	-2 quality level due to serious limitations
Consistency	-1 quality level due to high heterogeneity score
Directness	No subtraction of levels, as the population, outcomes and study design are direct
Precision	-1 quality level due to small sample size
Publication bias	No subtraction of levels, not reported as it is not possible to detect true symmetry when there are less than 10 studies
Overall quality	Low; our confidence in the effect estimate is limited

Table 6 Dietary quality of tools used to measure calcium and dairy intake

Study	Method	Validated tool	Dietary score: calculated using ACAORN criteria (Burrows et al., 2012)	
(Bohaty et al., 2008)	Dietary record	No	1.5	Poor
(Ehlert, 2010)	SNAAKS questionnaire	No	3	Acceptable/ reasonable
(Gerend and Shepherd, 2013)	55-item FFQ	Yes (Ilich et al., 1998)	4.5	Good
(Ha et al., 2009)	3-day food record	No	2.75	Acceptable/ reasonable
(Jung et al., 2011)	3-day food record	Yes (Thompson and Byers, 1994)	2	Poor
(Koszewski et al., 1990)	Previous 24-hour food intake	No	1.5	Poor
(Kwon and Chang, 2000)	3-day recall	No	2	Poor
(Martinelli, 2013)	7-day food record	No	2.5	Acceptable/ reasonable
(Peterson et al., 2000)	Hertzler and Frary's rapid assessment questionnaire	Yes (Hertzler and Frary, 1994)	4	Good
(Peterson et al., 2010)	FFQ intake	No	2.25	Acceptable/ reasonable
(Poddar et al., 2010)	7-day food record	No	3.25	Acceptable/ reasonable
(Poddar et al., 2012)	7-day food record	No	2.75	Acceptable/ reasonable
(Shahril et al., 2013)	Dietary recall	No	3.25	Acceptable/ reasonable
(Sueta and Fukuda, 1995)	3-day weighted food record	No	2.25	Acceptable/ reasonable
(Sueta, 2000)	3-day weighted food record	No	2.25	Acceptable/ reasonable
(Talpade and Caddell, 2015)	Capturing meal before and after photo	No	1	Poor

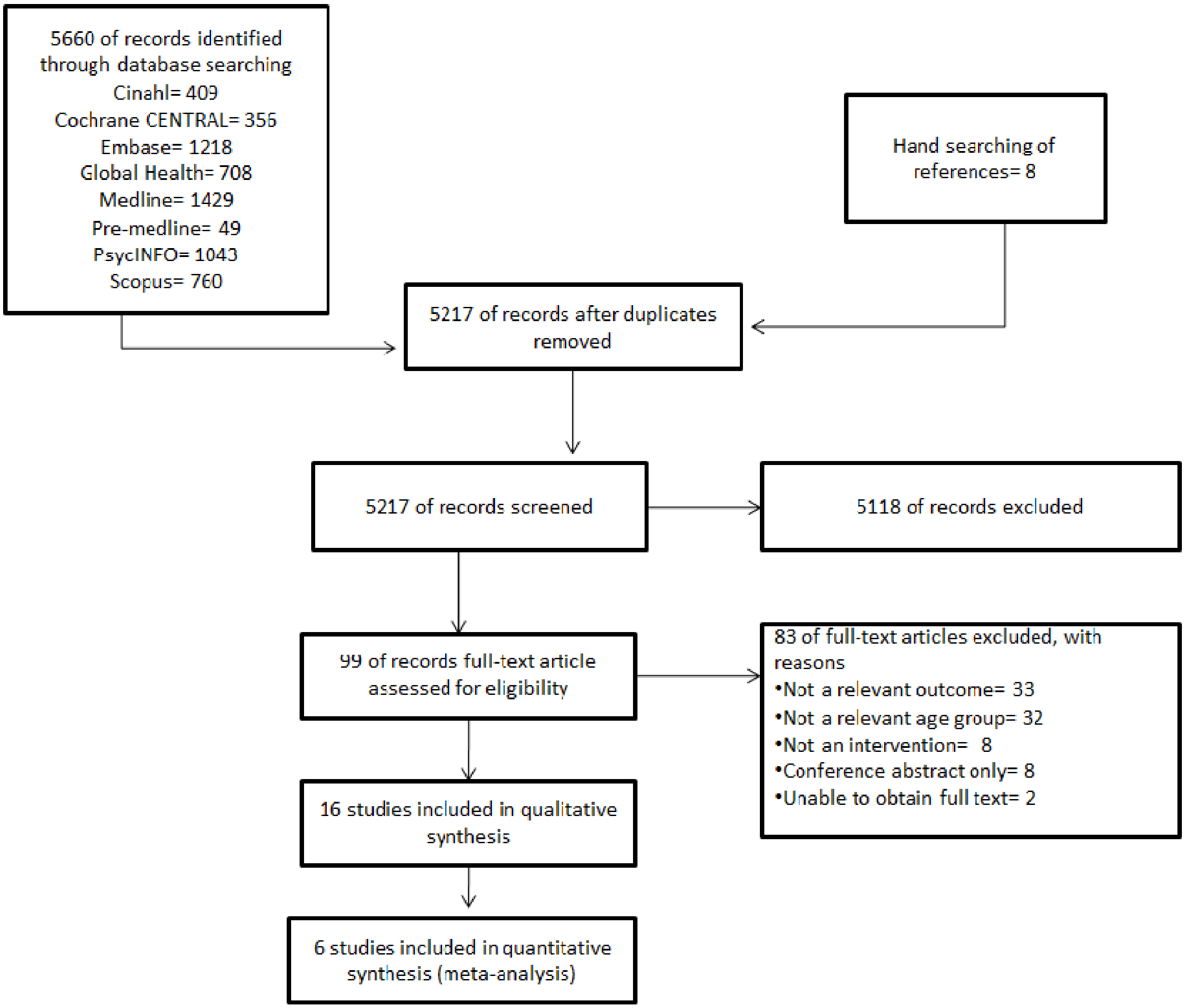

Figure 1 Flow diagram showing selection of studies

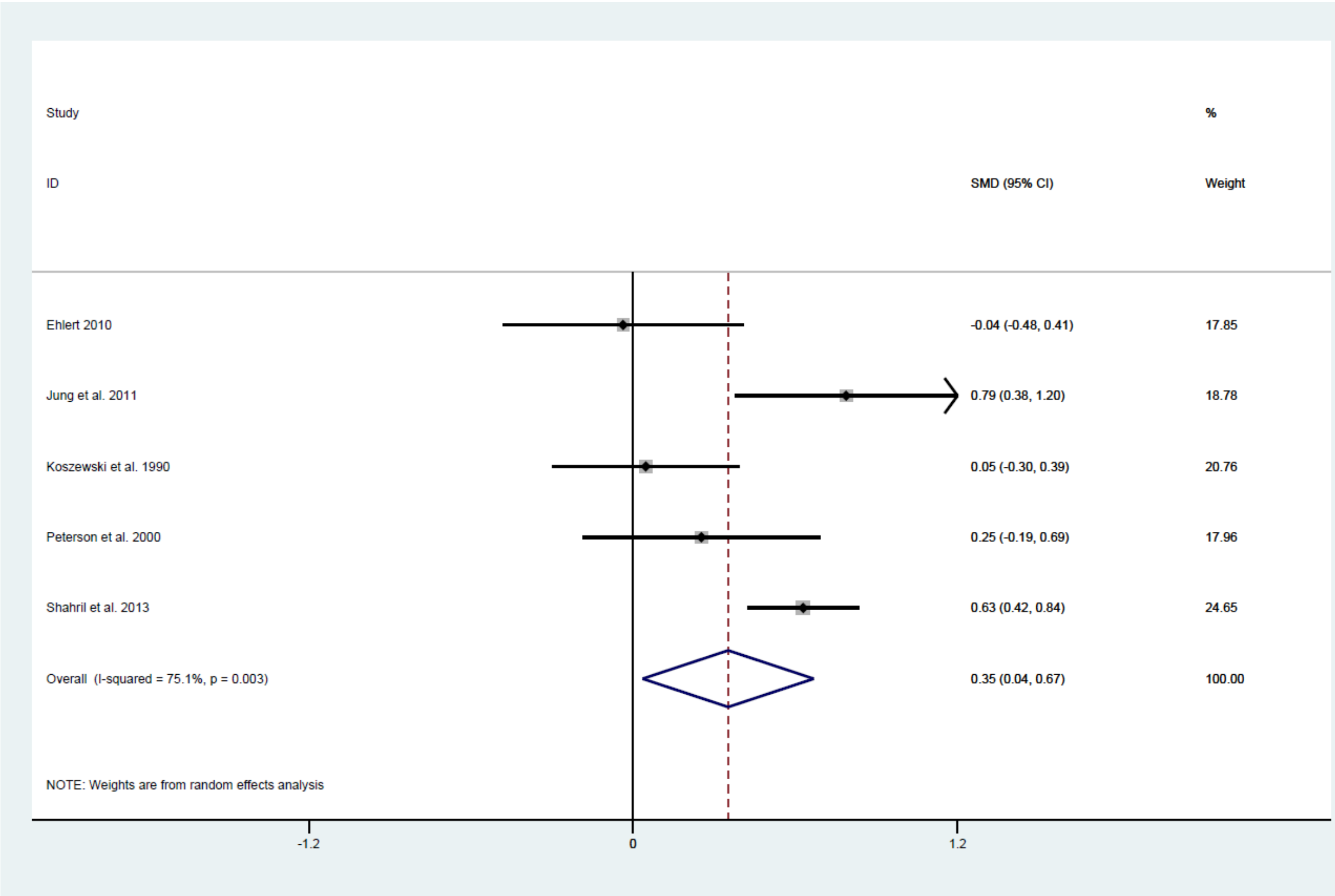

Figure 2 A forest plot of Cohen d effect size for interventions reporting calcium intake

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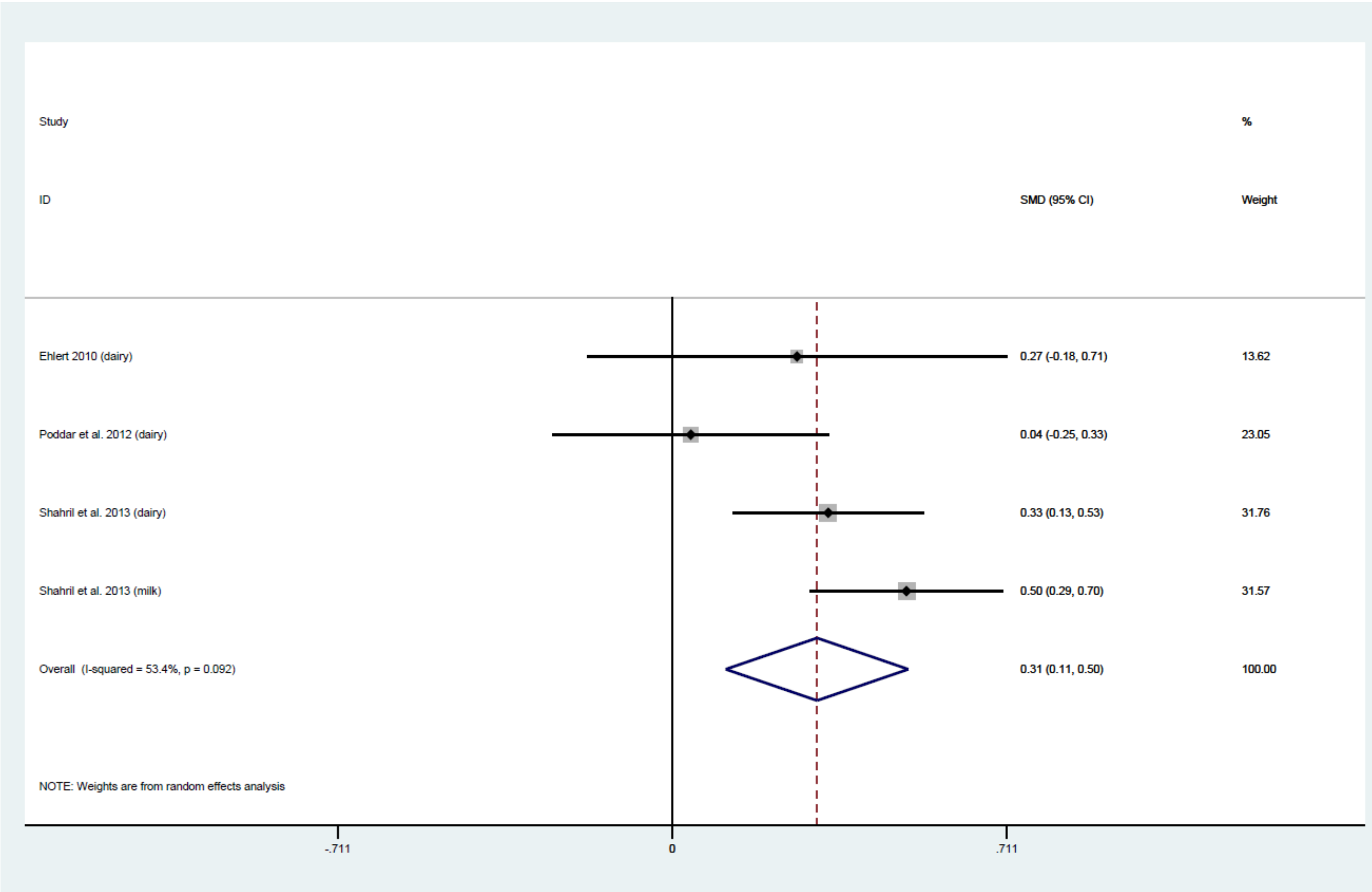

Figure 3 A forest plot of Cohen d effect size for interventions reporting dairy intake