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REVIEW

The impact of osteoporosis prevention programs on calcium intake: a systematic review

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Abstract Little is known about the dimensions of osteoporosis prevention programs essential to changing health behaviors. The purpose of this review was to determine the impact of select characteristics of structured osteoporosis prevention programs on calcium intake in women. This systematic review included 12 experimental and quasi-experimental studies conducted internationally with adult women participants. Studies were more likely to demonstrate differences when they were conducted outside the U.W.; participants had lower baseline calcium intake; and interventions were multi-dimensional and included factual information, skill training, and social contact delivered dynamically over time. The results document extensive variability across participants, programs, and measures. There is a need to document the source (total and sub-total) of calcium intake, to provide the necessary data to calculate effect sizes to enable comparison across studies, and to identify those moderating factors (such as menopausal status) that affect the ability to determine differences between sub-groups. Results indicate health behavior change is more likely to occur when patient-centered interventions designed to increase knowledge and health beliefs, skills and abilities, and social facilitation are delivered over time. There is an urgent need for the development and testing of new health behavior change theories, prevention programs, and delivery media to support and complement health care providers in the prevention and management of this common, debilitating condition.

Keywords Calcium · Osteoporosis · Prevention programs · Systematic review

Introduction

Osteoporosis is a pervasive disease affecting one out of two White women [1, 2], is rapidly increasing among populations of color [3–6], and causes high chronic disease burden worldwide [7]. In 2005, over two million fractures were treated at a cost of $17 billion in the USA alone [2]. It is estimated by 2025 the annual cost of treating fractures will increase by 50 % [2]. While development of osteoporosis is significantly impacted by genetics, hormones, and normal age-related changes, lifestyle choices influence the course of the condition. Current evidence supporting the prevention and management of osteoporosis includes recommendations for regular and routine engagement in health behaviors related to nutrition, physical activity, monitoring, medication use, and appropriate and timely use of health care. Failure to engage in these behaviors jeopardizes the health of the person, efficacy of health promotion programs and clinical care, and the accuracy of findings of clinical trials [8–10]. In developed countries, it is estimated less than 6 % of women have an adequate combination of nutrition and exercise [12, 13]. Results of a multi-country survey conducted by the International Osteoporosis Foundation indicate that during the postmenopausal period, many women deny their personal risk factors for osteoporosis, do not consult with their primary care providers about osteoporosis, and often do not seek diagnostic testing or treatment following an osteoporotic fracture [14]. Failure of women to engage in these health behaviors is of particular concern because menopausal transition and the years immediately following menopause are a time of significant bone loss [15–19].

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Participation in "educational" programs is an intervention used worldwide to increase people's engagement in health-promoting behaviors. It seems logical that participation in an osteoporosis program would increase people's engagement in prevention behaviors leading to positive health outcomes. In actuality, research findings indicate educational programs increase knowledge but do not result in health behavior change [11, 20]. Little is known about components of osteoporosis prevention programs related to changing health behaviors, and there is little agreement about best measures of behavior, when to obtain the measure, inclusion and exclusion criteria, and measuring and reporting dietary and supplemental sources of calcium. The purpose of this systematic review of the literature was to determine the impact of select characteristics of structured osteoporosis prevention programs on calcium intake in women.

Method

Design

This systematic review was based on the work of Cooper and Hedges [21] and was guided by a Population, Intervention, Comparison group, and Outcomes (PICO) Question [22]. The question guiding this project was: "In persons over 18 years of age, what is the impact of participating in an osteoporosis prevention program in comparison to receiving usual care on the outcome of calcium intake?" The choice to focus on calcium represents a research decision and is not intended to diminish the relative contribution of other health behaviors, monitoring, or pharmacology on the prevention and management of osteoporosis. Quality synthesis depends on comparison of conceptually congruent variables across studies [21]. Changing one type of health behavior differs from changing other types of health behavior or changing multiple behaviors at the same time. Hence, engagement in each behavior needs to be measured independently and findings compared across the studies to answer the PICO question.

Sample

The sample of articles was acquired by an electronic search of OVID, CINHAL, and Google Scholar using the following terms alone and in combination: osteoporosis, prevention, health behavior, behavior change, calcium, calcium intake, calcium supplementation, program, and intervention. Additional references were identified using the ancestral method (reference for the originally identified articles) and by finding studies serendipitously. Inclusion criteria consisted of experimental (randomized control trial) or quasi-experimental designs and a measure of calcium intake in milligrams or servings of specific calcium-rich foods. Studies were excluded if calcium was measured using global question (e.g., "has your intake of calcium rich foods increased, remained the same, or decreased?"), if the intervention was designed to change the behavior of providers rather than patients, or if data from same group of participants were reported in more than one article (when this occurred only information from the final report was included).

Measures

A standardized critique form was used to review individual articles. Content was obtained for the following variables and entered onto an evidence table (Table 1):

- Characteristics of the research (design, sample, setting, number of measurement times, and attrition)
- Characteristic of participants (age; gender; inclusion and exclusion criteria including menopausal status, bone density, and baseline calcium intake)
- Calcium (baseline calcium intake, changes in calcium intake over time, source of calcium including foods and supplementation, and specific measure of calcium intake)
- Characteristics of the intervention (content, delivery method, delivery processes, and intensity of the intervention).

Synthesis tables were used by the authors to facilitate identification of patterns across studies [23]. Information from select synthesis tables was consolidated and is available on Table 2.

Procedure

All studies initially identified were read to determine whether or not the study met the inclusion and exclusion criteria. Studies meeting the criteria were critiqued by two experienced reviewers. Working definitions and categorization of variables increased in precision over time through discussion and debate. Initially, all studies that included calcium intake as a variable were included in the collection of articles regardless of how calcium was measured. Milligrams of calcium either were directly measured or were able to be calculated in some studies (a quantitative assessment of calcium intake). Other studies evaluated participants' perceptions of a relative increase in calcium intake (a qualitative assessment of calcium intake). Because the qualitative measures were not comparable across studies, only those studies that measured or calculated milligrams of calcium were included in this analysis. The evidence table was created and revised until there was standardization of information across studies. A synthesis table was created to identify patterns across studies [23] (Table 2).

Results

After screening titles and abstracts, a total of 59 articles published between 2000 and 2011 were read and critiqued.

Table 1 Impact of an osteoporosis prevention program on calcium intake: an evidence table

Reference	Group/intervention	Method	Findings
Blalock et al. 2000 [32]	Group 1: Mailed a 4-page brochure containing factual information	Design: RCT; data collection 2 times prior to enrollment, 1, 3, and 12 months	No difference in calcium intake among groups
	Group 2: Mailed two brochures designed to assist the participant to create a personal action plan for diet and exercise	Sample: cohort; N=536; ages 35 to 43, pre-menopausal, no history osteoporosis	
	Group 3: Both group 1 and 2 material	Setting: Community; North Carolina, USA, names obtained from driver's license records	
	Group 4: No mailed brochures. All participants received personal feedback following initial assessment related to their calcium intake and level of exercise	Measures: Health Habits and History Questionnaire; Supplements	
Blalock et al. 2002 [33]	Group 1: Education tailored on stage of change and current behaviors; 2 mailings and 1 phone call	Design: RCT 2 X 2 factorial design (tailored/not tailored: community/ no community); pretest and 3-, 6-, and 12-month posttest	No difference in calcium intake among groups
	Group 2: Mailed, 2 packets of standardized information	Sample: Cluster (geographic); N=547; ages 40 to 56; no history of osteoporosis	Sub-group analysis indicated increases in calcium intake differed by baseline calcium and stage of change
	Group 3: Community partners provided free bone density assessment	Setting: Rural community in North Carolina, USA	
	Group 4: Community partners did not provide free bone density assessment	Measures: Abbreviated version of Block-NCI Health Habits and History Questionnaire	
Brecher et al. 2002 [34]	Group 1: One, 3-h small group session with lecture and interactive exercises	Design: RCT; data collected pre, immediate post, and at 3 months	No difference in calcium intake between groups
	Group 2: Wait list control	Sample: Convenience, N=110, ages 25 to 75; no history of osteoporosis	
		Setting: Community; New Jersey, USA	
		Measures: Short Food Frequency Questionnaire	
Hien et al. 2008 [28]	Group 1: Content matched to region and culture; written and verbal information, practice sessions, and daily involvement of trained lay person	Design: Quasi-experimental; data collected pre, 6, 12, and 18 months; random assignment of commune	Difference in calcium intake between groups
	Group 2: Control	Sample: Groups matched by age, years post-menopause, education, life occupation, current weight-bearing exercise, and calcium intake; N=140; 97 % farmers, ages 55–65; calcium intake <400 mg	
		Setting: Rural, Vietnam, live in commune	
		Measures: Food Frequency Questionnaire	
Kulp et al. 2004 [29]	Group 1: Educational video 10 min in length focusing on osteoporosis and prevention preceded visit with physician who was blinded to group assignment	Design: RCT; pre and 3 months post	Difference in calcium intake between groups (from supplementation)

Table 1 (continued)

Reference	Group/intervention	Method	Findings
	Group 2: Usual care	Sample: Convenience sample; N=195; ages 30 to 80 without osteopenia or osteoporosis Setting: Community; New Jersey, USA, routine gynecological examination USA Measures: Survey of calcium-rich food servings	
Lv and Brown 2011 [24]	Group 1: Six culturally focused weekly interactive small group lesions including food preparation demonstration, personal feedback, and involvement of family	Design: Quasi-experimental nested design; random assignment site; data collected pre, immediate post, and 3 months	Differences in calcium intake between groups
	Group 2: Control group; mailed financial lessons	Sample: Convenience; N=141; 1st generation Chinese-American women; ages 35–55 Setting: Community; Philadelphia, PA, USA, mothers of children attending Chinese culture programs USA Measures: Modified Food Frequency Questionnaire	
Manios et al. 2006 [26]	Group 1: Ten nutrition education sessions held biweekly for 1 h over 5 months; participants received low fat dairy products and participated in interactive discussion, and practicing meal planning	Design: RCT; data collected pre then 5 months Sample: Convenience; N=82; ages 55–65; at least 3 years postmenopausal; no osteoporosis	Difference in calcium intake between groups
	Group 2: Usual care	Setting: Community; Athens, Greece Measures: Dietary indices via a 3-day food diary	
Peterson et al. 2000 [30]	Group 1: Individualized DXA feedback, three small group dietary education sessions, and provided with calcium supplements	Design: RCT; data collected baseline, 3 and 6 months	Differences in calcium intake between groups
	Group 2: usual care	Sample: Convenience; N=82; pre-menopausal women ages 18–30; baseline calcium intake <700 mg Setting: Community; Memphis, TN, USA, university setting Measures: Calcium intake via Hertzler and Frary's Rapid Assessment	
Ribeiro and Blakely 2001 [25]	Group 1: Attended multidisciplinary day long education on osteoporosis with exercise practice sessions	Design: Quasi-experimental; data collected baseline, immediate post, and 6 months	Difference in calcium intake between groups
	Group 2: Attended workshop not related to osteoporosis	Sample: Convenience; N=138; ages 45–69 Setting: Community; Canadian Women's Institute Measures; Newly developed survey of calcium-rich foods	

Table 1 (continued)

Reference	Group/intervention	Method	Findings
Sedlak et al. 2005 [35]	Group 1: DXA feedback and tailored phone message Group 2: Printed DXA feedback	Design: Quasi-experimental; measurement pre and 6 months Sample: Convenience; N=124; ages 50–65 Setting: Community, USA Measures: Osteoporosis-Preventing Behaviors Survey	No difference in calcium intake between groups
Sedlak et al. 2007 [31]	Group I: Educational pamphlet and mailed DXA feedback Group 2: Educational pamphlet; Wait list control for DXA	Design: RCT; data collected baseline, 6 and 12 months Sample: Convenience; N=203; ages 50–65; post-menopausal; no chronic diseases; not on hormone replacement therapy Setting: Community; USA Measures: Osteoporosis Preventing Behaviors Survey	Difference in calcium intake between groups at Time 3 (12 months)
Winzenberg et al. 2006 [27]	Group 1: Feedback about bone density feedback and osteoporosis prevention and self-management course delivered via small group session held 2 h per week over 4 weeks	Design: RCT; data collected baseline and 2 years	No difference in calcium intake between groups
	Group 2: Printed bone density feedback	Sample: Random selection; N=470; ages 25–44 Setting: Community; Southern Tasmania, Australia; Names drawn from electoral roll Measures: Calcium Food Frequency Questionnaire	Increase use of calcium supplementation associated with low bone density

DXA dual-energy X-ray absorptiometry, *mg* milligrams, *RCT* randomized clinical trial/experimental design, *USA* United States of America

Twelve of these 59 studies met the inclusion and exclusion criteria for this review. Eight of the 12 studies were conducted in the USA with one limited to first-generation Chinese American women [24]. The other four studies were conducted in other countries including Canada [25], Greece [26], Southern Tasmania [27], and Vietnam [28]. Four of the five studies (80 %) conducted outside the USA or with first-generation women reported an increase in calcium [24–26, 28] and one did not [27]. In three of the seven studies (43 %) conducted in the USA, participants reported an increase in calcium intake [29–31] and four did not [32–35].

Characteristics of the research

Design, recruitment, comparison groups, and data collection time

Eight studies were RCTs and four used quasi-experimental designs (Tables 1 and 2). Participants were drawn from a community dwelling setting and were recruited via public advertisement (e.g., newspapers, flyers), public data bases (drivers license, electoral roll), worksites (colleges and business settings), physician offices, independent elderly community housing, places of business (e.g., beauty salons, exercise clubs), and community education programs. Nine of the studies included a usual care comparison group, two studies used an alternative treatment comparison group, and one study used both a usual care and alternative treatment group. Time of outcome measurement varied widely across studies: measurement time for studies with one post-intervention measure varied from 1 month to 1 year; studies with two post-intervention measures varied in the number of months between measures and the months of measurement; and studies with three measures continued collecting data for 1 to 2 years. Sample size varied from 80 to 547 participants, with a total of 2,121 participants in this synthesis. The mean sample size for studies that demonstrated an increase in calcium intake was 155, and the mean sample size was 344 for studies that did not demonstrate difference. The three studies with the

Table 2 Characteristics of studies and differences in calcium intake

Characteristics of the study		Calcium intake											
		Increase							No change				
Reference		[26]	[27]	[22]	[24]	[28]	[23]	[29]	[30]	[31]	[32]	[33]	[25]
Design	RCT		+		+	+		+	–	–	–		–
	Quasi-experimental	+		+			+					–	
Location	USA		+			+		+	–	–	–	–	
	Non-USA	+		+	+		+						–
Ca intake	Baseline	<400 mg/day	50 % of group >3 svgs/day	400 mg/day	700 mg/day	460 mg/day	>1,000 mg/day	<615 mg/day	25 % of group >1,000 mg/day	43 % of group >1,000 mg/day	2–3 svgs/day	<615 mg/day	>805 mg/day
Comparison group	Usual care	+	+	+	+	+	+	+		–	–	–	
	Alternative treatment								–	–			–
No. of post-measures	1 Post-measure		+		+		+					–	
	2 Post-measures			+		+		+			–		–
	3 Post-measures	+							—	—			
Attrition (%)		23	37	0	10	34	35	6	42	26	22	Not avail.	12
Menopausal status	Pre					+			–				–
	Transition and post	+			+			+		–		–	
	Mixed		+	+			+				–		
Intervention contact	1 limited contact		+				+	+	–	–	–	–	
	Extended contact	+		+	+	+						–	–
Effect size		4.4		.58	6.4	2.7	.43						

Menopausal status categorization: <45 years of age=pre; 45 to 55 years of age=transitional; >55 years of age=postmenopausal

– no significant differences between groups, + significant differences between groups, *svgs* servings per day, *CA intake* calcium intake, *mg* milligrams, *not avail.* information not available largest sample sizes did not result in an increased calcium intake between/across groups; n=536 [32], n=547 [33], n=407 [27].

Attrition

When attrition was reported, it ranged from 0 to 42.7 % (mean of approximately 23 % across all studies) and was higher in longer studies and in the control group (Table 2). Higher rates of attrition were reported in studies conducted in the USA.

Characteristics of participants

The participants in all studies were women ranging in age from 18 to 80. The ages of female participants are particularly relevant in studies of osteoporosis because of the relationship between age, menopausal status, and bone density [16–18, 36]. Categorizing women enables comparison across menopausal status. For this project, women under the age of 45 are categorized as pre-menopausal, women between 45 and 55 as in menopausal transition or early menopause, and women older than 55, as post-menopausal. Menopausal status of participants varied across studies, and women in menopausal transition and post-menopause were slightly more likely to change their health behaviors than pre-menopausal women (Table 2).

Inclusion and exclusion criteria of studies reviewed

In two studies, women were excluded from participation [28, 30] if their calcium intake met or exceeded recommended standards. In the other ten studies, calcium intake was not a condition of eligibility. There was considerable variation in the baseline calcium intake across studies (Table 2). A diagnosis of osteoporosis was an exclusion criteria in five studies (identified by self-report [32–34], bone density [26], or chart review [29]), and an inclusion criteria in two studies [24, 25].

Calcium measurement

Calcium intake was measured in a number of ways across these 12 studies. One type of measure asked participants to reflect on the foods they consumed over time (generally 6 or 12 months but sometimes as little as 1 week), and an estimate of their calcium intake was reported in milligrams [27, 28, 30, 32–34]. Some measures focused on calcium-rich foods rather than all nutrients, making the questionnaire shorter and less burdensome. This group of measures included questionnaires requiring recall of foods consumed in the past or documentation of foods currently being consumed. Questionnaires included the Block Health Habit Questionnaire Abbreviated version [33, 34], Semi-Quantitative Food Frequency Questionnaire [26, 28], The Food Frequency Questionnaire [24], Hertzler and Frary's Rapid Assessment [30], Food Frequency Angus [27], and a questionnaire developed specifically for the study [25].

Measuring nutritional substances, including calcium, is complex because it includes the food (recognizing that recipes contain many ingredients and different products contain different amounts of a nutrient), the amount of the food (translating from scientific to household measures or estimates), the frequency with which food is eaten, the period of time over which food consumption is measured, and differences between perceptions of past behaviors versus real time recording. The primary source(s) for each specific measure of calcium was reviewed by the authors prior to categorizing the type of measure.

One study used a traditional 3-day food diary which assessed all foods consumed on a daily basis over 3 days and reported calcium in milligrams [26]. One study reported number of servings of calcium-rich foods and compared percentage of persons increasing servings of calcium-rich foods over time [29]. Two studies [31, 35] assessed calcium intake via the Osteoporosis Prevention Behavior questionnaire which used questions from the Quick Calcium Intake (daily servings of milk, yogurt, cheese, calcium-fortified foods, and calcium supplements) to measure calcium intake in milligrams [37].

Characteristics of intervention

Bone density measures

Bone mineral density was obtained in six studies [26–28, 30, 31, 35] and was used as an intervention in three of these studies [27, 30, 31]. In two studies [30, 31], sharing the results of the bone mineral density testing was a major component of the intervention delivered to the experimental but not the comparison group. In two studies [27, 35], women in both the experimental and comparison groups received information about their bone mineral density as part of the study protocol. In one study [28], bone mineral density was a variable measured but not reported to participants, and in one study [26], bone density was used to determine eligibility, so women with low bone density were excluded from participating. In the two studies where results of bone density were reported to the experimental group but not the control group as part of the intervention [28, 31], there was an increase in calcium intake in the experimental group. In the study [35] that disclosed the results of bone density to participants in both groups, there was no change in calcium intake. In one study [27] where all participants were informed of their score and women with normal scores were informed, they were not at higher risk for fracture. In this same study [27], there was no difference in calcium intake between the control and experimental group, but there was a difference between groups in sub-group analyses. Sub-group analysis indicated that more women at risk for fracture in the experimental group increased their calcium intake than women at risk for fracture in the control group.

Delivery media

Paper was the only delivery media used in one study [32]; however, paper was coupled with other types of delivery media in three studies. In one study, paper was combined with phone call [33], in one study paper was combined with small group classes [26], and paper was combined with bone mineral density reports in one study [31]. Small group was the delivery media used in seven studies [24–26, 28, 30, 34, 35], but in two of those studies, the small group delivery method was combined with personal contact [24, 28]. Small groups were associated with an increase in calcium in five of the seven studies in which it was used [24–26, 28, 30]. Only one study used an electronic delivery media (a videotape), and it was coupled with a health care provider visit [29].

Number of contacts

Intervention included single and multiple contacts. Single contact occurred via paper [32], small group session [34], video with physician visit [29], a daylong session [25], by phone to provide results of dual-energy X-ray absorptiometry (DXA) and tailored information [35], and paper mailed results of DXA along with a pamphlet [31]. Multiple contacts occurred in 6 studies, specifically use of tailored packets including behavior specific activities and phone call follow-up[33]; daily contact with a lay advisor and weekly small group meetings over 18 months [28]; weekly sessions over 6 weeks plus home activities [24]; small group interactive sessions occurring over 5 months [26]; DXA scan with feedback, group sessions, and individualized counseling [30]; and DXA feedback and self-management course delivered over weeks in small group [27].

Single contact was associated with an increase in calcium in three of six single contact interventions, specifically video education preceding contact with physician [29], daylong session [25], and mailed feedback with DXA results [31]. Four of the six multiple contact interventions were associated with in increase calcium intake (daily contact with lay advisor and weekly small group meeting over 18 months [28], weekly sessions over 6 weeks plus home activities [24], small group interactive sessions occurring over 5 months [26], and DXA scan with feedback group sessions and individualized counseling [30]). Three of the six studies using single contacts resulted in increased calcium [25, 29, 31], whereas four of the six studies with multiple contacts resulted in increased calcium [24, 26, 28, 30].

Small groups and intensity

All of the small group session with higher intensity (multiple contacts) resulted in an increase in calcium intake. One small group session identified as single contact [25] was a full day session which resulted in an increase in calcium intake. With one exception [30], studies using small groups as a delivery media with multiple contacts contained more than informational content. In addition to increasing participant knowledge about osteoporosis and preventative health behaviors, the curriculum of these small groups contained content designed to increase knowledge of osteoporosis and prevention, activities to develop women's self-regulation skills to change their health behaviors (e.g., setting goals, reading labels, self-monitoring behaviors), and social interaction over time. One study [30] used a small group media, DXA scan, and provided participants with calcium supplements.

Effect sizes

Data needed to calculate effect sizes using the Cohen's d statistics, or the strength of the intervention, were available for 5 of the 12 studies [24–26, 28, 30]. Effect sizes are considered small if they are less than 0.3, medium if they are around 0.5, and large if equal to or greater than 0.8. Two studies [24, 25] had medium effect sizes, and three studies had large effect sizes [26, 28, 30].

Summary of findings

Studies were more likely to demonstrate differences between treatment and intervention groups when they had a combination of the following characteristics: study was conducted outside the USA; participants had lower baseline calcium intake; and the intervention was multi-dimensional and included factual information, skill training, and social contact. Interventions continuing over months tended to be more successful than shorter interventions. There was significant variability across studies with respect to sample size and characteristics of participants (age, menopausal status, and bone density), measurement of calcium intake, and characteristic of interventions (specifically the delivery media, content, and dosage). Widespread variability across the studies was a major determinant in choice of analysis in this project. Meta-analysis (the method that would have enabled pooling of data across studies to conduct a secondary analysis of data) was not possible because of the wide variance in variables and the absence of critical data from a number of the reports. The strength of the studies was controlled by accepting only experimental and quasi-experimental studies, and use of the systemic review permitted a qualitative review of the studies allowing pattern identification but failing to control for differences in study characteristics such as sample size and intervention.

Differences between groups were observed only when the intervention was compared with a usual care group and not with alternative interventions. When data were available, calculated effect sizes were medium and large, supporting the strength of the select studies. Attrition varied from 0 to 47 % with the mean attrition rates approximating the 23rd percentile. Attrition was higher in control than in experimental groups. Evidence of building knowledge from one study to the next was apparent across studies conducted by the same research team. In their later studies, some aspects of the studies (e.g., measurement of calcium) remained the same while select components of the intervention were singularly manipulated. This integrative review is limited by the inclusion of only published articles, a phenomenon known to be associated with positive bias [38, 39].

Discussion

Eligibility requirements of individual studies affect the ability to detect changes in health behavior caused by the intervention. Women already consuming adequate amounts of calcium are not likely to (or should not) increase their calcium intake. Hence, when women already consuming an adequate calcium intake are included in the same sample as women not taking an adequate amount of calcium, the ability to detect the impact of the intervention decreases because only a part of the sample will have a change in health behavior.

Sources of calcium intake need to be defined and standardized across studies. Calcium can be consumed through foods and supplements, and reports of calcium intake can focus on foods, supplements, or total intake. Research reports often fail to distinguish these differences. Differential reporting of dietary, supplemental, and total calcium intake could be helpful in understanding the current controversy associated with supplementation [1, 40–42] and in determining which interventions lead selectively to an increase in dietary consumption of calcium. The recommended amounts of calcium differ by menopausal status, but this difference is often not taken into account. Most frequently, difference in calcium intake is reported over time. Findings can be reported and information about differences between groups highlighted (providing information about mean totals and standard deviations), change scores reported, or percentage of required dose reported (accounting for menopausal status).

The variability across measurements of calcium was most pronounced as measures differed across every researcher/research team. Measures depending on reports of usual food consumption over the past 6 to 12 months have significant memory bias. Three-day food diaries are associated with significant burden and altering the behavior of persons in the intervention as well as the control group. There was some support for 3-day calcium-focused food diaries. These calcium-focused diaries were sensitive to change between groups, reduced participant burden, and associated with less reactivity (change occurring to persons in experimental and control group when the measure serves more as a tool for self-monitoring than for data collection [43]).

Interventions designed to teach people about osteoporosis, risk factors, and the recommended health behaviors resulted in an increase in knowledge but did not result in a change in health behavior. Interventions using only paper delivery media were not associated with behavior change except for one which linked the timing of the intervention to an outpatient physician visit. Small group interventions were associated with changes in health behaviors in a number of studies. These small group sessions did include an educational component, but the interventions delivered by small group media that were successful in changing health behavior also included the development and practice of the self-regulation skills needed to engage in health behavior change (e.g., goal setting, self monitoring, etc.). While not measured, use of small group delivery media afforded participants significant social contact and interaction which may have been related to health behavior change.

Attrition is a problem common to health behavior change programs especially as change is measured over time. Attrition is a complex phenomenon caused by both dropping out of a study and discontinuing a health behavior. These two phenomenons need to be differentiated in order to better understand health behavior change processes and trajectories. The dynamics of health behavior change could be better understood by obtaining measures of the behavior throughout the study in addition to the measurement of outcomes at fixed intervals months apart.

There was a noticeable absence of electronic interventions in this collection of articles. With decreasing participation in small group sessions [44] and increasing use of mobile health (m-Health) interventions [45–48], one could expect technology to play a larger role in osteoporosis prevention interventions in the future. Innovative approaches to the measurement of calcium are possible because of m-Health, and results of these new measures need to be tested. Future studies using m-Health interventions will have the capacity to measure fidelity automatically which will facilitate determination of the effect of intervention dose on behavior change.

Conclusion

The effectiveness of preventative care and medical treatment will only ever be as good as peoples' use of recommendations and treatments. Failure to initiate and maintain health behavior change affects the impact of programs on health outcomes. It is of critical importance to better understand how to facilitate long-term health behavior change. The results of this integrative review inform future research and practice in a number of ways including documentation of the extensive variability in measures (need to document the source, total, and sub-totals of calcium intake) and selection of appropriate eligibility criteria to increase the power of the intervention. Programs need to expand beyond imparting factual information to the facilitating health behavior change through the use of patient-centered interventions designed to increase knowledge and health beliefs, skills and abilities, and social facilitation using a variety of long-term delivery media, dynamically, over time. Until alternative approaches are identified to support health care practitioners in the provision of individualized care, health care providers need to provide the mainstay of care for prevention and management of this common, debilitating condition.

Conflicts of interest None.

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