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Increasing calcium intake in young women through gain-framed, targeted messages: A randomised controlled trial

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Background: Adequate calcium consumption during early adulthood can help prevent osteoporosis in women.
Purpose: The effects of gain-framed, targeted messaging on calcium intake were examined over 12 months.
Methods: Young women (18–19 years) not consuming sufficient calcium were randomly assigned to receive standard care materials (control) or gain-framed, targeted materials (experimental). Health belief model (HBM) constructs, calcium intake and markers of bone formation, resorption and bone mineral density were assessed at various time points throughout the year.
Results: Calcium intake increased significantly more in the experimental *versus* the control condition ($p < 0.01$). Self-efficacy was the only HBM construct to improve significantly more in the experimental condition *versus* control ($p = 0.05$). The HBM did not mediate changes in calcium intake. Measures of bone health did not differ between conditions by the end of this nonpharmacological intervention (p's > 0.05).
Conclusions: It is possible to increase young women's calcium consumption through gain-framed, targeted messages.

Keywords: calcium consumption; message framing; health belief model

Osteoporosis (OP) is a disease resulting from low bone mass and is associated with debilitating and costly fractures (Cooper, Campion, & Melton, 1992). Women, in particular, are at an increased risk of developing OP due to low bone mass (Osteoporosis Society of Canada [OSC], 2001a, 2001b). Since little bone mineral can be added to the female skeleton after the age of 20 (Heaney, 2002), gearing preventive interventions towards women who have not yet reached this age is crucial. Consuming adequate calcium is one important modifiable factor for attaining optimal peak bone mass (Ho et al., 1997).

Despite the known benefits of calcium intake on bone health, the vast majority of North American women in bone accrual years consume less than the dietary reference

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intake (DRI) recommended levels of calcium ($1300\,mg\,day^{-1}$ for ages 14–18 and $1000\,mg\,day^{-1}$ for ages 19–50; DRI, 2005; Food and Nutrition Board Institute of Medicine [FNBIM], 1999; Gray-Donald, Jacobs-Starkey, & Johnson-Down, 2000). In college-aged women, low calcium intake has been associated with appearance concerns and weight-loss attempts (Ali, 1996; Ali & Siktberg, 2001), which may be explained by young women's perceptions of calcium-rich foods as fattening (Georgiou, Betts, Hoos, & Glenn, 1996; Horwath, Parnell, Wilson, & Russell, 2001). Considering the majority of female university students are attempting to lose weight (American College Health Association-National College Health Assessment [ACHA-NCHA], 2008; George & Johnson, 2001), this population may be at a particularly high risk for not consuming adequate amounts of calcium. Further, female university students on restrictive diets have been shown to have lower total body bone mineral content than those not on restrictive diets (McLean, Barr, & Prior, 2001). It is therefore essential to target calcium interventions to university women to assure adequate calcium consumption during bone accrual years.

Educational materials have been developed as a cost-effective attempt to increase calcium intake among women. The content of these materials has been based primarily on the tenets of the health belief model (HBM; Rosenstock, 1974). The HBM posits that individuals will take action concerning a health condition based on the perceived threat of the disease (operationalised by perceived severity and perceived susceptibility of the negative health outcome), as well as perceived effectiveness (perceived benefits) and perceived negative consequences (perceived barriers) of performing actions to reduce the threat of the illness. The model's predictive ability improved substantially with the addition of self-efficacy. Self-efficacy, borrowed from social cognitive theory (SCT; Bandura, 1986), was added to the HBM in 1988 (Rosenstock, Strecher, & Becker, 1988). Because this model was designed for prediction of protective health behaviours, it is one of the most frequently used models in prevention studies (Janz & Becker, 1984). The five constructs of the HBM – self-efficacy, perceived severity, susceptibility, benefits and barriers – have each been reported to be correlated with calcium intake in cross-sectional studies (Ali, 1996; Ali & Twibell, 1995; Carlsson & Johnson, 2004; Ievers-Landis et al., 2003; Taggart & Connor, 1995).

HBM-based educational materials have been successful at increasing intentions to consume adequate amounts of calcium (Smith Klohn & Rogers, 1991), knowledge about OP (Blalock et al., 2000; Sedlak, Doheny, & Jones, 2000) and even cognitions about the relationship between calcium intake and OP (Sedlak et al., 2000). But unfortunately, they have not been successful at increasing young women's calcium intake. For example, a 3-week OP education program significantly increased female college students' knowledge of OP and perceived benefits of dietary calcium, yet had no impact on their calcium intake (Sedlak et al., 2000). These findings suggest that young women's calcium intake behaviours are not always responsive to existing educational materials.

One potential explanation for the materials' failures is that the informational materials are not meaningful to young women. Many existing OP educational materials focus on the long-term health consequences of OP, such as decreased bone density and risk of fracture in old age (OSC, 2001a, 2001b). Young women appear to be more motivated to perform preventive behaviours when informed about more proximal physique and appearance-related consequences rather than long-term health consequences (Ali, 1996; Ali & Siktberg, 2001; Georgiou et al., 1996;

Hayes & Ross, 1987). For instance, Smith Klohn and Rogers (1991) found that messages pertaining to the physically disfiguring consequences of OP increased young women's intentions to consume calcium, but general OP information describing long-term health consequences did not. Thus, young women may respond more to educational materials promoting OP prevention if the materials emphasise consequences of OP that are relevant to this population.

In addition, the common practice of providing information on calcium content of particular foods may work to increase calcium intake in older women, but is ineffective for increasing calcium intake in younger women (Cinciripini, 1984; Davis & Rogers, 1982). Studies have consistently found that weight control, energy content, hunger and food cravings, time considerations and convenience are factors that influence young women's food choices, not information on calcium content (Betts, Amos, Keim, Peters, & Stewart, 1997; Glanz, Basil, Maiback, Goldberg, & Snyder, 1998; Neumark-Sztainer, Story, Perry, & Casey, 1999). In line with these findings, Buscher, Martin and Crocker (2001) found a 97% increase in yoghurt consumption in university cafeterias after signs were posted highlighting its budget-friendly, energising, tasty and convenience attributes. These findings suggest that calcium intake messages will be most effective if they are relevant and targeted to the intended audience.

A second possible reason for the failure of educational materials to increase calcium intake is that they are loss-framed. According to prospect theory (Kahneman & Tversky, 1979), the framing of information influences one's choices, preferences, attitudes and behaviours (Rothman, Salovey, Antone, Keough, & Drake Martin, 1993). Messages or other information provided in educational interventions can be phrased in either a gain-framed (emphasises the benefits of performing a behaviour) or loss-framed manner (emphasises the costs of not performing a behaviour). When attempting to increase the performance of preventive behaviours, such as calcium intake, gain-framed messages are most effective (Rothman & Salovey, 1997; Rothman et al., 1993). Unfortunately, most of the existing OP educational materials emphasise losses, not gains, associated with calcium-deficient diets or the development of OP. To date, no published study has assessed whether incorporating gain-framed messages into pre-existing educational messages can promote changes in dietary intake despite their effectiveness for changing other preventive behaviours (sunscreen use, Rothman et al., 1993; intentions to exercise, Robberson & Rogers, 1988; exercise attendance, McCall & Martin Ginis, 2004). In addition to targeting messages towards young women, incorporating gain-framed messages to increase calcium intake in this population should yield behavioural effects.

The primary purpose of this study was to compare the effectiveness of standard OP educational materials to gain-framed, targeted materials for increasing calcium intake in young women. This issue was addressed by conducting a 1-year, prospective randomised controlled trial. It was hypothesised that participants who received gain-framed, targeted messages (experimental condition) would report greater calcium consumption than participants who received standard materials (control condition). Consistent with past OP prevention interventions (Blalock et al., 2000; Sedlak et al., 2000; Smith Klohn & Rogers, 1991), constructs of the HBM (Rosenstock, 1974) were assessed as potential mediators of calcium intake behaviour change. Specifically, it was hypothesised that participants in the experimental condition would experience greater changes in HBM constructs (increases in perceived benefits, susceptibility, severity, self-efficacy and decreases in perceived barriers) than participants in the control condition. While the cognitions assessed by the HBM appear to be related to calcium intake behaviour, there is not yet sufficient evidence to ascertain the precise nature of this relationship (i.e. predictor or mediator). It was hypothesised that changes in these five health beliefs would mediate the relationship between condition and calcium intake behaviour. A secondary objective was to assess the intervention's effect on bone health. Forearm bone mineral density (BMD) and biochemical markers of bone turnover were thus examined to assess any potential changes in bone parameters.

Method

Participants

Required sample size was calculated based on the degree of change expected in bone parameters, as these variables were expected to change the least. Using previous data from a study examining BMD changes in 15–19-year-old females after supplementation with fortified dairy products (Merrilees et al., 2000), sample size was calculated using an alpha level of 0.05 and beta of 0.20; $N/\text{group} = 2[(\alpha + \beta) \cdot (\text{SD}/\text{difference})]^2$. This calculation yielded 51 participants per group. In accordance with the typical dropout rate reported in dietary interventions (Merrilees et al., 2000; Piaseu, Schepp, & Belza, 2002), a dropout rate of $\leq 30\%$ was budgeted. Thus, it was estimated that recruitment of 66 women per group would provide sufficient statistical power to detect changes in BMD. Recruitment took place at the McMaster University campus club fair held at the beginning of the school year (September 2002). Eligibility criteria included: female, absence of any hormonal or eating disorder that could affect bone health, currently less than 19 years of age, living in university residence (to control for portion sizes, food preparation and thus better estimation of calcium content) and consuming less than the DRI for calcium as reported in a calcium food frequency questionnaire. Of the 290 young women who met these criteria, 133 agreed to participate (Figure 1).

Measures

Demographic questionnaire

A baseline questionnaire assessed demographic characteristics (e.g. ethnicity, age of menarche) and lifestyle factors (e.g. weight-bearing physical activity, milk consumption during childhood) associated with bone density.

Three-day food log

Participants recorded everything they ate and drank in a 3-day food log. Two weekdays and one weekend day were reported. Often considered the gold standard of dietary analysis, logs are both valid and reliable (Thompson, Byers, & Kohlmeier, 1994). The quantity and brand of all food and drink reported were subsequently entered into a dietary analysis program (Nutritionist Five, version 5). Mean calcium intake from each 3-day assessment was used in the data analysis.

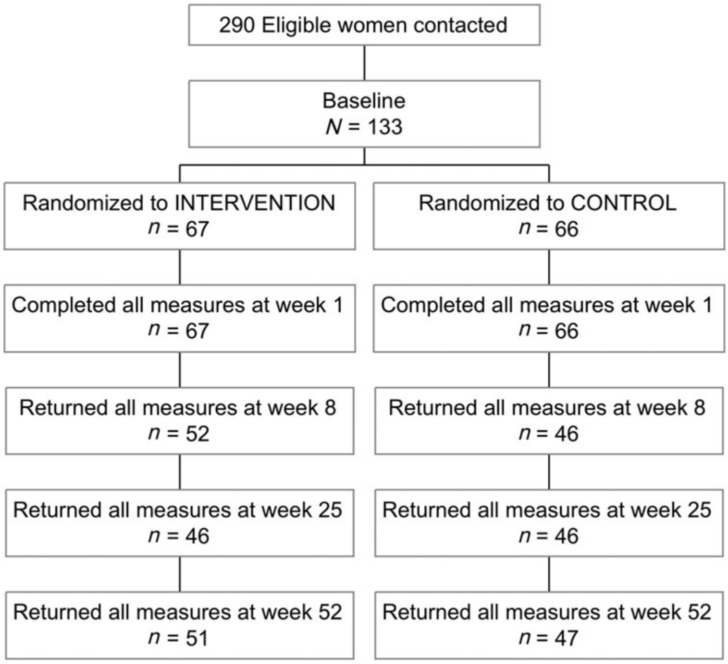

Figure 1. Participant flow.
Notes: Pre to post analysis: $n = 98$ (51 experimental, 47 control). Complete data available at each time point: $n = 68$ (33 experimental, 35 control).

Osteocalcin. Significant changes in bone density as a result of supplement interventions often take several years to detect (Cummings, Bates, & Black, 2002). Osteocalcin, a bone-specific protein produced by osteoblasts, can be used as a more rapid index of early changes in bone formation (Löfman, Magnusson, Toss, & Larsson, 2005). Plasma osteocalcin was measured using a commercially available enzyme-linked immunosorbent assay (ELISA) kit (Invitrogen, Osteocalcin ELISA Kit, Zymed®, Burlington, ON).

Deoxypyridinoline

Deoxypyridinoline (DPD) is a marker of bone resorption, and, like osteocalcin, is also a more sensitive alternative to measures of bone density (Garnero, Hausherr, & Chapuy, 1996). Urinary DPD was assessed using a commercially available ELISA kit (Quidel, The Metra® tDPD, San Diego, CA).

Bone mineral density

BMD was measured using peripheral quantitative computed tomography (pQCT; Stratec XCT 960, Pforzheim, Germany). The length of each participant's nondominant forearm, from olecranon to ulnar styloid process, was measured to the nearest millimetre. Radiation dose for one scan was 0.3 mSv. *In vitro* reproducibility of the pQCT method was assessed by daily measurements of a standard phantom with a defined content of hydroxyapatite provided from the manufacturer. We first conducted a coronal computed radiograph (scout view) of the forearm. The scout view was used to position the scanner at 4% of forearm length, where total BMD and trabecular BMD were assessed. Total BMD and trabecular BMD are highly correlated with BMD values measured by dual X-ray absorptiomety (Butz, Wüster, Scheidt-Nave, Götz, & Ziegler, 1994).

Health belief model (Rosenstock, 1974)

The five HBM constructs: (1) perceived barriers (6 items), (2) perceived benefits (15 items), (3) perceived susceptibility (10 items), (4) perceived severity (11 items) and (5) self-efficacy (12 items), were assessed using a modified version of Kim, Horan, and Gendler's (1991) OP health belief scale. We pilot tested the scale in a sample of university students and found it to be reliable. Additional information on how each of the five cognitions was assessed can be found online at http://www.informaworld.com/gpsh.

Message development

The OSC's 'Speaking of Bones' slide presentation and two pamphlets 'Osteoporosis and You' and 'Calcium: An Essential Element for Bone Health' served as the educational materials in the control condition. The experimental condition's materials were designed to parallel these existing resources but were modified from the originals in three ways.[1] First, information about health consequences of OP was complemented with information about 11 physique and appearance-related consequences (e.g. brittle nails). The experimental condition's slide presentation also included a picture of a woman with OP (with a noticeable hump back) next to a woman without OP. Second, messages pertaining to nutritional information of calcium-rich foods were replaced with messages emphasising the taste, cost, convenience and weight control aspects of these foods (e.g. 'Got a sweet tooth? Try these inexpensive, yummy, calcium-rich foods!'). In total, 93 targeted messages were embedded in the experimental materials. These 93 targeted messages replaced 93 messages pertaining to calcium content of specific foods, information on lactose intolerance, vegetarian and vegan diets in the control materials. The third modification was in the framing of the factual messages. Whereas the control condition's messages emphasised the losses associated with not consuming adequate calcium (e.g. 'Many individuals can no longer live independently following a hip fracture'), the experimental condition's messages emphasised the benefits associated with consuming adequate calcium (e.g. 'Prevention of hip fractures means that many individuals can continue to live independently'). In total, there were 20 gain-framed messages embedded in the experimental materials, as compared to 11 loss-framed messages in the control materials.

Procedure

This protocol was approved by the Hamilton Health Sciences Research Ethics Board and conducted at McMaster University in Hamilton, Ontario, Canada, from September 2002 to September 2003.

Assessment at baseline (week 0)

Participants provided informed consent and a first morning void urine sample, which was immediately transferred to a -50°C freezer for subsequent DPD analysis. Participants proceeded through the following measurement stations in a randomised order: anthropometrics, phlebotomy, questionnaires and pQCT bone scan. Full procedures for this study are provided at http://www.informaworld.com/gpsh.

Educational seminar (week 1)

A registered dietitian presented a 45 min seminar. Both the experimental and control condition seminars were based around the OSC's 2001 slide presentation package entitled 'Speaking of Bones.' This informative slide package was designed for the general public and is accompanied with a script. The control condition received this presentation verbatim, as it was considered standard care. The experimental condition received the targeted, gain-framed version as described in the message development section. Following the seminar, a manipulation check was administered to ensure each group paid equal attention to the presentation. This check consisted of 10 true or false questions about general OP information. Next, participants completed the HBM questionnaire and submitted their 3-day food log.

Mail-delivered interventions (weeks 6 and 14) and follow-up (week 8 and 25)

A package consisting of two booklets and an information letter was mailed to each participant's dormitory room via campus mail during week 6. The letter requested that participants read the booklets as soon as possible and indicated that questionnaires would be arriving in 2 weeks. As a standard care intervention, participants in the control condition received the OSC's 'Osteoporosis and You' and 'Calcium: An Essential Element for Bone Health' booklets. Participants in the experimental condition received modified targeted, gain-framed versions of these booklets.

At week 8, a second package consisting of a pre-addressed return envelope, manipulation check, 3-day food log and HBM measures packet was sent. The manipulation check assessed the degree of attention paid to the booklets by asking the participants to list five outcomes of consuming calcium in their diet, and five foods high in calcium that they enjoy. Answers were coded as correct or incorrect based on the information provided in the booklets. A reminder telephone call and email message were sent out to those who had not returned their package in 7 days.

At week 14, the second mail-delivered intervention was distributed. Each participant received a notepad, sticker and instruction sheet. Participants were instructed to adhere the sticker to an object they used often (e.g. day planner) or place it in a highly visible location (e.g. mirror in their room). Similarly, they were asked to place the notepad where they would most likely use it, such as by the phone. The control condition's notepad was 50 pages. At the top of each page was the heading 'Calcium Rich: FOOD IDEAS,' followed by one calcium-rich food item and its calcium content (e.g. yoghurt, 295 mg). The experimental condition's notepad also had the heading 'Calcium Rich: FOOD IDEAS' and contained 50 pages. Instead of listing the calcium content in each food item, each page mentioned the same food items as used in the control condition's notepad, but in a manner more appropriately targeted to young women (e.g. 'Try a cold and creamy milk shake or smoothie made with calcium-fortified soy milk'). The control condition's sticker displayed Canadian recommended calcium intakes for different age groups on 4×3.5 in. adhesive paper (e.g. 'Age 19–49 needs 1000 mg'). The experimental condition's sticker displayed gain-framed preventive effects of consuming adequate amounts of calcium that were targeted to the study population (e.g. 'build strong nails').

At week 25, a package consisting of a manipulation check questionnaire, 3-day food log, HBM measures packet and a pre-addressed return envelope was mailed to participants. The manipulation check questionnaire consisted of 10 questions pertaining to where the sticker and notepad were placed, if they were used and to what extent. Participants were also asked to list five outcomes of consuming calcium, five foods high in calcium that they enjoy and to report the DRI of calcium for women between the ages of 17 and 18. These latter items were administered to assess whether the content of the intervention materials was read. Reminder phone calls and email were sent to participants who did not return this package within 7 days.

Assessment at 1 year (week 52)

During the first week of September (week 49), participants were contacted to arrange a post-test appointment and to confirm their new school address. A 3-day food log, sterile urine cup and reminder note specifying their appointment time were delivered to each participant's new school address. Participants were told to bring a urine sample from their first urination of the test day and the 3-day food log for their final assessment.

The post-testing procedure was identical to baseline testing. Research assistants at each station were blind to participants' random assignment. The only modifications were in the wording of the demographic questions to make them more pertinent to the time period of the study. The primary researcher debriefed each participant individually. Participants received \$10 compensation for each laboratory session they attended (week 0, 1 and 52), and \$5 for every package of questionnaires completed and returned.

Results

Preliminary analyses

Participant flow through the study protocol is depicted in Figure 1. The significance level for all statistical tests was set at $p < 0.05$. There were no significant correlations between demographic variables, lifestyle factors and any outcome variables, thus these items were not used as covariates in subsequent analyses. The experimental and control conditions were compared using independent *t*-tests on all demographic and baseline measures of the study variables. There were no demographic differences between groups (Table 1). Participants in the two conditions did not differ significantly on kilocalories consumed $t(131) = 1.15$, $p = 0.25$ or amount of calcium ingested $t(131) = 0.61$, $p = 0.55$ at baseline (Table 2). Of all baseline measures, only mean perceived severity of OP differed between groups, such that participants in the experimental condition had higher perceived severity scores at baseline than participants in the control condition $t(131) = 2.10$, $p = 0.04$ (Table 3).

All data assumptions for MANOVA and multiple regression were tested in accordance with Tabachnick and Fidell's (2001) recommendations.

Table 1. Descriptive statistics for demographics of participants at baseline.

	Experimental $n = 67$		Control $n = 66$	
	M	SD	*M*	SD
Age	18.4	0.66	18.6	0.55
Weight (kg)	62.0	8.3	60.2	9.6
BMI ($kg\,m^{-2}$)	22.9	3.0	22.4	3.3
Osteocalcin ($ng\,mL^{-1}$)	13.3	8.66	13.13	11.39
DPD ($nmol\,L^{-1}$)	102.55	68.37	89.87	65.10

Table 2. Descriptive statistics for calcium and kilocalorie intakes (unadjusted).

	Week 1		Week 8		Week 25		Week 52	
Variable	*M*	SD	*M*	SD	*M*	SD	*M*	SD
Experimental								
Calcium intake (mg)	927	369	1004	393	1109*	568	1144**	514
Kilocalories (kcal)	2129	458	2096	486	2020	607	1950	441
Control								
Calcium Intake (mg)	891	286	956	344	951*	371	813**	286
Kilocalories (kcal)	2101	453	2033	521	1931	504	1825	456

Note: Significant differences between conditions: $*p < 0.05$ and $**p < 0.01$.

Table 3. Descriptive statistics for HBM study variables (unadjusted).

	Baseline		Week 1		Week 8		Week 25		Week 52	
Construct	*M*	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD
Experimental										
Self-efficacy[ab]	83.2	18.0	90.0	15.3	90.6	16.1	91.2	13.8	91.2	15.3
Perceived benefits[a]	43.02	8.14	50.50	8.36	48.13	8.12	47.88	7.47	48.19	8.56
Total Perceived barriers[a]	1.40	1.18	1.33	1.32	1.07	1.22	1.01	1.42	0.90	1.32
Perceived susceptibility[a]	29.65	7.21	24.46	7.18	28.86	7.72	27.76	8.95	35.46	9.37
Perceived severity	24.83	5.99	23.39	6.52	22.88	5.81	22.77	6.80	22.75	5.29
Control										
Self-efficacy[ab]	80.1	18.5	85.8	17.3	82.9	17.4	82.8	18.0	86.7	17.3
Perceived benefits[a]	42.77	7.68	46.70	7.80	45.41	8.42	45.72	7.56	46.76	7.50
Total perceived barriers[a]	1.48	1.29	1.36	1.47	1.26	1.53	1.03	1.37	1.03	1.28
Perceived susceptibility[a]	28.88	6.95	26.55	8.36	27.45	9.27	28.54	9.49	35.05	7.93
Perceived severity	22.60	5.95	21.21	5.59	21.51	6.14	21.56	5.71	21.86	5.94

Notes: Possible scale ranges: self-efficacy 0–100%, perceived benefits 13–65, perceived barriers 0–6, perceived susceptibility 10–50 (low scores indicate high susceptibility) and perceived severity 11–55 (low scores indicate high severity).
[a]Significant main effects for time.
[b]Significant main effects for condition.

Mediational analysis was conducted as per Baron and Kenny's (1986) recommendations via prospective hierarchical linear regressions. A series of independent t-tests, Pearson chi-squared tests and a MANOVA were used to test the manipulation checks. No differences between conditions were found on the degree of attention paid to any of the intervention materials. All manipulation check scores were relatively high, indicating that the intervention material was adequately read by both conditions. It was thus considered safe to proceed with testing the study hypotheses.

Comparison of reported energy intakes between groups

To ensure that any potential changes in calcium intake were due to an increased proportion of calcium-rich foods in the diet, and not to an overall increase in calories with the proportion coming from calcium-rich foods staying the same, analysis of total energy consumed at each time point was conducted. A repeated measures ANOVA demonstrated a significant main effect for time, such that all participants reduced their energy intake over time $F(3, 198) = 3.67$, $p = 0.01$. The main effect for condition and the interaction effect proved nonsignificant $F(1, 66) = 2.16$, $p = 0.15$ and $F(3, 198) = 0.93$, $p = 0.43$, respectively. These results indicate that there was no difference in the decline in reported energy intake between conditions across time (Table 2). Because participants were consuming fewer calories throughout the study than at baseline, any increases in calcium intake found in the subsequent analyses would be due to an increase in proportion of calcium to calories in the diet.

Comparison of reported calcium intakes between groups

Using only those participants who returned their diet logs at all time points ($n = 68$), a 2 (condition) $\times$ 4 (time) repeated measures ANOVA on mean calcium intake at each measurement point was conducted. Levene's test of equality of error variances indicated that mean calcium intake during week 52 did not meet the assumption of homogeneity of variance $F(1, 66)$ 5.45, $p = 0.02$. After this mildly skewed variable was square root transformed (Tabachnick & Fidell, 2001), the Levene's test was no longer significant ($p > 0.05$). To keep the unit of measurement of calcium intake the same at all time points, every calcium intake measurement point was subjected to a square root transformation. There was no main effect for time $F(3, 198) = 1.31$, $p = 0.27$. However, as hypothesised, a significant main effect for condition, $F(1, 66) = 4.05$, $p = 0.048$, and a time by condition interaction were found $F(3, 198) = 2.94$, $p = 0.03$. Bonferroni-adjusted post hoc independent t-tests (adjusted p value for four tests $= 0.013$) revealed significant differences in calcium consumption between the two conditions at week 52, $t(96) = 6.62$, $p < 0.01$, Cohen's $d = 0.81$. Furthermore, as shown in Table 2, those in the experimental condition increased the amount of calcium in their diet over the span of the study, whereas calcium intake decreased slightly in the control condition during the same time frame.

A pre-to-post analysis was also conducted on all participants who completed the year-long trial ($n = 98$). A 2 (condition) $\times$ 2 (time: week 0–week 52) repeated measures ANOVA revealed no main effect for time $F(1, 96) = 1.15$, $p = 0.29$. The main effect for condition approached significance, such that those in the experimental condition had higher calcium intakes than those in the control condition, $F(1, 96) = 3.70$, $p = 0.06$. As hypothesised, the time by condition interaction was significant $F(1, 96) = 8.33$, $p < 0.01$. Post hoc paired t-tests revealed that the experimental condition significantly increased their calcium consumption from the beginning of the study, $t(51) = -2.38$, $p = 0.02$, Cohen's $d = 0.48$. In contrast, there was a trend for calcium intake in the control condition to decrease, $t(47) = 1.62$, $p = 0.11$, Cohen's $d = 0.27$. A post hoc paired t-test also demonstrated that the experimental condition had significantly higher calcium intake than the control condition at week 52, $t(96) = 3.18$, $p < 0.001$, Cohen's $d = 0.64$.

Effects of the intervention on the HBM constructs

To test the second hypothesis, separate 2 (condition) $\times$ 5 (time) repeated measures ANOVAs were conducted for each HBM variable with the exception of perceived severity. Perceived severity was analysed in an ANCOVA that controlled for baseline differences on this measure. A repeated measures MANOVA analysing all HBM constructs simultaneously would have been ideal; however, our design was underpowered for this statistical test (Tabachnick & Fidell, 2001).

Main effects for time were found for self-efficacy (increased), perceived susceptibility (decreased), perceived benefits (increased) and perceived barriers (decreased; all p's < 0.001). Only self-efficacy had a significant main effect for condition (Table 3). Those in the experimental condition had higher self-efficacy than those in the control condition $F(1, 68) = 3.87$, $p = 0.05$. There were no significant times by group interactions for any HBM constructs.

Testing the HBM constructs as mediators in the group-calcium intake relationship

According to Baron and Kenny (1986), true mediation can only occur if the proposed mediator significantly predicts the outcome variable. It was hypothesised that the HBM constructs would mediate the relationship between experimental condition and calcium intake. However, none of the measures of calcium intake (weeks 1, 8, 15 and 52) were significantly predicted by any of the HBM constructs (assessed at weeks 0, 6, 14 and 25; all p's > 0.05). Thus, the mediational analyses did not proceed.

Effects of the intervention on bone density and biochemical markers of bone turnover

A 2 (condition) $\times$ 2 (time: week 0–week 52) repeated measures MANOVA was conducted on osteocalcin, DPD, total BMD and trabecular BMD. The only significant main effect for time was for osteocalcin, such that participants' osteocalcin scores increased from pre-to-post study $F(1, 63) = 8.78$, $p < 0.01$. However, there were no significant main effects for condition and no significant time by condition interactions.

Discussion

The purpose of this study was to test the effects of message-framing and targeted messages on calcium intake behaviour in young women who were consuming less than the recommended amount of dietary calcium. Framing messages in terms of benefits and targeting calcium information for the study population had a large, positive effect on young women's reported calcium intake. This finding supports the primary hypothesis – young women were more likely to perform a preventive behaviour (i.e. consume adequate amounts of calcium) when informed of the benefits associated with that behaviour for people like themselves.

Targeting the materials to the study population likely contributed to our intervention's success. While numerous interventions have tailored materials at the individual level, fewer have targeted interventions to a specific subset of a population (Kreuter & Wray, 2003). The cost efficiency and greater potential for targeted interventions to reach larger audiences can make them more advantageous than tailored interventions. The targeted messages we used highlighted issues shown to be of high concern to women the same age as our study population. In contrast, Schneider et al. (2001) failed to change breast cancer screening behaviour in women over the age of 40. Differences in study findings may be due to the demographic variable targeted (we targeted age while Schneider et al. targeted ethnicity) and the level of 'meaningfulness' achieved by the targeted material (we highlighted physique-salient information, Schneider et al. matched pictures in the intervention video to the ethnicity of participants).

This study also extends previous health prevention research by demonstrating the potential effects of an intervention that incorporates gain-framed messages over a prolonged period of time. Gain-framed messages have been shown to be more effective than loss-framed messages (McCall & Martin Ginis, 2004; Robberson & Rogers, 1988; Rothman et al., 1993), but only immediately after presentation of the messages. To the best of our knowledge, our 12-month study is the first to use gain-framed, targeted messages and find long-term changes in dietary calcium intake behaviour.

Contrary to what was hypothesised, not all HBM constructs changed after the educational intervention. OSC materials provided the basis for developing the intervention materials and already contained information pertaining to the perceived severity, susceptibility, benefits and barriers of adequate calcium intake. It is thus not surprising that both experimental and control conditions improved in these HBM constructs, given that both received these OSC materials.

Self-efficacy for consuming adequate amounts of calcium was the only HBM construct to improve more in the experimental condition *versus* control. According to SCT (Bandura, 1986), encouraging messages can lead to temporary improvements in self-efficacy, while more long-lasting changes in self-efficacy are most likely a result of successful mastery experiences with that specific behaviour. The population-specific messages embedded in the experimental condition's materials made reference to how easy it is to incorporate calcium-rich foods into one's diet (e.g. 'No time for calcium? These calcium-rich foods are easy to eat on the run'). In accordance with SCT (Bandura, 1986), these targeted messages likely boosted confidence in one's ability to consume calcium-rich foods in the face of various barriers, and, in turn, led to more actual mastery experiences of consuming calcium-rich foods. Long-term improvements in self-efficacy may have been due to repeated mastery experiences (Bandura, 1986). Although there may have been greater differences between experimental and control conditions on HBM constructs had we compared the intervention materials to a no-treatment control condition, we felt that it was more meaningful to evaluate the effectiveness relative to standard care.

Also contrary to study hypotheses, the HBM constructs did not mediate changes in calcium intake. According to the HBM, how threatening the perceived outcome is (i.e. perceived severity and susceptibility of OP) and one's evaluation of the behavioural outcome (whether perceived benefits outweigh perceived barriers of consuming adequate amounts of calcium) should determine calcium consumption. Overall, our intervention had similar effects on HBM constructs as the control condition, but only those in the experimental condition increased their calcium intake. Having found no significant time by group interaction effects for the HBM variables, it is not surprising that the HBM failed to predict calcium intake. These nonsignificant results suggest that there are factors other than health beliefs that are important in determining whether young women consume adequate calcium. One of those factors may simply be how interested they are in the information provided.

The HBM assumes that individuals are cognitively processing the intervention materials. In this study, we did not assess level of processing. It has been suggested that high participant interest leads to systematic processing (Petty & Cacioppo, 1981). It may have been that those in the intervention condition were more interested in their materials, and thus referred to their material more frequently and/or remembered more of the calcium-rich food suggestions than the control condition. Indeed, the elaboration likelihood model (ELM; Petty & Cacioppo, 1979) suggests that messages that attract greater attention are processed more thoroughly, are remembered longer and are taken into greater consideration than messages that are of less interest. For example, each page of the notepad given to the intervention condition had a gain-framed message aimed at enticing the participants to consume calcium-rich foods. Paraphrasing each calcium-rich food item with appetising adjectives may have lead to greater interest as compared to the control condition notepad, in which only the amount of calcium in milligrams was written beside each calcium-rich food.

The population-specific messages may have also lead to greater systematic processing of the materials. Petty and Cacioppo (1979) found that by making messages relevant to participants, they were able to increase the cognitive response to the messages. In our study, we made the messages relevant to our study sample by targeting issues of high concern to women of this age. Since the population-specific materials were designed to target physique issues proven to be of high concern to young women (e.g. 'Eating a calcium-rich diet can help you look better by building strong, healthy nails' and 'making your hair look shiny and healthy'), it is quite possible that the women in the intervention condition were processing the material more systematically than the control condition, where the issues presented to the standard care materials were not as of high concern. Because greater cognitive integration of the materials is achieved through systematic processing, it is possible that those in the intervention condition were better able to recall the calcium-rich food suggestions than the control condition. If systematic processing was the reason for the differences in calcium intake between groups, this would explain why the HBM failed to predict calcium consumption.

In addition to not measuring the level of processing, another study limitation is that the experimental condition's intervention materials contained both gain-framed and targeted messages. We deliberately packaged the interventions this way in order to maximise their potential impact. However, this strategy precluded our ability to determine which message elements improved calcium intake. Additional research is needed to tease out the effects of message framing *versus* targeting. Parenthetically, we did subsequently undertake a small study ($n = 88$ residence-dwelling, female undergraduates) in which the framing and targeting of the messages in our educational seminar (see week 1) were independently manipulated in a 2 (gain- *versus* loss-framed) $\times$ 2 (targeted *versus* generic) full factorial design (Harding & Martin

Ginis, 2004). Two weeks after the seminar, women who received targeted messages were consuming more calcium than those who received generic messages ($p < 0.05$). There was no effect for framing, which suggests that at least with regards to the seminar materials and over a relatively short time period, targeting was more influential than framing.

Despite a couple of study limitations, a key strength in this study is the inclusion of measures of changes in bone health. The majority of OP interventions have failed to assess physiological changes in bone (Blalock et al., 2000; Sedlak et al., 2000; Smith Klohn & Rogers, 1991). Although the gain-framed, targeted materials were successful at increasing calcium intake over 12 months, these changes were not associated with improvements in selected markers of bone health. In hindsight, it was optimistic to expect significant group differences in these markers, given previous research (Cummings et al., 2002) suggests detectable changes in BMD require nutritional supplementation, pharmaceutical, mechanical loading interventions or a longer follow-up period (Brown & Josse, 2002). Furthermore, high intra-individual variability of these measures (Christenson, 1997) may make modest changes difficult to detect.

In summary, the present research provides evidence that, for young women, framing messages in terms of the benefits to be gained and highlighting population-specific information, is more effective for promoting dietary calcium intake than framing messages in terms of what stands to be lost and providing generic information. Rephrasing existing materials to be gain-framed and population-specific would require little time and cost. Although it is unrealistic to develop unique materials for each subset of the population, young women should be given special attention given the high incidence of OP in women.

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Note

1. Please contact Dr Jung at mjung32@uwo.ca if you would like to see a copy of the intervention materials.

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