

Running Head: STRUCTURAL MODEL FOR OSTEOPOROSIS PREVENTING BEHAVIOR

Structural Model for Osteoporosis Preventing Behavior in Postmenopausal Women

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## Abstract

**Background:** Specific osteoporosis prevention behaviors (OPB) can prevent and delay bone deterioration; dual energy x-ray absorptiometry (DXA) scan can identify osteoporosis and provide personal osteoporosis risk information that may promote prevention behaviors.

**Objectives:** This study was designed to estimate the relationships between receiving personal knowledge of bone mineral density (BMD), gained through DXA scan, revised health belief (RHBM) variables, and two OPBs (increasing calcium intake and weight-bearing exercise) in healthy postmenopausal women 50 to 65 years of age.

**Methods:** Data from this randomized experiment were collected by questionnaire at three time points (initial [T1]; 6 month [T2]; 12 month [T3]) and by bone density assessment from 203 women over 18 months in 2001-2003. Data analysis included descriptive statistics and covariance structure analysis.

**Results:** Fit statistics showed measurement and structural models for calcium and exercise both fit well. There was a direct positive effect ( $\beta=.23$ ,  $p<.05$ ) of the experimentally manipulated provision of DXA results on calcium intake at T2, and indirectly on T3 through T2. Women in the experimental group who found out they had osteopenia or osteoporosis had a greater T1-T2 change in daily calcium than those with normal bone density ( $\beta=.30$ ,  $p < .05$ ). However, provision of DXA results did not relate to change in exercise. Motivation health beliefs predicted initial calcium and exercise levels; there was tentative evidence that susceptibility beliefs mediate between DXA provision and change in calcium intake.

**Discussion:** Personal knowledge of DXA results was significantly related to increases in calcium intake in post menopausal women, but not exercise. Directions for further study are discussed.

**Key Words:** bone density, health behavior, osteoporosis, structural equation model

Osteoporosis is a silent disease that primarily affects women, causing a debilitating loss of bone mass. Over 44 million people in the United States are at risk for developing osteoporosis and subsequent fracture of the hip and vertebrae (National Osteoporosis Foundation, [NOF] 2003). By the year 2020, it is estimated that 50% of Americans >50 years of age will either have or be at risk for having osteoporosis (U.S. Department of Health and Human Services, 2004). Yet, many effective osteoporosis prevention behaviors are easily implemented, including increasing calcium, exercise, Vitamin D intake, and weight-bearing activities; as well as not smoking; avoiding high levels of alcohol intake and nonhormonal/hormonal drug therapies.

The availability of good diagnostic tools for osteoporosis allows for early diagnosis of bone density and an increased opportunity for women to initiate or maintain osteoporosis preventing behaviors (OPB). Dual energy x-ray absorptiometry (DXA) is considered to be the gold standard for measuring bone mineral density (Berard, Bravo, & Gauthier, 1997; Kleerekoper, 1998; NOF, 2003). It is highly accurate and noninvasive, and provides personal information regarding one's bone density and risk for osteoporosis (Delmas, 1995; Marshall, Johnell, & Wedel, 1996, NOF, 2003 ). DXA can identify osteoporosis before the occurrence of a fracture, predict fracture risk, assess rate of bone loss, and monitor outcomes of osteoporosis treatment. Test results can motivate osteoporosis prevention, disability prevention, and health promotion (Rubin & Cummings, 1992; Silverman, Greenwald, Klein, & Drinkwater, 1997).

A baseline bone density scan is often recommended by health care providers for older women ( $\geq 65$  years). Yet younger women ( $< 65$ ) usually are not screened due to the high costs. Unfortunately, waiting until age 65 to have an initial bone density measurement may be too late since >50% of postmenopausal women between the ages of 50 to 65 already have compromised bone density (Sedlak, Doheny, Estok, & Zeller, 2004). Personal information about individual

risk gained through bone density screening may be influential in facilitating osteoporosis prevention behaviors before serious problems can develop.

Research findings on how personal knowledge of bone density affects women's decisions about osteoporosis preventing behaviors (OPB) are varied. For example, Ryan, Harrison, Blake, and Fogelman (1993) and Silverman, et al. (1997), found that personal knowledge of bone density gained through a DXA influenced decisions about postmenopausal hormonal therapy and OPB. Because, the study was retrospective, it was unclear whether the DXA, consultation with the physician, characteristics of the women, or patient education was the influencing factor. Others have found no relationship between knowledge gained from bone density measurement and OPB (Rubin & Cummings, 1992). Here we use a prospective design to further explore the relationship between personal knowledge and OPB. The study additionally explores the effects of general knowledge about osteoporosis and health beliefs.

#### Relevant Literature

Knowledge and health beliefs are proposed to be potential antecedents of two specific OPBs (calcium intake and exercise). The revised Health Belief Model (RHBM), initially developed by Rosenstock (1966) and revised by Rosenstock, Strecher, and Becker (1988) to include self-efficacy (SE), is used to explain why and under what conditions individuals take preventive actions (Nemcek, 1990). This model addresses how one reaches readiness for conducting health behaviors (Connell, Sharpe, & Gallant, 1995). Based on the RHBM, we propose women are more likely to participate in osteoporosis preventive behaviors to prevent or slow bone density loss if they: (a) perceive themselves to be more *susceptible* to osteoporosis; (b) believe osteoporosis is a *serious* threat; (c) show *efficacy* in their beliefs that they can modify their risks (*SE*); (d) perceive fewer *barriers* associated with preventive behaviors; (e) have a concern about their general health and a drive to improve it (*benefits* and *motivation*) (Salazar,

1991).

Previous empirical studies of the relationship between health beliefs and preventive behaviors show mixed results. Janz and Becker's (1984) meta-analysis found perceived barriers and susceptibility to be powerful behavioral influences on a variety of preventive health behaviors. In other studies specific to osteoporosis, the researchers found perceived susceptibility, seriousness, barriers, and benefits to be related to OPB (Kim, Horan, & Gendler 1991a; Rubin & Cummings 1992; Kim, Horan, Gendler, & Patel, 1991b). Still other studies found no relationship between HBM and OPB (Hsieh, Novielli, Diamond, & Cheruva 2001).

In addition to health beliefs, we investigate the effects of three types of knowledge about osteoporosis. Two represent general knowledge, in the sense that they apply to all persons. This general knowledge can be about broad aspects of osteoporosis or specific aspects of exercise or calcium intake. The third type of knowledge is the more personalized knowledge provided by a DXA scan. While general knowledge about osteoporosis is designed to address the risks, treatment, and necessary prevention behaviors of the disease, it has often been found inadequate to produce health behavior changes (Prochaska, DiClemente, & Norcross, 1992). We propose that specific personal knowledge about an individual's own bone density via DXA may serve as a stimulus for using general knowledge about osteoporosis to change health beliefs, and alter osteoporosis preventing behaviors.

In sum, the purpose of the present study was to examine the relationships among personal knowledge of bone mineral density gained through dual energy x-ray absorptiometry (DXA) screening, general knowledge of osteoporosis, revised health belief model (RHBM) variables, and osteoporosis preventing behaviors (calcium intake and exercise). Figure 1 summarizes the theoretical model.

## Method

Structural equation modeling (SEM) was used to evaluate a predictive model for the OPB (calcium intake and exercise) and to identify the effect among the variables influencing the OPBs in healthy postmenopausal women between 50 to 65 years of age.

### *Population, Sample*

The convenience sample included 203 community-based women aged 50-65 who responded to media advertisements and met study criteria. Eligibility criteria were; ability to read and write English; no prior bone density test; postmenopausal; general good health with no chronic diseases; not on hormonal therapy (HT) or medications that could affect bone density; ability to travel to a DXA office site for a bone density test. Approval for the study was obtained through the Institutional Review Board, and written informed consent was obtained from all subjects. Data were collected over an 18-month period from 2001-2003.

The typical study participant was in her mid-50s ( $M=56.65$ ,  $SD=3.93$ ), white (91%), married (61%), and had at least some post-high school education (76%). The median income range from \$35,001-\$50,000. Most participants had a body mass index (BMI) in the mid- to high 20s ( $M=27.80$ ,  $SD=6.19$ ). They typically did not smoke (87%) or smoked one pack or less per day (9%).

Based on the World Health Organization (WHO) Study Group (1994) osteoporosis rating criteria 42% of the participants in the current study had normal bone density, 45% had osteopenia, and 13% had osteoporosis. None of the participants was ever previously told that she had compromised bone density. Participants with osteopenia or osteoporosis tended to be slightly over an inch shorter than those with normal bone density ( $t=-3.606$ ,  $p<.001$ ), weighed about 30 pounds less ( $t=-5.662$ ,  $p < .001$ ), and had a lower BMI ( $t=-4.681$ ,  $p < .001$ ). They did not differ in average age ( $t=-.288$ ,  $p=.774$ ).

A brief inspection of the experimental and control groups was made to assess their equivalence. T-tests comparing the two groups on the continuous age, height, and weight variables showed no significant differences. The two groups were also similar in terms of demographic characteristics, such as ethnicity, marital status, education, income level, and health variables, such as menopausal status and smoking. Finally, the groups were compared on their WHO osteoporosis categories. A chi-square test showed no significant differences between groups in the proportion for each osteoporosis category,  $\chi^2(df=2) = 3.642, p=.162$ . In sum, the two groups appear to represent equivalent samples.

#### *Variables, Instruments*

*Group assignment.* Group assignment is an exogenous variable resulting from the experimental manipulation used to randomly assign participants to receive a DXA (n=101) or not (control group; n=102).

*Osteoporosis Preventing Behaviors Survey (OPBS).* The OPBS (Doheny & Sedlak, 1995) is a 27-item multiple-choice, self-report instrument addressing OPB. Sociodemographic data included self-reported age, race, marital status, education, income, living arrangement, and occupation. The instrument has content validity and equivalent form reliability.

*Osteoporosis Knowledge Test (OKT), Osteoporosis Health Belief Scale (OHBS), and the Osteoporosis Self-Efficacy Scale (OSES).* Scales developed by Kim and colleagues (Horan, Kim, Gendler, Froman, & Patel, 1993; Kim, et al., 1991a, 1991b) were used. Principal component analytic evidence from the present study strongly replicated the health belief factors defined by Kim, et al. (1991b). Specifically, principal components analysis (with varimax rotation) of the 42 health belief items and 12 self-efficacy items produced a rotated factor structure in which every item designed to measure each health belief loaded most strongly on its appropriate factor. Thus, the dimensions identified by Kim, et al. (1991b) were observed in the present study; Cook and

Campbell's (1980) criteria of convergent and discriminant validity were clearly supported. Finally, internal consistency at Times 1, 2, and 3 for each of the OHBS and OSES scales ranged from .76 to .92 in the present study, which was similar to the figures reported by Kim, et al. (1991a, 1991b). Stability coefficients for the subscales generally ranged from .54 to .83, a greater range than found by Kim, et al. The lower stability coefficients most likely reflected true change in participants over the study testing period. Specific descriptions of each scale follow.

*Osteoporosis Knowledge Test (OKT).* The OKT (Kim, et al., 1991a) is a 24-item tool assessing general knowledge of osteoporosis. The possible range of scores is 0 to 24. The OKT items are generally combined to make two subscales: OKT Calcium (items 1-9 and 17-24) and OKT Exercise (items 1-16). However, these two subscales share 9 common items (items 1-9), which assess very general aspects of osteoporosis knowledge. For our modeling purposes, we created three subscales consisting of items 1-9 (general knowledge), items 10-16 (specific knowledge: exercise) and items 17-24 (specific knowledge: calcium). Cronbach's alphas for the knowledge test on the data in the present study ranged from .52 to .66, however these were likely underestimates of reliability, given the dichotomous item responses. Test-retest correlations for a total scale score were  $r_{12}=.76$  and  $r_{23}=.74$ .

*The Osteoporosis Health Belief Scale (OHBS).* The OHBS (Kim, et al., 1991b) is a 42-item tool consisting of 7 subscales (susceptibility, seriousness, benefits and barriers to calcium and exercise, and motivation). Each item is rated using a 5-point scale. The possible range of scores for each subscale is 6 to 30, with a possible range of 42 to 210 for the total scale. Test-retest reliability for the total instrument is .90, and subscale reliabilities range from .71-.82. In the present study, test-retest reliabilities for the total instrument at times 1, 2, and 3 ranged from .74 to .77. Subscale reliabilities at times 1, 2, and 3 ranged from .76-.92.

*Osteoporosis Self-Efficacy Scale (OSES).* The OSES (Horan, et al., 1993) rating scale has

two versions. The 12-item version of the OSES was used to avoid subject fatigue. It consists of 2 subscales (Osteoporosis Self-Efficacy Exercise scale items 1-6; Osteoporosis Self-Efficacy Calcium scale items 7-12). Scoring is done by adding the number given to each item and multiplying by 10. The possible range of scores for each item is 0-100, thus, the possible score range for each subscale is 0 to 600, with a possible range of 0 to 1200 for the total scale. The reliability coefficient for the total tool and the two subscales was  $\alpha = .90$ . For the present study, they were  $\alpha = .95$  to  $.96$  and  $.96$  to  $.98$ , respectively.

*DXA.* DXA has low precision error, low radiation exposure, and ability to measure multiple skeletal sites (Wahner & Fogelman, 1994). Measurements of bone mineral density of the AP lumbar spine (L1-L4, anterior posterior) and femur were made using the Lunar model DPX-IQ or DPX-A dual energy x-ray absorptiometer. The DXA takes only a few minutes, has significantly less radiation and can predict future risk of fractures in asymptomatic patients (NOF, 2003a).

*DXA-T score.* The DXA result is expressed as a T-score (or young adult Z-score). The T-score is independent of age (Delmas, 1995) and is used to compare the DXA result with the mean peak bone mass of a young adult in terms of a standard deviation (SD). At any skeletal site, a decrease in bone mass of one SD approximately doubles the relative risk of subsequent fracture. DXA scores were coded using WHO prescribed categories; 0= normal (T-score above -1 SD in both sites); 1=osteopenia (T-score between -1 and -2.5 SD in one or both sites); 2=osteoporosis (T-score below -2.5 SD in one or both sites).

### *Procedures*

Media advertisements for the study included a toll-free phone number for interested participants. Following contact by a potential subject, and after screening to determine eligibility, a consent form with an explanation of the study and the initial questionnaire were mailed. Completion of the questionnaire took approximately 20 minutes. Participants who did not return the battery of

questionnaires within 2 weeks were sent reminder cards. Upon receipt of the completed questionnaire and consent form, participants assigned to the treatment group were mailed a prescription for the DXA, addresses of the three DXA site locations, and a phone number to use when making the appointment. On the day of the scheduled DXA, the participant was asked to sign consent for bone density screening and release of DXA results to the researchers. Data were collected at three time points; initially (T1); 6 months (T2); 12 months (T3). The control group women were offered a free DXA following the 12 month data collection period. Five-dollar store merchandise certificates were given to the women at the two data collection points when DXA scans were not being offered.

The DXA scan took no more than 15 minutes. A radiologist certified in reading bone density scans interpreted the scans and identified the appropriate T-score rating. After the researcher received the results, letters written at an eighth grade education level were mailed to the women. The letters included a description and interpretation of normal bone density, osteopenia, or osteoporosis and highlighted the participants' own results. If the DXA showed below normal results, follow-up with the participant's physician was recommended.

#### Data Screening and SEM Analysis Procedures

Following dependent variable screening, the structural equation modeling process proceeded through multiple steps, as recommended by Mulaik and Millsap (2000). This included an initial assessment of measurement dimensionality, testing the fit of a confirmatory factor analytic measurement model, testing the fit of the proposed structural model, and finally, investigating variations of the proposed structural model.

*Dependent variable screening.* The distributions of the two dependent variables -- exercise and calcium intake -- were inspected using both statistical and graphical techniques to determine whether there were any issues with outliers/extreme values and/or non-normality that

might influence the structural equation modeling results. The calcium values had only relatively minor deviations from normality, but the exercise variable distribution posed some issues for subsequent analyses. Specifically, about 10% of the sample (20-21 persons at each measurement time) engaged in substantially more weight-bearing exercise (about 280 minutes of weight-bearing exercise a week) than the rest of the sample, making this group of participants somewhat anomalous. Because our measurement technique imposed a ceiling at the top of the exercise values, participants who were at this extreme could not possibly change their level of exercise in a positive (increasing) direction at the next measurement time (i.e., T1->T2 or T2->T3). A square root transformation of the exercise values was used to address the non-normality. In addition, supplemental analyses were performed that included a dummy variable coding for membership in the strenuous exercise group or dropped persons who were at the top exercise level at T1 or T2. Conclusions from these supplemental analyses did not substantially differ from those presented in the current paper.

*SEM modeling procedures.* Fit of the measurement and structural models was assessed using the  $\chi^2$  goodness-of-fit test. A well-fitting model is one for which the resulting  $\chi^2$  value is not statistically significant. However, the  $\chi^2$  is easily rejected for what are often minor and theoretically uninteresting sources of misfit. Thus, it is customary to supplement the  $\chi^2$  test with various additional fit indices that may indicate that the model fits adequately, even if the  $\chi^2$  test is statistically significant (Kline, 2005). Our choice of supplemental fit indices was guided by Hu and Bentler's (1999) two-index strategy for determining fit. For maximum likelihood estimation (as used in the current study) and sample sizes of  $\leq 250$ , this index consists of a cutoff value of about .95 for the Comparative Fit Index (CFI; Bentler, 1990), combined with a cutoff value of about .09 for the Standardized Root Mean Residual (SRMR; based on Jöreskog & Sörbom,

1986). In other words, models with a CFI below .95 and an SRMR of greater than .09 do not fit adequately. Other models are accepted as plausible.

### Results

Tables 1 and 2 present descriptive statistics (means, standard deviations, and correlations) for scale scores. The remaining portions of this section describe tests of comprehensive models relating antecedent variables reflecting knowledge about osteoporosis and the health beliefs components to the osteoporosis preventing behavior (OPB) outcomes. First, SEM measurement models for calcium and exercise were tested (see Figures 2 and 3). Next, SEM structural models were specified to test whether the experimental manipulation (DXA screening) affected OPBs at the final two measurement times. We anticipated that providing the DXA screening information would have a general effect of increasing OPBs, and that this effect might be mediated by knowledge and health beliefs.

#### *Specification and Test of Measurement Models*

A first step was to introduce some conceptual parsimony into the set of antecedent health beliefs and knowledge measures. Exploratory factor analysis, inspection of correlations among the measures, and conceptual meaning were used to develop a plausible measurement model that captured higher level commonalities among the measures. These analyses suggested that the set of measures likely reflected three broader constructs: (a) motivation to engage in OPBs; (b) beliefs about susceptibility to osteoporosis; (c) knowledge about osteoporosis. Most of the health beliefs and knowledge measures fit quite cleanly within this framework, with two exceptions. First, the seriousness subscale of the OHBS was eliminated from further analysis as preliminary analyses showed it did not relate substantially to other health beliefs, knowledge, or OPBs. Second, the Benefits variable, which was initially thought of as a motivational force, seemed

primarily to reflect knowledge in the calcium measurement model, and to reflect both motivation and knowledge in the exercise measurement model.

SEM measurement models consistent with the three-construct framework just described were fit to the T1 data to determine whether this model was empirically defensible. Figures 2 and 3 depict the measurement models for Calcium and Exercise. Each model specified three latent constructs (Motivation, Susceptibility, and Knowledge), which were allowed to freely intercorrelate. Each latent construct, in turn, had either three or four indicators.

More specifically, the indicators for the Motivation construct were the: (a) health motivation subscale of the OHBS; (b) exercise or calcium-related self-efficacy (OSES) subscale; (c) calcium or exercise barriers subscale of the OHBS; (d) in the case of the exercise model, the benefits subscale of the OHBS. The indicators for Knowledge were: (a) a composite score based on a subset of the general osteoporosis knowledge items of the OKT; (b) a composite score based on the osteoporosis knowledge items specific to either exercise or calcium; (c) the benefits subscale of the OHBS. Finally, the Susceptibility construct indicators consisted of three item parcels constructed by averaging: (a) items #1 and #2; (b) items #3 and #4; (c) items #5 and #6 of the susceptibility subscale of the OHBS. There is some overlap in the indicators used for the two measurement models (i.e., the health motivation, general osteoporosis knowledge, and susceptibility measures), but the specific knowledge, barriers, benefits, and self-efficacy subscales were unique to either the exercise or the calcium measurement model.

For both measurement models, although the chi-square statistic was statistically significant, the remaining indices suggested an adequate to excellent fit. For the Calcium model,  $\chi^2 = 40.302$ ,  $df=25$ ,  $p=.0268$ ,  $CFI=.970$ ,  $SRMR=.050$ . For the Exercise model,  $\chi^2 = 56.37$ ,  $df=24$ ,  $p=.0002$ ,  $CFI=.950$ ,  $SRMR=.052$ . Standardized parameter estimates for these two measurement models are presented in Figures 2 and 3. All factor loadings are statistically

significant, and most are quite strong. An exception was the Benefits subscale, which tended to have lower loadings than other subscales, and cross-loaded on the Motivation construct in the Exercise model. Importantly for our purposes, intercorrelations between the Motivation, Susceptibility, and Knowledge constructs were low magnitude, and mostly non-significant. This reduction of the measures to three more parsimonious and largely unrelated constructs facilitated interpretation and diminished multi-collinearity in subsequent tests of the structural models.

#### *Specification and Tests of Structural Models*

Next, two structural models were tested (see Figures 4 and 5). The models related either exercise or calcium OPB to the health motivation, susceptibility, and osteoporosis knowledge antecedents. They also incorporated the experimental effect of receiving DXA screening information or not. Each model included the calcium or exercise OPB at all three measurement times, and specified the OPB values of later time periods as dependent upon values at earlier time periods, as would be expected if there were at least some degree of stability over time in the OPB measures. This also controlled for the effects of earlier OPBs on later OPBs, so that estimates of any predictor variable effects on later OPBs were unconfounded with prior behavior. T1 health motivation, susceptibility, and knowledge constructs were specified to influence only the T1 calcium or exercise OPB. This was done because we assumed that any subsequent effects of these antecedents were carried through the relationship of the T1 OPB to later OPB measurements.

*Calcium structural model.* Figure 4 shows the results of the test of this model for the Daily Calcium OPB. The model fit well,  $\chi^2=90.465$ ,  $df=55$ ,  $p=.0018$ ,  $CFI=.955$ ,  $SRMR=.054$ , thus we proceeded to an inspection of the parameter estimates. First, the paths corresponding to the directional relationships among T1, T2, and T3 Daily Calcium OPB are all statistically significant and positive. This suggests that study participants were relatively stable in their

relative standings with respect to calcium intake over the three measurement periods, although group means did also vary over time.

Second, persons in the experimental group had, on average, a significantly higher T2 Calcium intake than the control group, as indicated by the significant path coefficient from group assignment,  $\beta=.23, p < .05$ . Because the effects of membership in the experimental group were carried to T3 Daily Calcium through the T2 Daily Calcium measure, there was no additional direct effect on T3 Daily Calcium associated with being in the experimental group, as indicated by the non-significant path from group assignment. Third, both T1 Motivation ( $\beta=.30, p < .05$ ) and Knowledge ( $\beta=.25, p < .05$ ) have moderate positive paths to the T1 Daily Calcium intake, suggesting that study participants who had higher levels of health motivation and greater osteoporosis knowledge tended to have higher levels of daily calcium intake. In contrast, Susceptibility at T1 does not significantly predict T1 Daily Calcium intake. Finally, the proportion of variance in Daily Calcium explained by the full model was 20, 38, and 51%, respectively, for the T1, T2, and T3 Daily Calcium measurements.

*Exercise structural model.* The exercise structural model is depicted in Figure 5. This model fit adequately, but not quite as well as the calcium model,  $\chi^2=107.314, df=56, p<.0001, CFI=.945, SRMR=.054$ . Again, as expected, the paths between the three Weight-Bearing Exercise measurements showed significant stability in rank orderings across time, suggesting that those participants who engaged in more exercise at the initial measurement time tended to also do so at later times. However, contrary to the research hypothesis, there was not a significant effect of experimental group membership on T2 Weight-Bearing Exercise ( $\beta=.09, ns$ ). And in the exercise model, only T1 Motivation significantly predicted T1 Weight-Bearing Exercise ( $\beta=.45, p < .05$ ), the effects of Motivation and Knowledge were non-significant.

Finally, the proportion of variance in Weight-Bearing Exercise explained by the full model was 22, 42, and 49%, respectively, for the T1, T2, and T3 measurements.

*Supplementary calcium models.* Given the significant effect of the experimental manipulation observed in the calcium model, exploratory analyses were undertaken to further probe the relationship and try to determine if the effects of the DXA screening were mediated by T2 Motivation, Susceptibility, or Knowledge. Preliminary analyses determined that the experimental manipulation had no detectable effect on T2 Motivation or Knowledge, but might relate to T2 Susceptibility. Thus, the model shown in Figure 6 was tested. This model was similar to the earlier calcium structural model of Figure 4, except that it added T2 Susceptibility as an intervening variable between experimental group membership and T2 Daily Calcium intake. (Because T1 Susceptibility was shown to have no appreciable effect in the previous calcium model, it was not included in the analysis.)

This model fit well,  $\chi^2=83.367$ ,  $df=58$ ,  $p=.0162$ ,  $CFI=.969$ ,  $SRMR=.060$ . The evidence for a mediating effect of Susceptibility was equivocal. The path from the experimental manipulation to Susceptibility ( $\beta=.13$ ) was not significant at the  $p < .05$  level, but was significant at  $p < .10$ . The path from Susceptibility to T2 Daily Calcium ( $\beta=.14$ ) was significant at  $p < .05$ . This suggests the potential for a weak mediating effect of Susceptibility on the relationship between the DXA screening manipulation and Daily Calcium intake. However, it is clear that at best the relationship is one of partial mediation, as there is a remaining significant direct effect of the manipulation on Daily Calcium,  $\beta=.21$ ,  $p < .05$ . This suggests that there may be other potential mediators, that were not included in the current study.

Finally, another exploratory model was tested using only the experimental group participants. This analysis addressed whether the specific information received from the DXA screening related to increase in Daily Calcium intake at T2 or T3. To perform this test, a

dichotomous “WHO category” variable was created; it was coded “0” for those participants whose DXA screening results indicated a normal bone density, and “1” for those participants whose screening indicated osteopenia or osteoporosis. This was used in a simplified model that included paths among the Daily Calcium intake variables at T1-T3 as before, and also including paths from the WHO category to T2 and T3 Daily Calcium (see Figure 7). Because this model was fully saturated, fit was perfect. Of most interest, however, is the path coefficient of  $\beta=.30$ ,  $p < .05$  from WHO category to T2 Daily Calcium. This result indicated that experimental group participants who were told that they had osteopenia or osteoporosis had a greater change in Daily Calcium from T1 to T2 than did those who were told their bone density was normal.

### Discussion

This study was designed to explore the relationships among osteoporosis knowledge, personal knowledge of bone density gained through DXA, RHBM variables, and OPB. The proposed model appeared most useful for understanding factors influencing calcium intake. Specifically, we found that personal knowledge of DXA screening results explained a significant proportion of the T1-T2 change in the osteoporosis preventing behavior of calcium intake in post menopausal women. In contrast, we did not observe a significant effect of the experimental provision of DXA screening results on exercise. This may be because making changes in calcium intake may require less effort and lower self-regulatory demand than making major changes in exercise behavior. Changes in exercise behavior likely require more personal involvement and more intensive interventions (Blalock, et al., 2002). To benefit from the motivating effects of DXA information, women may need additional help in determining the type of exercise or scheduling of exercise, as well as ongoing motivational encouragement. This requires further study.

Our findings were consistent with some previous health prevention research in that health motivation and knowledge of osteoporosis were significant predictors of calcium intake, and health motivation predicted exercise behavior. Our tentative finding that perceived susceptibility had a partial mediation effect on the relationship between personalized knowledge (DXA) and calcium intake is intriguing. It suggests that personalized knowledge has some effect via changes in susceptibility beliefs. This interpretation was reinforced by results from the test of the model depicted in Figure 7, which found that women who had abnormal DXA results were more likely to increase their calcium intake than those who had normal bone density. As a practical implication, the finding that health motivation and knowledge had a direct effect on calcium intake for the women in this study reinforces the importance of health care provider and media efforts to increase the public's knowledge of osteoporosis.

More than half (57%) of the postmenopausal women between 50-65 years of age in the current study were diagnosed with significant bone density loss. Receiving personal information from bone density screening regarding this loss was an effective intervention in getting them to increase their calcium intake. These results imply that routine screening for osteoporosis in women only after age 65 may be short-sighted in the effort to decrease/prevent osteoporosis. The financial and personal cost of osteoporosis takes a great toll on the well being of individuals, families, the nation, and is predicted to increase. Bone density screening of postmenopausal women <65 years of age and earlier intervention may be a cost effective method to lower this risk.

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Table 1

*Descriptive Statistics for Health Belief and Knowledge Variables.*

|   | M      | SD     | 2   | 3   | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   | 13   |
|---|--------|--------|-----|-----|------|------|------|------|------|------|------|------|------|------|
| <i>Health Belief Variables (at Time 1 unless otherwise noted)</i> |        |        |     |     |      |      |      |      |      |      |      |      |      |      |
| 1. Susceptibility   | 17.01  | 5.35   | .68 | .17 | -.11 | -.03 | .05  | .07  | .01  | .04  | -.10 | .17  | .03  | -.01 |
| 2. Susceptibility (T2)  | 17.56  | 5.77   | --- | .12 | -.15 | -.09 | .09  | .10  | .04  | .08  | -.11 | .15  | .01  | -.02 |
| 3. Seriousness  | 18.71  | 4.04   |     | —   | -.19 | -.25 | .32  | .35  | .06  | .01  | -.18 | .04  | .05  | .01  |
| 4. Self-efficacy: Calcium   | 459.61 | 128.51 |     |     | —    | .48  | -.43 | -.38 | .22  | .28  | .40  | .03  | .20  | .09  |
| 5. Self-efficacy: Exercise  | 402.61 | 138.56 |     |     |      | —    | -.31 | -.67 | .11  | .34  | .44  | -.06 | .08  | .04  |
| 6. Barriers: Calcium  | 12.34  | 3.78   |     |     |      |      | ---  | .55  | -.09 | -.38 | -.34 | -.16 | -.15 | -.17 |
| 7. Barriers: Exercise   | 12.43  | 4.53   |     |     |      |      |      | —    | -.14 | -.38 | -.42 | -.10 | -.22 | -.20 |
| 8. Benefits: Calcium  | 22.72  | 3.51   |     |     |      |      |      |      | —    | .55  | .10  | .19  | .20  | .21  |
| 9. Benefits: Exercise   | 24.45  | 3.15   |     |     |      |      |      |      |      | —    | .24  | .32  | .26  | .36  |
| 10. Motivation  | 23.36  | 3.42   |     |     |      |      |      |      |      |      | —    | -.02 | .14  | .00  |
| <i>Knowledge Variables (at Time 1)</i>                            |        |        |     |     |      |      |      |      |      |      |      |      |      |      |
| 11. General Osteoporosis  | 5.76   | 1.94   |     |     |      |      |      |      |      |      |      | —    | .50  | .43  |
| 12. Specific: Calcium   | 6.04   | 1.52   |     |     |      |      |      |      |      |      |      |      | ---  | .37  |
| 13. Specific: Exercise  | 4.62   | 1.57   |     |     |      |      |      |      |      |      |      |      |      | ---  |

*Note.* Correlations greater than .13 are statistically significant at  $p < .05$ .

Table 2

*Correlations of Health Belief and Knowledge Variables with Daily Calcium and Weight-Bearing Exercise OPBs*

|   | Daily Calcium Intake<br>( mg, square root-transformed) |       |       | Weight-Bearing Exercise<br>(min/week) |       |       |
|---|--|-------|-------|---------------------------------------|-------|-------|
|   | T1   | T2    | T3    | T1                                    | T2    | T3    |
| <i>Health Belief Variables (at Time 1 unless otherwise noted)</i> |  |       |       |                                       |       |       |
| 1. Susceptibility   | -.07   | -.04  | .03   | .00                                   | .02   | .03   |
| 2. Susceptibility (T2)  | -.10   | -.09  | -.08  | -.03                                  | .05   | -.01  |
| 3. Seriousness  | -.03   | -.09  | .01   | .05                                   | -.05  | .01   |
| 4. Self-efficacy: Calcium   | .25  | .22   | .21   | .19                                   | .16   | .11   |
| 5. Self-efficacy: Exercise  | .04  | .05   | .12   | .35                                   | .31   | .30   |
| 6. Barriers: Calcium  | -.23   | -.32  | -.30  | -.14                                  | -.24  | -.11  |
| 7. Barriers: Exercise   | -.14   | -.17  | -.14  | -.43                                  | -.40  | -.37  |
| 8. Benefits: Calcium  | .11  | .10   | .08   | .09                                   | .00   | .08   |
| 9. Benefits: Exercise   | .18  | .22   | .21   | .22                                   | .19   | .12   |
| 10. Motivation  | .24  | .16   | .18   | .15                                   | .16   | .20   |
| <i>Knowledge Variables</i>  |  |       |       |                                       |       |       |
| 11. General Osteoporosis  | .26  | .22   | .17   | .07                                   | .15   | .12   |
| 12. Specific: Exercise  | .12  | .11   | .08   | .14                                   | .18   | .13   |
| 13. Specific: Calcium   | .23  | .20   | .07   | .16                                   | .21   | .19   |
| Mean  | 14.89  | 15.31 | 16.15 | 73.26                                 | 73.85 | 78.10 |
| Standard Deviation  | 6.70   | 6.63  | 6.12  | 82.69                                 | 81.89 | 80.81 |

*Figure 1.* Depicts the experimental design of the study to examine the effect of personal knowledge gained via DXA on mediating variables of general knowledge of osteoporosis and health beliefs, and the resulting effects on the dependent osteoporosis preventing behaviors (OPB) variables.

*Note: Sample was comprised of women 50 to 65 years of age, who were randomized between the treatment and control groups.*

Figure 2

Diagram of Calcium Measurement Model with Standardized Parameter Estimates

Figure 3

Exercise Measurement Model with Standardized Parameter Estimates

Figure 4

Calcium Structural Model with Standardized Parameter Estimates

Figure 5

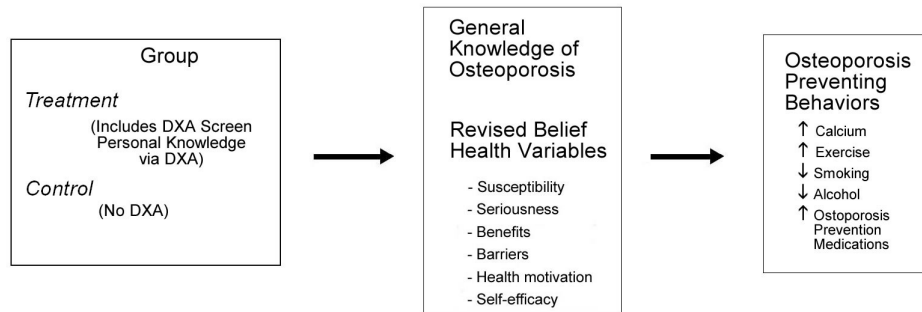
Exercise Structural Model with Standardized Parameter Estimates

Figure 6

Calcium Structural Model with Mediating Path

Figure 7

Calcium Structural Model: Effect of WHO Category on Change in Daily Calcium Intake  
(Experimental Group Only)



*Figure 1.* Depicts the experimental design of the study to examine the effect of personal knowledge gained via DXA on mediating variables of general knowledge of osteoporosis and health beliefs, and the resulting effects on the dependent osteoporosis preventing behaviors (OPB) variables.

*Note:* Sample was comprised of women 50 to 65 years of age, who were randomized between the treatment and control groups.

Figure 2

Diagram of Calcium Measurement Model with Standardized Parameter Estimates.

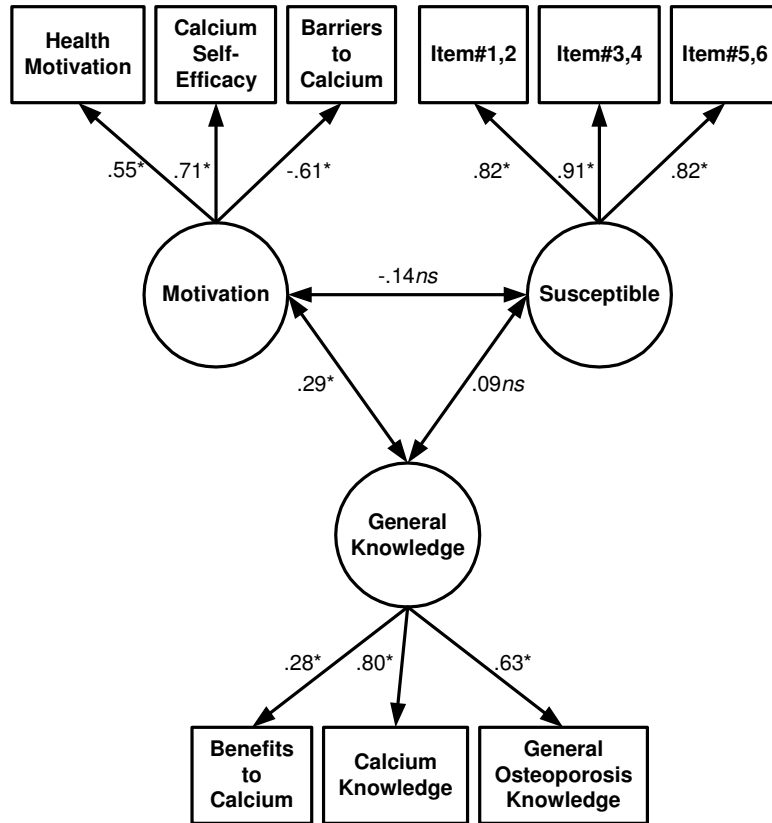


Figure 3

*Exercise Measurement Model with Standardized Parameter Estimates.*

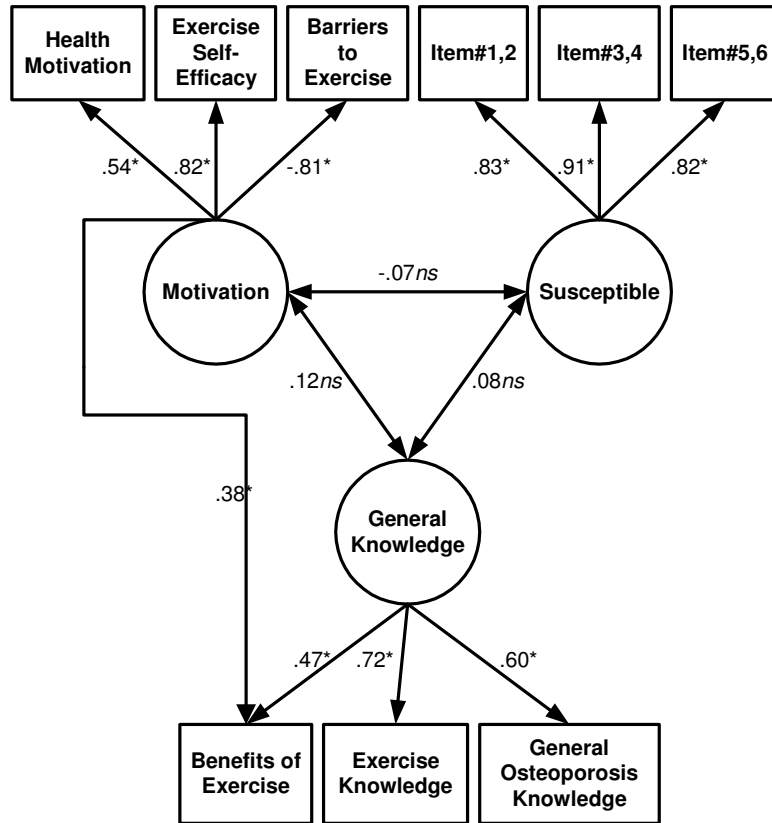
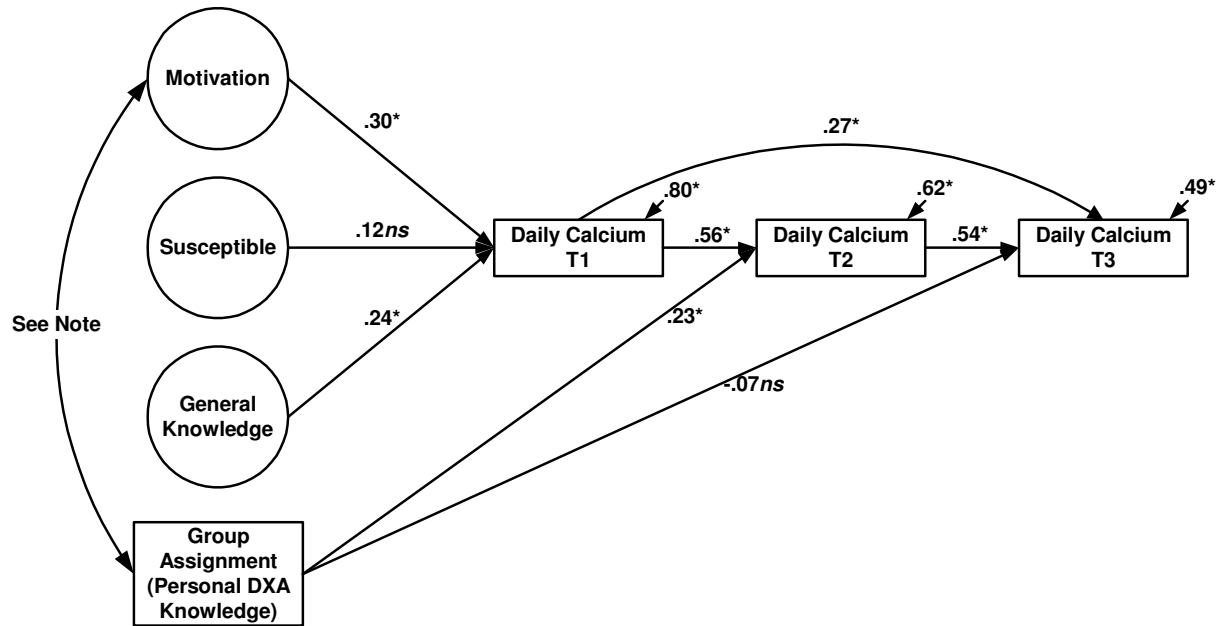


Figure 4

Calcium Structural Model with Standardized Parameter Estimates.



Note. All correlations among exogenous variables were non-significant with the exception of the  $.29$  relationship between Motivation and Knowledge.

Figure 5

*Exercise Structural Model with Standardized Parameter Estimates.*

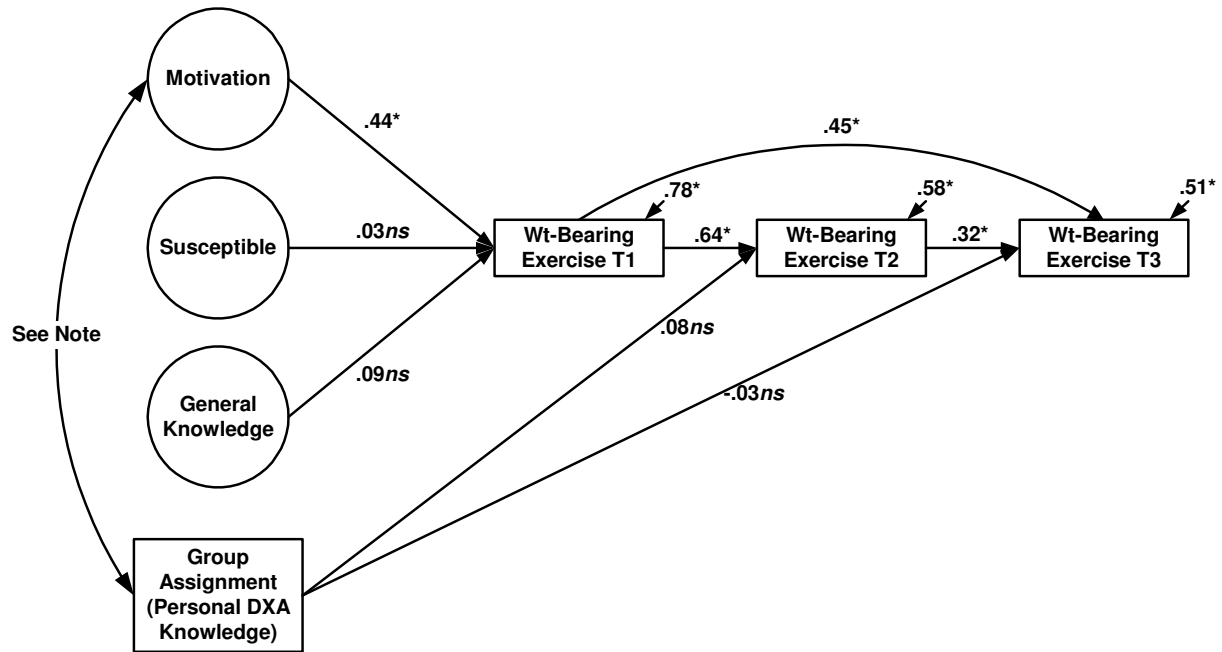
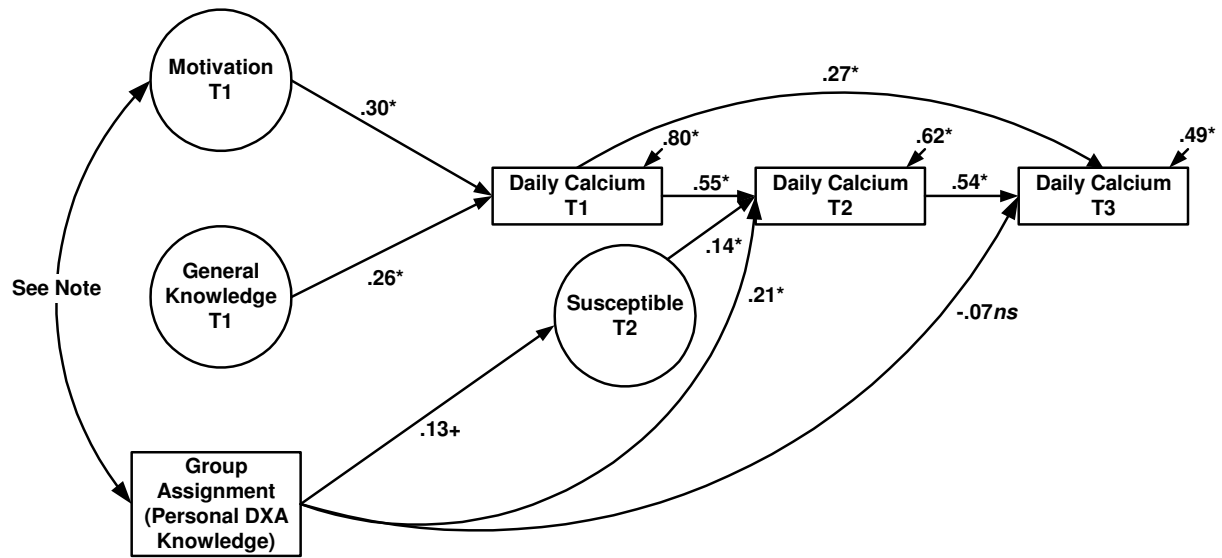


Figure 6

Calcium Structural Model with Mediating Path.



Note. All correlations among exogenous variables were non-significant with the exception of the  $.29$  relationship between Motivation and Knowledge.

Figure 7

*Calcium Structural Model: Effect of WHO Category on Change in Daily Calcium Intake (Experimental Group Only).*

