MARKERS OF BONE HEALTH: RELATIONSHIPS WITH HEALTH BELIEFS AND PHYSICAL ACTIVITY IN YOUNG ADULT FEMALES

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Abstract

The purpose of the present investigation was to assess health beliefs associated with osteoporosis in a young adult female sample. Further, inter-relationships between beliefs, self-reported physical activity behavior, and a physiological marker of bone properties was considered. Questionnaires consisting of items assessing health beliefs and physical activity behavior were administered to 100 females. Quantitative ultrasound measurements were used to assess tibial speed of sound (SOS). A pattern of weak to moderate relationships between health beliefs associated with osteoporosis and physical activity were reported. Weak relationships between health beliefs and physical activity on SOS scores were noted. Regression analyses supported the role of health beliefs and physical activity on dominant tibial SOS scores. The results highlight the need for further investigation into the relationship between beliefs and osteo-protective behaviors on physiological markers of bone health among young adult females.

Introduction

Osteoporosis is a skeletal disease which results in increased fragility and fracture rates (World Health Organization, 1994). Affliction rates suggest that one in four females over the age of fifty develop osteoporosis (Tenenhouse et al., 2000). The development of osteoporosis is credited to either insufficient accumulation of peak bone mass or to excessive bone loss across the lifespan and has been associated with varied financial, physical, and psychological costs (Lorraine et al., 2003; Sawka et al., 2005). The majority (i.e.,

>90%) of maximal peak bone mass is acquired by the age of 20 and fully reached by 30 (Matkovic, Badenhop-Stevens, Ha, Mobley, & Landoll, 2001; National Institute of Health, 2006). Therefore, targeting university-aged females provides a unique opportunity to employ strategies aimed to optimizing and maintaining bone health across the lifespan.

Research experts have called for to call for more theory driven research to help understand health behavior and prevention and design more useful intervention strategies (Bouchard, Blair, & Haskell, 2006). One such theoretical orientation is the Health Belief Model (HBM; Rosenstock, 1974). The HBM suggests that a health condition perceived to be a *threat*, will result in motivated behavior to avoid the threat. *Perceived susceptibility* (the perception that one is at risk for a disease) and *perceived severity* (the perceived seriousness of that disease) are the two components contributing to perceived *threat*. In addition, *perceived benefits* of taking action need to outweigh the *perceived barriers* for an individual to engage in preventative behaviors. Diverse demographic, socio-psychological, and structural variables (e.g., educational attainment, age, gender, and prior knowledge) affect an individual's perceptions and thus indirectly influence health-related behavior. *Cues to action* are thought to affect perceived threat by initiating the decision to take preventative action. Finally, health motivation contributes to engaging in the healthy behaviors and distinguishes illness and sick-role behavior from health behavior (Becker, 1985). Research has demonstrated that university/college aged females perceive low susceptibility to developing osteoporosis, moderate seriousness, and moderate to high benefits of calcium and physical activity (Taggart & Connor, 1995; Ziccardi, Sedlak, & Doheny, 2004).

One behavioral variable linked to the prevention of osteoporosis is physical activity as bone mass is responsive to the mechanical load placed on the skeleton (Bouchard et al., 2006).

Further, the influence of physical activity ceases when activity is stopped or reduced (Bonaiuti et al., 2002; United States Department of Health & Human Services, 2005). Research examining the relationship between health beliefs and physical activity is somewhat equivocal with some reporting a positive relationship (Ziccardi et al., 2004) and others reporting no relationship (Kasper, Peterson, Allegrante, Galsworthy, & Gutin, 1994; Piaseu, Scheep, & Belza, 2002).

The bulk of heath belief research in osteoporosis has examined their association to knowledge (Taggart & Connor, 1995; Ziccardi et al., 2004) or osteo-protective behaviors (Kasper, Peterson, & Allegrante 2001; Piaseu et al., 2002) with minimal attention linking these variables to physiological markers of bone health. Quantitative ultrasound (QUS) is an emerging low cost, radiation free screening technique to assess bone properties of the peripheral skeleton consistent with WHO criteria for osteoporosis diagnosis. Cross-sectional and prospective studies have shown QUS to be highly correlated (r = .93) with bone mineral density estimates and predictive of osteoporotic fractures in levels comparable to the gold standard (Chen, Chen, Fund, Lin, & Yao, 2004; Marín, González-Macías, Díez-Pérez, Palma, & Delgado-Rodríguez, 2006). Research has demonstrated support for a positive relationship between QUS measurements and physical activity behavior in female adolescents (Murphy, Ni Dhuinn, Browne, & O'Rathaille, 2006) and post-menopausal women (Blanchet et al., 2003). Consideration of health beliefs as related to physiological markers of bone properties has not yet been investigated. Convergent support for the role of health beliefs on behavior may be offered through empirical investigation.

The overall purpose of this study was to examine health beliefs associated with osteoporosis in a convenience sample of university female students. Further, the inter-relationship between health beliefs, physical activity, and bone properties as assessed by

QUS was considered. Based on inconclusive findings (e.g., Kasper et al., 1994; Wallace, 2002), no hypotheses were advanced for the relationship between health beliefs and physical activity. As research has not examined the relationship between health beliefs and QUS, no hypotheses were advanced. Consistent with previous research (Blanchet al al., 2003; Murphy et al., 2006), it was hypothesized that physical activity behavior would be positively correlated with bone ultrasound measurements.

Methods

Participants: A convenience sample of 100 university female students aged 18-25 years (*M* = 20.65; *SD* = 1.55) were recruited to participate. Inclusion criteria were Caucasian, eumerorrheic (i.e., regular menses for more than 2 years) females. Average physical activity (M_{GETLQ} = 52.63; *SD* = 19.63) and body mass index (BMI) scores (*M* = 22.57; *SD* = 2.57) were calculated. According to anthropometric guidelines (World Health Organization, 2000), 16% of participants were underweight (BMI < 18.5), 83% were in the normal range (BMI = 18.5-24.9), and 1% were classified as obese (BMI > 30). Of the total sample, 69% reported currently taking oral contraceptives and 2% currently smoked.

Measures

Demographics: Relevant demographic variables including age and lifestyle behaviors (e.g., smoking and oral contraceptive use) were queried. Height (cm) and weight (kg) were measured according to the Canadian Physical Activity, Fitness & Lifestyle Appraisal assessment protocol (Canadian Society for Exercise Physiology, 2002). BMI was determined by the formula weight divided by height squared (kg/m^2).

Osteoporosis Knowledge Test. The Osteoporosis Knowledge Test (OKT; Kim et al., 1991) was completed as an assessment of general knowledge of osteoporosis. The OKT is a 24 item measure of controllable and uncontrollable risk factors using a multiple-choice format. Scores range from 0 to 24, with higher scores indicative of greater overall knowledge. Scores can also be reported as percent correct. Preliminary support for content validity has been documented (Kim et al., 1991) with internal reliability scores ranging from 0.40 to 0.86 (Werner, 2005).

Osteoporosis Health Belief Scale (OHBS). The OHBS (Kim, Horan, Gendler, & Patel, 1991) consists of seven subscales reflecting constructs identified in the Health Belief Model. Subscale assessment include measures of susceptibility, seriousness, benefits and barriers of calcium and exercise, and health motivation. Items are rated across a 5-point Likert scale anchored at the extremes by (1) Strongly disagree to (5) Strongly agree. Content, concurrent, and test-retest reliability have been documented (Kim et al., 1991; Taggart & Connor, 1995).

Godin Leisure Time Exercise Questionnaire (GLTEQ). Participants completed the *GLTEQ* as an index of physical activity participation over a typical week (Godin & Shepherd, 1985). The *GLTEQ* assesses the frequency of *mild*, *moderate*, and *strenuous* exercise completed over a typical week for a minimum duration of 15 minutes. A global physical activity total score (*GLTEQ*-METS) was calculated by averaging the weighted responses using the following formula: $\Sigma[(\textit{mild} \times 3) + (\textit{moderate} \times 5) + (\textit{strenuous} \times 9)]$ with validity and reliability in adult populations demonstrated (Godin & Shephard; Jacobs, Ainsworth, Hartman, & Leon, 1993).

Quantitative Ultrasound (QUS). Bone properties of the peripheral skeleton were determined from the speed of sound (SOS) measured by Quantitative Ultrasound (QUS, Sunlight Omnisense™ 7000S, Sunlight Medical, Ltd., Israel) at the mid-shaft of the dominant and non-dominant tibia in meters per second (m/s). The tibia was chosen as the measurement site as research has documented that weight bearing physical activity and higher habitual physical activity is more likely to affect lower than upper extremities (Morris, Naughton, Gibbs, Carlson, & Wark, 1997; Wolff, van Croonenborg, & Kemper, 1999).

Procedures for SOS measurement were conducted as described by Njeh, Boivin, and Langton (1997). Briefly, the probe contains a set of two transmitters and two receivers, housed in a compact holder. The SOS measurement reflects the shortest time that elapses between pulse transmission and the first reception of a signal. The path of the signal is determined by Snell's law: as the signal enters the bone from the soft tissue, it is refracted through a critical angle, which is a function of the ratio of the SOS in soft tissue and bone. After it propagates along the bone, the sound wave emerges at the same critical angle. The time taken for the signal to travel between the transmitting and receiving transducers is used to determine the SOS in bone that it is influenced by the density, elasticity and cohesiveness of the bone; the faster the speed of propagation, the stronger the bone.

Procedure

Ethical clearance for this study and related procedures was obtained from the institutional review board prior to participant recruitment and data collection. Participants were recruited via poster advertisements. Once initial contact was made, the study was explained in full detail along with possible risks and benefits. With adherence to inclusion criteria determined, participants were invited for two laboratory visits. First, questions and concerns were addressed, the consent form signed, and the questionnaire package administered. Height and weight were measured by a trained researcher. During the second visit, quantitative ultrasound measurements were taken at the dominant and non-dominant tibia. System quality verification procedures (i.e., standard Perpex phantom) was performed daily and all SOS measurements were conducted by one researcher and always during the follicular phase of participants' cycle (days 3-6) to ensure consistency. The first and second laboratory visits were scheduled one to three weeks apart depending upon their menstrual cycle timing.

Statistical Analysis

Data analysis proceeded in sequential stages. First, data was screened for out of range responses, non-response errors, and examined for compliance with statistical assumptions. Second, descriptive statistics and reliability estimates were calculated for relevant study variables. Third, Pearson Product Moment Correlations were used to determine the pattern of relationships among all relevant study variables. Finally hierarchical multiple regressions were calculated to examine the influence of scores derived from measures of health beliefs (i.e., OKT and OHBS) and physical activity on SOS.

Results

Preliminary Data Analysis

No missing cases or aberrant responses were observed in the data. Examination of unvaried skew ness and kurtosis demonstrated no substantial deviation from normality for all but one study variable (see Table 1). The subscale benefits of calcium demonstrated a leptokurtic distribution. Internal consistency reliability (Cronbach's α; Cronbach, 1951) estimates ranged from 0.68 to 0.90 (see Table 1).

Health Beliefs

Descriptive statistics suggest that females reported moderate levels of knowledge of osteo-protective behaviors, perceived susceptibility and seriousness (see Table 1). The benefits of exercise and calcium intake were strongly endorsed (M = 4.04; SD = 0.64; M = 4.22; SD = 0.64 respectively). Participants perceived low to moderate barriers to exercise (M = 2.49; SD = 0.79) and calcium intake (M = 2.10; SD = 0.83). Finally, participants reported moderate to high levels of health motivation (M = 3.82; SD = 0.79).

Relationships between study variables

Weak to moderate bivariate correlations were found between measures of the HBM with patterns of relationships ranging from ($r_{\text{knowledge.calcuim barriers}}$ = -.04 to $r_{\text{calcium benefits.exercise benefits}}$ = .42) (see Table 1). Similarly, physical activity behavior demonstrated weak to moderate patterns of relationships with estimates of health beliefs with the strongest correlation observed between physical activity and health motivation (r = .45). The direction and magnitude of the relationships were similar for dominant and non-dominant tibia SOS scores. Small relationships were noted between susceptibility and SOS (r = .21) and calcium barriers and SOS (r = .22) for the dominant tibia with a pattern of weak associations between other health belief indicators and physical activity scores.

Upon examination of standardized residuals and case wise diagnostics one participant was deemed an outlier and was subsequently deleted from the analysis. With the influence of this participant removed, a hierarchical multiple regression analysis was conducted to determine the predictive relationship between the health beliefs (Step 1) and physical activity (Step 2) on dominant tibia SOS scores. Ten percent of the variance in dominant tibia SOS was accounted for by health belief scores (R^2_{adj} = .10; F (8, 89) = 2.23, p = .03) after Step 1. With the inclusion of physical activity scores in Step 2, a significant overall regression analysis was retained, however the percent variance accounted for in SOS scores dropped slightly (R^2_{adj} = .08; F(9, 88) = 1.96, p = .05). Beta weights associated with the unique predictors ranged from -.21 to .17 (p > .05). For the prediction equation with non-dominant tibia SOS as the outcome variable of interest, neither health beliefs (Step 1; R^2_{adj} = .02; F (8, 89) = 1.23, p = .28) or health beliefs with the inclusion of physical activity scores (R^2_{adj} = .01; F (9, 88) = 1.10, p = .37) attained statistical significance.

Table-1
Descriptive statistics and bivariate correlations between study variables

Variables	*M*	*SD*	*Skew*	*Kurt.*	α	1	2	3	4	5	6	7	8	9	10	11
1. KNOW	16.09	2.56	-.19	.31	–	–										
2. SUSCEPT	2.59	.93	.62	-.09	.90	.04	–									
3. SERIOUS	3.47	.81	-.31	-.10	.69	-.02	.03	–								
4. CABEN	4.22	.64	-1.01	3.29	.76	.06	.02	.23	–							
5. CABAR	2.10	.83	.82	.56	.73	-.04	.36	.18	-.05	–						
6.EXBEN	4.04	.64	.07	-.37	.70	.36	.11	.01	.42	-.12	–					
7. EXBAR	2.49	.79	.28	-.38	.68	.03	.08	-.01	-.08	.12	-.13	–				
8. HMOT	3.82	.79	-.82	.82	.70	.06	-.09	-.10	.04	-.12	.23	-.37	–			
9. PA	52.63	19.63	.25	-.36	–	.04	-.15	.06	.07	-.11	.30	-.35	.45	–		
10. DOMTIB	3925.66	110.57	-.62	.18	–	-.14	.21	.02	-.13	.22	.09	-.03	.16	.12	–	
11.NON-DOMTIB	3903.77	111.17	-.58	.29	–	-.11	.06	-.01	-.10	.17	.01	-.03	.19	.07	.76	–

Note: KNOW = Knowledge, SUSCEPT = Susceptibility, SERIOUS = Seriousness, CABEN = Calcium Benefits, CABAR = Calcium Barriers, EXBEN = Exercise Benefits, EXBAR = Exercise Barriers, HMOT = Health Motivation, PA = Physical Activity, DOMTIB = Dominant Tibial SOS, NON-MTIB = Non-Dominant Tibial SOS. *M* = Item/Subscale Mean. *SD* =tem/Subscale Standard Deviation *Skew*. = Univariate Skewness. *Kurt*. = Univariate Kurtosis. α = Internal consistency reliability estimate (Cronbach's α; Cronbach, 1951). Sample size is consistent for each pairwise comparison made in the matrix. All *r*'s > |.25| significant at $p < .01$ (two-tailed). All *r*'s > |.20| significant at $p < .05$ (two-tailed)

Discussion

Health beliefs and behaviors formed during young adulthood may have a sustained impact on health in later life. The prevention of osteoporosis begins in childhood and continues across the lifespan. Consequently, developing an understanding of health beliefs, and their relationship to osteo-protective behaviors and bone properties, is of import. The purpose of this investigation was to explore osteoporosis health beliefs in a convenience sample of university females. The relationship of health beliefs on physical activity (a known osteo-protective behavior) and a physiological measure of bone health was then considered.

Tenants of the HBM (Rosenstock, 1974) were used to examine beliefs and barriers associated with osteoporosis and its protective behaviors. Young adult females in the present investigation perceived moderate levels susceptibility and seriousness to osteoporosis which was in line with existing literature (Kasper et al., 2001; Taggart & Connor, 1995). The benefits of calcium as an osteo-protective behavior were more strongly endorsed than that of physical activity with low-moderate barriers reported to engaging these protective behaviors. These findings provide useful implications for furthering our understanding osteoporosis risk factors in university aged samples.

The secondary purpose was to examine the pattern of inter-relationships between health beliefs, physical activity, and bone properties of the peripheral skeleton. Results demonstrated that higher levels of physical activity were associated with greater health motivation, higher perceived benefits of physical activity, and lower barriers of physical activity. The above is consistent with previous research conducted on university aged females and osteo-protective behaviors (Kasper et al., 1994; Taggart & Connor, 1995; Ziccardi et al., 2004). Where relationships have emerged in adult populations, the dimensions of exercise benefits, exercise barriers, and health motivation have been most notable (e.g., Ali-Ali & Haddad, 2004; Mirotznick, Feldman, & Stein, 1995). Results of the regression analyses demonstrated that health beliefs associated with osteoporosis may be somewhat more influential than physical activity on physiological markers of bone health. Given the myriad of lifestyle factors influencing bone health including smoking, caffeine ingestion, and medication use (United States Department of Health and Human Services, 2005), future research may explore additional controllable factors associated with markers of bone health in young adult females.

Finally, the present investigation extends current literature through its consideration of health beliefs and physical activity on physiological markers of bone health. When considering the relationship between health beliefs and bone SOS, those with higher perceived susceptibility and barriers to calcium intake reported higher tibial SOS scores. It may be that those who perceive themselves most susceptible to the condition engage in a myriad of osteo-protective behaviors (of which physical activity is one) which translate into greater bone health. Further, given that the tibia is a weight bearing bone, the influence of calcium ingestion is lower. As such, those who perceive greater barriers to calcium ingestion, (whether it be attributed to lactose intolerance, perceived cost of calcium rich food, or caloric intake) may compensate through increased adoption of other known osteo-protective behaviors.

Physical activity was very weakly positively related to tibial SOS measurements. Possible explanations for this finding include a consideration of the measure of physical activity, physical activity history, and calcium intake. First, the measure of physical activity employed (i.e., the GLTEQ) identifies intensity without consideration of the type of activity. Therefore, although average physical activity scores were comparable to those documented in other university aged samples (e.g., Hayes, Crocker, & Kowalski, 1999; Wilson et al., 2004), the frequency of weight bearing (e.g., swimming, biking, etc) exercise (known contributors bone strength) could not be determined. Further, in a sample of young adult women, Omasu et al. (2004) found that average physical activity accumulated in hours/week in high school predicted SOS scores, but not current engagement in physical activity levels. Consequently physical activity during adolescence may be a stronger influence on bone properties than that engaged in during young adulthood.

The influence of health beliefs on physical activity behavior and bone strength seems plausible on theoretical and empirical grounds. Although the findings from this study extend previous research, a number of limitations should be recognized. First, given the cross-sectional nature of the design, and the consequent inability to control for threats to internal validity this study is restricted to cross-sectional data causality cannot be inferred. Future research should consider examining study purposes using experimental or longitudinal research designs that afford greater confidence to causality. Second, this study examined only one important osteo-protective behavior. Future studies may consider examining the role of calcium and vitamin D intake, smoking, alcohol use, and caffeine intake. Finally, cues-to-action as a health belief were not examined in the present investigation. Future research may want to consider the role of cues-to-action (e.g., media, health educators) to health beliefs, physical activity, and bone properties.

The results of this investigation make it apparent that health beliefs have a small influence on physical activity and tibial SOS in female undergraduate students. Although the reported effects in the present investigation are negligible to weak (Cohen, 1992), further investigation into their relative meaningfulness is relevant when considering the challenge of changing health behavior at the population level (Prentice & Miller, 1992). Although the relationships between health beliefs and physical activity are not novel, the present study represents an initial attempt to evaluate the relationship among health beliefs, physical activity and bone properties. Although the present investigation is preliminary, it would seem prudent on the basis of these findings to further investigate the above relationships. Given the significant public health agenda inherent to the prevention of osteoporosis, insight into variables linked with prevention cannot be ignored.

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