African Journal for Physical, Health Education, Recreation and Dance (AJPHERD),
Vol. 16, No. 1 (March) 2010, pp. 93-100.

Influence of nutritional status on bone health in young South African women

D.S. LESOLA[1], P.S. WOOD[2] AND C.C. GRANT[1]

[1]Section Sports Medicine, [2]Department of Biokinetics, Sport and Leisure Sciences, University of Pretoria, Pretoria, South Africa; E-mail: docdas@vodamail.co.za

(Received: 13 November 2009 Revision Accepted: 21 January 2010)

Abstract

Osteoporosis is a public health problem worldwide, with consequences of increasing risk of fragility fractures, disability and premature mortality. This study sought to establish the link between nutrition and bone health in young South African women. This cross-sectional study involved 28 South African females aged 18 to 22 years. Total muscle mass, bone mass, fat mass, spine and femur were measured using dual-energy X-ray absorptiometry. Participants also completed a food intake questionnaire. Nutritional indicators were isolated. Collected data was captured and analyzed by means of statistical package for the social sciences (SPSS). Spearman's correlation method was used to determine the correlations between the selected nutrients and bone density measurements. Positive low-moderate correlations (r=0.4) were found between phytate and total body mass and between phytate and total bone mass. A positive low-moderate correlation (r=0.4) was also found between vitamin K and T-score (lumbar spine). No statistically significant correlations were found between other nutrients and bone density measurements. The fact that this study was unable to illustrate an association between bone mineral density (BMD) and some of these nutrients should not be considered that these nutrients are less significant to bone and general health. Bone mineral status is only one aspect of health in which these nutrients may have long-term beneficial consequences.

Key words: nutrition, dual-energy X-ray absorptiometry (DEXA), bone density, South African women.

Introduction

Osteoporosis is a major public health problem worldwide, with its consequences of increasing the risk of fragility fractures, disability and premature mortality (Ginty, Lanskey, Micro, Muniz, O'Connell, Prentice, Prynne & Yan, 2006). Among other factors, nutrition and rapid bone loss during menopause have been acknowledged as increasing the risk of osteoporosis (Prynne, Mishra, O'Connell, Muniz, Laskey, Yan, Prentice & Ginty, 2006). Since nutrition is a modifiable factor, efforts should be concentrated on trying to clarify its effect on bone health.

Although osteoporosis affects mainly the middle and older age groups (Nakamura, Nishiwaki, Okuda, Saito, Tsuchiya, Ueno & Yamamoto, 2005), it has been established that maximizing the peak bone mass attained at the early stage of life can serve as the most optimum preventive measure for osteoporosis (Johnston, Lyle, Teegarden & Weaver, 1999; Weaver, 2000).

Researchers have shown that many nutrients play a fundamental role in bone health; these include calcium, magnesium and casein phosphopeptides, (Johnston, Knight, Lyle, Michon McCabe, McCabe, Proulx, Teegarden & Weaver, 1998; Kalkwarf, Khoury & Lanphear, 2003; Aoe, Ishida, Toba, Itabashi, Takada & Uenishi, 2006). Some of these nutrients, such as calcium and magnesium, are direct components of bone tissue, whilst others are enhancers of calcium absorption, such as vitamin D and casein phosphopeptides. Vitamin K and isoflavones have been shown to directly affect bone cells and bone metabolism, whilst milk basic protein promotes bone formation, suppresses resorption and increases bone mineral density (BMD) in humans (Aoe *et al*., 2006). Since minerals comprise two-thirds of bone weight, mineral density is regarded as the predictor of bone strength, i.e. the resistance to fracture (Weaver, 2000).

Studies have, in the past, predominantly focused on older adults who are at high risk of osteoporosis (Johnston *et al.,* 1998; Hudes & Simon, 2001; Boyle, Faulkner, Mirwald, Thompson & Whiting, 2002). Recent studies have also investigated the influence of these factors in children and young adults (Johnston *et al*., 1998; Weaver, 2000; Bailey, Baxter-Jones, Faulkner, Vatanparast & Whiting, 2005). Although many studies have investigated the relationship between nutrition and bone health amongst females of various age groups, few, if any, have investigated the influence of various nutrients on bone health in young African or South African women. Hence this study sought to establish whether any correlation existed between selected nutrients and bone density measurements in young South African women.

Methodology

This study was conducted on a group (n=28) of young females, aged 18-22 years. The research protocol was approved by the Ethical Committee of the University of Pretoria. Participation was voluntary, and prior to testing each participant completed and signed an informed consent. Pregnant candidates and those who suffered from any chronic diseases were excluded from the study. A standardised nutrition questionnaire recommended by a dietician was completed by the participants (Grant, Langenhoven, Stockton, Day & Bauermeister, 1992). Participants underwent a dual-energy X-ray absorptiometry scan (DEXA)

(Prodigy; GE/Lunar Corporation, Madison, WI) for BMD assessment. This was performed by a qualified radiographer, at a leading South African hospital.

In all subjects, height (m) which was later converted to centimetres and weight (kg), which was later converted to grams, were measured. Total muscle mass (g), total bone mass (g), total fat mass (g), lumbar spine and femur bone mineral mass were measured by DEXA scan. The following nutritional parameters were isolated from the completed general food intake record questionnaire due to their potential role in bone health, as per recommendation of the dietician: energy (kj); total protein (g); total dietary fibre (g); calcium (mg); magnesium (mg); phosphate (mg); sodium (mg); vitamin A (mcg); total carotenoids (mcg); vitamin C (mg); vitamin D (mcg); vitamin K (mcg); alcohol (g); phytate (mg); caffeine (mg); percentage energy protein; fat and carbohydrate. The Food-finder analyses program was utilized for the analysis of the food intake record questionnaire (Grant *et al.,* 1992).

Both nutrients and DEXA variables were captured on computer and analyzed by means of the SPSS package (Statistical Package for the Social Sciences). Descriptive statistics were produced and Spearman's correlation method was used to determine if any correlation existed between any of the selected nutrient and bone density measurements. The latter correlations method, a non-parametric version of the Pearson correlation coefficient, is based on the ranks of the data rather than the actual values appropriate for this ordinal data that do not satisfy the normality assumption due to the small sample group. Values of the coefficient range from -1 to +1. The sign of the coefficient indicates the direction of the relationship, and its absolute value indicates the strength, with larger absolute values indicating stronger relationships (Thomas & Nelson, 2001). Non-parametric statistics were used to accommodate the small sample size. An α level of 0.05 was used for all statistics.

Results

The young female participants' descriptive statistics are outlined in Table 1. Spearman's correlation analysis shows positive low-moderate correlations between phytate and total body mass (r=0, 4) and between phytate and total bone mass (r=0, 4). Additionally, a positive moderate correlation was found between vitamin K and T-score (L) (r=0, 4).

No other statistically significant correlation was found between any of the other nutrients investigated and bone density measurements on the 5% level of significance.

Table 1: Descriptive characteristics of the participants, BMD and selected nutrients analyzed

Variable	Minimum	Maximum	Mean	Std Deviation
Age (yrs)	19.0	23.2	21.0	1.1
Height (m)	2.0	2.0	2.0	5.3
Total body mass (kg)	48.3	78.0	61.0	7.0
T.fat.m (kg)	10.4	37.0	20.0	6.0
T.muscle.m (kg)	32.4	44.2	38.3	3.4
T.bone.m (kg)	47.0	74.2	58.4	7.0
Energy (kjl)	2910.0	15617.0	8303.1	2951.4
T.protein (g)	17.1	138.0	76.0	33.2
T.diet. fib. (g)	4.4	44.0	16.0	9.4
Calcium (mg)	46.0	1265.0	443.0	261.0
Magnesium (mg)	77.0	523.0	246.0	108.0
Phosphate (mg)	288.0	1743.0	971.1	383.3
Sodium (mg)	442.0	4139.0	1774.0	941.0
Vitamin A (mcg)	22.0	3582.0	612.0	876.0
T.carot. (mcg)	30.0	21338.0	2813.3	5299.0
Vitamin C (mcg)	4.0	551.0	134.0	156.4
Vitamin D (mcg)	0.04	18.0	5.0	5.4
Vitamin K (mcg)	1.2	1397.0	181.2	352.0
Phytate (mg)	0	383.0	149.3	119.0
Caffeine (mg)	0	3.0	0.1	1.0
T.score (TB)	-2.1	2.0	0.4	1.0
T.score (L)	-2.2	2.2	0.2	1.0
T.score (F)	-2.0	3.2	1.0	1.1

T=total; P=protein; Fib=fibre; Carot=carotene; TB=total body; L=lumbar; F=femur

Table 2: Relationships between BMD measurements and selected nutrient (Spearman's rho. correlation coefficient)

Nutrients	**T score: Total body**	**T score: lumbar bone**	**T score: femur bone**	**Total body mass**	**Total bone mass**	**Total muscle mass**	**Total fat mass**
Energy	0.2	0.3	0.2	0.3	0.3	0.3	0.2
Total protein	0.2	0.3	0.2	0.1	0.1	-0.0	0.2
T. dietary fibre	-0.1	0.3	-0.0	0.1	0.1	-0.2	0.3
Calcium	0.0	0.1	0.1	-0.0	-0.0	-0.3	0.1
Magnesium	0.0	0.3	0.1	0.0	0.0	-0.1	0.1
Phosphate	0.1	0.3	0.2	0.1	0.1	-0.1	0.2
Sodium	-0.2	-0.1	-0.1	-0.0	-0.0	0.1	-0.1
Vitamin A	0.2	0.3	-0.1	0.2	0.2	-0.1	0.3
Carotene	0.1	0.2	-0.3	0.1	0.1	-0.2	0.3
Vitamin C	-0.0	0.0	0.1	0.1	0.1	0.2	0.0
Vitamin D	0.1	0.2	0.0	0.2	0.2	0.2	0.3
Vitamin K	0.2	0.4*	0.0	0.3	0.3	-0.0	0.3
Phytate	0.2	0.2	0.1	0.4*	0.4*	0.2	0.3
Caffeine	0.3	0.1	0.2	-0.2	-0.1	-0.2	0.1

* Correlation is significant at the .05 level; ** Correlation is significant at the .01 level

Discussion

The primary focus of this study was to examine the correlation between BMD and nutrition in young South African females. Positive low-moderate correlations (0.4) were found between phytate and total body mass and total bone mass, which implies that the higher the phytate scores, the higher the total body mass and total bone mass measurements to a low-moderate extent. Several studies support this correlation in other population groups. Since total bone weight is the strongest predictor of bone mineral density, it confirms the importance of dairy products in bone health (Johnston *et al*., 1999; Weaver, 2000; Kalkwarf *et al*., 2003). Vitamin K has a vital and direct effect on bone cells and bone metabolism; thus the positive moderate correlation (0.4) which was found between vitamin K and lumbar bone density was expected in this young population group (Aoe *et al*., 2006) and is supported by several other studies (Booth, Broe, Cupples, Dawson-Hughes, Gagnon, Hannan, Kiel, Mclean, Tucker & Wilson, 2003; Aoe *et al*., 2006; Azar, Bouxsein, Brain, Cummings, Hong, Hsu, Li, Rosen, Tang, Torpedo, Wang, Wu, Xu, Zalloua & Zang, 2007). As the spine is predominantly a trabecular bone and thus has a high metabolic turnover rate compared with a cortical bone, the ability of dietary intakes to affect it in all age groups is not surprising (Johnson *et al*., 1998).

Published studies have found positive BMD correlations with calcium, phosphate, vitamin D, magnesium and zinc that are traditionally known to have a positive effect on bone growth and mineralization (Kalkwarf *et al*., 2003; Badenhop-Stevens, Crncevic-Orlic, Goel, Ha, Landoll, Li and Matokovic, 2004; Barnard, Berkow & Lanou, 2005; Bailey *et al*., 2007). However, this study failed to find statistically significant correlations between any of the other nutrition and bone density measurements. The possibility that the small sample group used in the study or the narrow age range of the participants (18-22 yrs) and the cross-sectional study design used must not be excluded when interpreting these results.

Caution should be exercised when generalizing these findings to the rest of the South African female population due to shortcoming of this study. These include the small sample size of 28 female participants which is considered to be too small for a survey study and the narrow age range which limits generalisability of the findings. The findings should rather be investigated further in a larger sample group with a wider age range. Additionally, the apparent BMD peaks should be interpreted with caution due to the cross-sectional design of the study (Bakheet, Ghannam, Hammami & Khan, 1999; Bischoff-Ferrari, Dawson-Hughes, Dietrich & Orav, 2004). Finally, self reported nutritional status may have attributed to the participant either under- or over-estimating the nutritional values. A longitudinal design without self-reporting methods is suggested for future studies.

In conclusion, although a significant positive association between phytate, potassium and BMD was observed, several studies documented a positive correlation of BMD and other nutrients such as calcium, magnesium, vitamin D and phosphate (Badenhop-Stevens *et al.*, 2004; Barnard *et al*., 2005; Bailey *et al*., 2007). The fact that this study failed to find an association between BMD and some of these nutrients should not be taken to mean that the nutrients are less significant to bone and our general health. Bone mineral status is only one aspect of health in which these nutrients may have long-term beneficial consequences.

References

Aoe, S., Ishida, H., Toba, Y., Itabashi, A., Takada, Y. & Uenishi, K. (2006). Milk basic protein increases bone mineral density and improves bone metabolism in healthy young women. *Osteoporosis International,* 18(3), 385-390.

Azar, S.T., Bouxsein, M.L., Brain, J., Cummings, S., Hong, X., Hsu, Y.H., Li, Z., Rosen, J.C., Tang, G., Torpedo, H., Wang, B.R., Wu, D., Xu, X., Zalloua, P.A. & Zang, T. (2007). Impact of seafood and fruit consumption on bone mineral density. *Maturitas - The European Menopause Journal*, 56, 1-11.

Badenhop-Stevens, N.E., Crncevic-Orlic, Z., Goel, P., Ha, E.Y., Landoll, J.D., Li, B. & Matkovic, V. (2004). Nutrition influences skeletal development from childhood to adulthood: a study of hip, spine and forearm in adolescent female. *The Journal of Nutrition*, 134, 701-705.

Bailey, D.A., Baxter-Jones, A.D.G., Faulkner, R.A., Vatanparast, H. & Whiting, S.J. (2005). Positive effects of vegetable and fruit consumption and calcium intake on bone mineral accrual in boys during growth from childhood to adolescence: the University of Saskatchewan Pediatric Bone Mineral Accrual Study. *American Journal of Clinical Nutrition,* 82(3), 700-706.

Bailey, D.A., Baxter-Jones, A.D.G., Vatanparast, H. & Whiting, S.J. (2007). The effects of dietary protein on bone mineral mass in young adults may be modulated by adolescent calcium intake. *The Journal of Nutrition*, 137, 2674-2679.

Bakheet, S.M, Ghannam, N.N., Hammami, M.M. & Khan, B.A. (1999). Bone mineral density of the spine and femur in the healthy Saudi females: relation to vitamin D status, pregnancy and lactation. *Calcified Tissue International*, 65, 23-28.

Barnard, N.D., Berkow, S.E. & Lanou, A.J. (2005). Calcium, dairy products and bone health in children and young adults: a reevaluation of the evidence. *Pediatrics*, 115, 736-793.

Bischoff-Ferrari, H.A., Dawson-Hughes, B., Dietrich, T. & Orav, E.J. (2004). Positive association between 25 hydroxy vitamin D levels and bone mineral density study of younger and older adults. *The American Journal of Medicine*, 116, 634-638.

Booth, S.L, Broe, K.E., Cupples, L.A., Dawson-Hughes, B., Gagnon, D.R., Hannan, M.T., Kiel, D.P., McLean, R.R., Tucker, K.L. & Wilson, P.W.F. (2003). Vitamin K intake and bone mineral density in women and men. *American Journal of Clinical Nutrition*, 77, 512-516.

Boyle, J.L., Faulkner, R.A., Mirwald, R.L., Thompson, A. & Whiting, S.J. (2002). Dietary protein phosphorus and potassium are beneficial to bone mineral density in adult men consuming adequate dietary calcium. *Journal of the American College of Nutrition*, 21(5), 402-409.

Ginty, F., Lanskey, M.A., Micro, G.D., Muniz, G., O'Connell, M.A., Prentice. A., Prynne. C.J. & Yan, L. (2006). Fruit and vegetable intake and bone mineral status: a cross-sectional study in 5 age and sex cohorts. *American Journal of Clinical Nutrition*, 83(6), 1420-1428.

Grant, K.I., Langenhoven, M.L., Stockton, M.A., Day, R.S. & Bauermeister, P. (1992). Foodfinder, *Dietary Analysis Software*, Release 1.1. Tygerberg, WC: National Research Programme for Nutritional Intervention: South African Medical Research Council,

Hudes, E.S. & Simon, J.A. (2001). Relation of ascorbic acid to bone mineral density and self-reported fractures among US adults. *American Journal of Epidemiology*, 154, 427-433.

Johnston, C.C., Knight, A.P., Lyle, R.M., Michon, K., McCabe, G.P., McCabe, L.B., Proulx, W.R., Teegarden, D. & Weaver, C.M. (1998). Dietary calcium, protein and phosphorus are related to bone mineral density and content in young women. *American Journal of Clinical Nutrition,* 68, 749-754.

Johnston, C.C., Lyle, M., Proulx, W.R., Teegarden, D. & Weaver, C.M. (1999). Previous milk consumption is associated with greater bone density in young women. *American Journal of Clinical Nutrition*, 69, 1014-1017.

Kalkwarf, H.J., Khoury, J.C. & Lanphear, B.P. (2003). Milk intake during childhood and adolescence, adult bone density and osteoporotic fractures in US women. *American Journal of Clinical Nutrition*, 77(1), 257-265.

Nakamara, K., Nishiwaki, T., Okuda, Y., Saito, T., Tsuchiya, Y., Ueno, K. & Yamamoto, M. (2005). Nutrition, mild hyperparathyroidism and bone mineral density in young Japanese women. *American Journal of Clinical Nutrition*, 82(5), 1127-1133.

Prynne, C.J., Mishra, G.D., O'Connell, M.A., Muniz, G., Laskey, M.A., Yan, L., Prentice, A. & Ginty. F. (2006). Fruit and vegetable intakes and bone mineral status: a cross-sectional study in 5 age and sex cohorts. *American Journal of Clinical Nutrition*, 83(6), 1140-1428.

Thomas, J.R. & Nelson, J.K. (2001). *Research Methods in Physical Activity* (4th ed.). Champaign, IL: Human Kinetics.

Weaver, C.M. (2000). Calcium and magnesium requirements of children and adolescents and peak bone mass. *Nutrition*, 16(7/8), 514-516.