Original Article

Relationship of lipid parameters with bone mineral density in Indian population

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ABSTRACT

Introduction: Cardiovascular disease and osteoporosis share common risk factors including dyslipidemia. There are conflicting reports of differential relation of various lipid parameters on bone mineral density (BMD). Hence, we studied the correlation between lipid parameters and BMD in healthy adult. Materials and Methods: A total of 2347 participants (male 39.4%; female 60.6%) included in this cross-sectional study were divided according to sex and age. Fasting blood samples were drawn for biochemical parameters. BMD at lumbar spine, femur, and forearm were measured by dual energy X-ray absorptiometry (DXA). Results: In males, BMD at femur and lumbar spine decreased significantly with increasing quartiles of total cholesterol (TC) (P < 0.0001, and 0.004) and low-density lipoprotein cholesterol (LDL-c) (P = 0.001, and 0.01). In premenopausal women, BMD at femoral neck (P = 0.001) and lumbar spine (P = 0.029) showed declining trend with LDL-c (P = 0.007). In postmenopausal women, only BMD at total femur decreased significantly with TC (P = 0.024) and LDL-c (P = 0.036). All above findings were confirmed in correlation studies. In multiple regression analysis after adjusting for age, body mass index, ionized calcium, alkaline phosphatase, 25 hydroxy vitamin D, and parathyroid hormone levels correlation of BMD with TC and LDL-c persisted. TC, LDL-c was higher in subjects with low bone density compared those with normal bone density in both sexes. Conclusions: TC and LDL-c had weak but significant negative correlation with BMD at femur and lumbar spine.

Key words: Bone mineral density, dual energy X-ray absorptiometry, high-density lipoprotein-cholesterol, low-density lipoprotein-cholesterol, lipid Profile, total cholesterol, triglycerides

INTRODUCTION

Epidemiological studies suggested a relation between cardiovascular diseases and osteoporosis. Lipids are strong risk factors for cardiovascular disease. Studies evaluating the relationship between lipid parameters and bone mineral density (BMD) in healthy adults and those with metabolic syndrome have revealed inconsistent results. While most of the studies have been performed in women, there are a few studies in men and adolescents. Since Indians have differences in lipid profiles [higher prevalence of high triglycerides (TGs) and low high density lipoprotein cholesterol] compared with other populations, we assessed the relationship between various lipid parameters with BMD at different sites in previously conducted cross-sectional population in healthy Indian volunteers.

MATERIALS AND METHODS

This study was carried out as part of voluntary general health check-up of all members of Resident Welfare Associations of four residential colonies, one each from North, South, East, and West Delhi. The study included all participants > 20 years of age (2347 participants-Male 39.4%; Female 60.6%) excluding those with infectious,
hepatic, renal, neoplastic, gastrointestinal, dermatological, and endocrine disorders, steroid intake or alcoholism, and drugs affecting lipid parameters like statins, fibrates, diuretics, and beta-blockers. Demographic, anthropometric, and clinical data were ascertained and a detailed physical examination conducted. Body mass index (BMI) was calculated by weight in kilogram divided by square of height in meters.

Fasting blood samples were drawn for the estimation of serum 25-hydroxy vitamin D [25(OH) D], intact parathyroid hormone (iPTH), total and ionized calcium, inorganic phosphorus, alkaline phosphatase (ALP), total cholesterol (TC), TGs, high-density lipoprotein cholesterol (HDL-c), and low-density lipoprotein cholesterol (LDL-c). Biochemical parameters were carried out using automated analyzer (Hitachi 902 fully automated biochemistry analyzer; Roche, Manheim, Germany) and commercial kits (Roche, Manheim, Germany). Measurements of plasma glucose were done by glucose oxidase-peroxidase method by Trinder (Clonital, Italy). Dyslipidemia was defined by TC >240 mg/dL, serum TG >150 mg/dL, HDL-c <40 mg/dL in males, and <50 mg/dL in females, and LDL-c >160 mg/dL.

All participants were divided according to age with cut-off of 50 years so that pre- and postmenopausal women can be separated. Total population was divided and grouped for analysis into three groups—male (n = 924), female <50 years (premenopausal, n = 788), and females >50 years (postmenopausal, n = 635). All lipid parameters were divided according to quartiles in all three groups separately. Interquartile range for TC was 47.75, 34, and 51 mg/dL; for TG was 59, 26.75, and 58 mg/dL; for HDL was 8, 5, and 8 mg/dL; for LDL 32, 14.75, and 39 mg/dL; for three groups, respectively. The study was approved by the ethics committee of the Institute of Nuclear Medicine and Allied Sciences and all participants gave written informed consent.

The normal range for different biochemical parameters are as follows: Serum total calcium (8.5-10.5 mg/dL), ionized calcium (1.12-1.32 mmol/L), inorganic phosphorus (2.5-4.5 mg/dL), ALP were (females: <240 U/L; males: <270 U/L), serum TC (110-230 mg/dL), serum TG (<150 mg/dL), HDL cholesterol (>35 mg/dL), and LDL (<100 mg/dL). The serum concentrations of 25(OH) D (reference range: 10-23 ng/dL) and PTH (reference range: 10-65 pg/mL) were measured by RIA (Diasorin, Stillwater, MN, USA) and electrochemiluminescence assay (Roche diagnostics, GmDH-Manheim, Germany), respectively.

BMD at anteroposterior (AP) lumbar spine (L1-L4), femur (total hip, femoral neck), forearm (33% radius), and total body was measured using the Prodigy Oracle (GE Lunar Corp., Madison, WI, USA) according to standard protocol. Low BMD is defined as Z-score <-1.0 in age group <50 years and T-score <-1.0 in age group >50 years in both sexes as also defined by another study,[30] while values higher than these were considered as normal BMD. Quality control procedures were carried out in accordance with the manufacturer’s recommendations. Instrument variation was determined regularly using a phantom supplied by the manufacturer and mean coefficient of variation was <0.5%. For in vivo measurements, mean coefficients of variation for all sites were <1%.

Statistical analysis was carried out using software SPSS for windows version 20.0 (SPSS, Inc., Chicago, USA). Data were presented as mean ± standard deviation or number (%) unless specified. All parametric data were analysed by independent student’s t-test between age groups. All nonparametric data were analyzed by Chi-square test. P-for trends were applied to assess significance of differences in BMD among the four quartiles of lipid parameters. Pearson’s correlation coefficient was calculated to assess the strength of relationship between lipid parameters and BMD at various sites. Multiple regression analysis was done to ascertain association between lipid parameters with BMD at various sites after adjustment with variables like age, BMI, serum ionized calcium, ALP, 25(OH) D, and iPTH levels. A P < 0.05 was considered statistically significant.

Results

This study included 2347 participants >20 years of age (male 39.4%; female 60.6%). Mean age and BMI were 49.1 ± 18.2 years (range: 21-90 years) and 25.0 ± 4.7 kg/m² (range: 13.0-49.8) respectively. There were 788 (55.4%) premenopausal (≤50 years) and 635 (44.6%) postmenopausal women (>50 years). Male were older than females (54.0 ± 16.7 vs. 45.9 ± 18.5 years; P < 0.00001). Basic characteristics of the population are given in Table 1.

Males

BMD at all sites, except radius, decreased significantly from lowest quartile to highest quartile of TC and LDL-c. BMD at femoral neck showed increasing trend with quartiles of TGs, but the relationship was not significant at lumbar spine and radius [Table 2]. BMD at femoral neck, femur total, and lumbar spine were negatively correlated with TC and LDL-c and positively with TG, which further supported the earlier analysis [Table 3]. There was no obvious trend for BMD at any site with quartiles of HDL-c.
In multiple regression analysis, after adjusting for age, BMI, serum ionized calcium, ALP, 25(OH) D, and iPTH levels, the relationship between BMD and TC and LDL persisted, while that with TG became insignificant [Table 4].

Postmenopausal women (females > 50 years)
BMD at total femur decreased from lowest quartile to highest quartile of TC and LDL-c. No significant trends were observed at any other sites with other lipid parameters [supplementary Table 1]. A significant negative correlation was noticed between BMD at femur total and TC and LDL-c. TG showed a negative correlation with BMD at femur neck; and HDL-c showed positive correlation and BMD lumbar spine [Table 3]. In multiple regression analysis, after adjusting for age, BMI, serum ionized calcium, ALP, 25(OH) D, and iPTH levels, the above-observed correlation was maintained except for TG, which became nonsignificant [Table 4].

Premenopausal women (female < 50 years)
BMD at femoral neck decreased from second to highest quartiles of LDL-c, but no significant trend was noticed with TC, TG, and HDL-c. BMD at lumbar spine decreased significantly with quartiles of LDL-c and increased with TG. HDL-c had no effect on BMD at any site [supplementary Table 2].
However, there was no correlation of any lipid parameters with BMD at any site in premenopausal women [Table 3]. In multiple regression analysis, after adjusting for age, BMI, serum ionized calcium, ALP, 25(OH) D, and iPTH levels, LDL-c showed significant but weak negative correlation with BMD at femoral neck, total femur, and lumbar spine, but correlation with TG became nonsignificant [Table 4].

Total population was categorized into subjects with normal BMD (1239-52.8%) and low BMD (1108-47.2%). In subjects with normal bone density, TC and LDL-c were significantly lower compared with subjects with low bone density in both sexes (Men: TC-159 ± 35 vs. 167 ± 35 mg/dL, P = 0.001; LDL-c- 99 ± 24 vs. 105 ± 25 mg/dL, P < 0.0001; Women: TC - 153 ± 32 vs. 174 ± 38 mg/dL, P < 0.0001; LDL-c- 91 ± 18 vs. 106 ± 25, P < 0.0001).

There was no significant difference in BMD at any site in any group when study population was categorized according to dyslipidemia (data not shown).

**DISCUSSION**

In the present large population-based cross-sectional study, we found that femoral BMD was inversely correlated with total cholesterol and LDL-c in both men and women BMD at lumbar spine was negatively correlated with TC and LDL-c in men, and only with LDL-c in pre-menopausal women. There was no correlation of BMD at radius with any lipid parameters.

Similar to our results, a Korean study also found a weak positive correlation of BMD with lipid profile (TC

### Table 3: Correlation of lipid parameters with bone mineral density

|                   | Femoral neck (r value (P value)) | Femur total (r value (P value)) | Spine L1-L4 (r value (P value)) | Radius 33% (r value (P value)) |
|-------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Total cholesterol |                                 |                                 |                                 |                                 |
| Male              | -0.136 (< 0.0001)               | -0.159 (< 0.0001)               | -0.076 (0.021)                  | -0.017 (0.613)                  |
| Female (< 50 years)| 0.025 (0.481)                  | 0.040 (0.259)                  | 0.023 (0.528)                  | 0.006 (0.856)                  |
| Female (> 50 years)| -0.069 (0.082)                | -0.091 (0.022)                | -0.026 (0.512)                | 0.007 (0.857)                  |
| LDL-cholesterol   |                                 |                                 |                                 |                                 |
| Male              | -0.116 (< 0.0001)               | -0.093 (0.004)                  | -0.103 (0.002)                 | 0.053 (0.108)                  |
| Female (< 50 years)| -0.056 (0.114)                  | -0.017 (0.631)                  | -0.057 (0.109)                  | -0.034 (0.345)                  |
| Female (> 50 years)| -0.047 (0.239)                  | -0.080 (0.044)                 | -0.058 (0.142)                 | 0.009 (0.820)                  |
| Triglycerides     |                                 |                                 |                                 |                                 |
| Male              | 0.085 (0.01)                    | 0.084 (0.01)                    | 0.065 (0.047)                  | 0.061 (0.066)                  |
| Female (< 50 years)| -0.015 (0.669)                  | 0.020 (0.579)                  | -0.019 (0.591)                 | -0.003 (0.943)                  |
| Female (> 50 years)| -0.078 (0.049)                  | -0.031 (0.431)                 | -0.025 (0.528)                 | 0.032 (0.416)                  |
| HDL-cholesterol   |                                 |                                 |                                 |                                 |
| Male              | 0.014 (0.674)                   | -0.020 (0.547)                  | -0.009 (0.792)                 | -0.016 (0.609)                  |
| Female (< 50 years)| 0.024 (0.500)                   | 0.016 (0.600)                  | 0.012 (0.747)                  | -0.029 (0.420)                  |
| Female (> 50 years)| 0.073 (0.065)                   | -0.019 (0.627)                 | 0.096 (0.019)                  | 0.028 (0.481)                  |

HDL: High-density lipoprotein, LDL: Low-density lipoprotein
and LDL-c after adjustment with age, BMI and age at menarche in pre- and postmenopausal women. In contrast, studies from USA (National Health and Nutrition Examination Survey-NHANES) and UK (Framingham Osteoporosis Study-FOS) reported no association of lipid parameters and BMD. Both these studies (NHANES and FOS) have only evaluated women and have not provided data separately for pre- and postmenopausal women. Further, women with associated comorbidities, including alcohol and drug intake, were not excluded in these studies. Many smaller studies have reported stronger but less significant correlation; however, larger studies have found weaker but more significant correlation being large sample.

### Supplementary Table 2: Bone mineral density (g/cm²) in premenopausal women (females<50 years) with quartiles of lipid parameters

| Lipid Parameters | 1st Quartile | 2nd Quartile | 3rd Quartile | 4th Quartile | P for trend |
|------------------|--------------|--------------|--------------|--------------|------------|
| Cholesterol      | (≤128) N=205 | (128–145) N=202 | (145–162) N=189 | (162) N=191 | 0.921 |
| Femoral neck BMD | 0.98±0.198   | 0.98±0.188   | 0.96±0.130   | 0.96±0.135  | 0.001 |
| Femur total BMD  | 1.02±0.177   | 1.01±0.163   | 1.01±0.150   | 1.02±0.120  | 0.001 |
| Spine (L-1-L-4) BMD | 1.01±0.144  | 1.02±0.120   | 1.01±0.130   | 1.11±0.130  | 0.118 |
| Radius 33% BMD   | 0.65±0.056   | 0.66±0.103   | 0.65±0.061   | 0.65±0.067  | 0.088 |
| LDL-cholesterol   | (≤79.25) N=197 | (79.25–86) N=200 | (86–94) N=192 | (94) N=199 | 0.118 |
| Femoral neck BMD | 1.00±0.106   | 1.00±0.120   | 0.97±0.127   | 0.95±0.147  | 0.001 |
| Femur total BMD  | 1.02±0.112   | 1.02±0.116   | 1.01±0.120   | 1.00±0.140  | 0.161 |
| Spine (L-1-L-4) BMD | 1.12±0.128  | 1.11±0.126   | 1.11±0.131   | 1.09±0.132  | 0.031 |
| Radius 33% BMD   | 0.66±0.058   | 0.66±0.057   | 0.66±0.110   | 0.64±0.063  | 0.118 |
| Triglycerides    | (≤121) N=205 | (121–132) N=201 | (132–147) N=185 | (147) N=197 | 0.118 |
| Femoral neck BMD | 0.98±0.127   | 0.99±0.127   | 0.98±0.123   | 0.97±0.127  | 0.118 |
| Femur total BMD  | 1.00±0.119   | 1.02±0.120   | 1.03±0.114   | 1.03±0.114  | 0.060 |
| Spine (L-1-L-4) BMD | 1.10±0.134  | 1.12±0.133   | 1.12±0.124   | 1.07±0.124  | 0.007 |
| Radius 33% BMD   | 0.66±0.099   | 0.65±0.059   | 0.66±0.062   | 0.65±0.068  | 0.086 |
| HDL-cholesterol   | (≤41) N=195 | (41–143) N=203 | (43–148) N=180 | (46) N=210 | 0.118 |
| Femoral neck BMD | 0.98±0.115   | 0.97±0.119   | 0.98±0.134   | 0.98±0.135  | 0.042 |
| Femur total BMD  | 1.01±0.110   | 1.01±0.128   | 1.02±0.125   | 1.02±0.123  | 0.361 |
| Spine (L-1-L-4) BMD | 1.12±0.118  | 1.10±0.128   | 1.12±0.131   | 1.13±0.137  | 0.906 |
| Radius 33% BMD   | 0.66±0.052   | 0.65±0.060   | 0.65±0.065   | 0.66±0.103  | 0.118 |

BMD: Bone mineral density, HDL: High-density lipoprotein, LDL: Low-density lipoprotein

**Men**

There are very few studies which have evaluated the relationship between lipid parameters and BMD in men, mostly with small sample size. Only two large community-based studies have reported the relationship between lipid parameters and BMD in men, but are not suitable for comparison because in one instance data for...
men was not separately reported, while in the other, BMD was measured only at the wrist. The NHANES-III also reported a similar trend of a negative association between TC and LDL-c with BMD, though it became insignificant after adjusting for multiple variables. Smaller studies among European men reported either absent or positive association of TC and LDL-c with BMD at femur and spine. These differences can probably be explained by ethnic differences in BMD and lipid levels. It has been proposed that oxidized LDL increase Receptor activator of nuclear factor kappa-B ligand expression on osteoblast and increase interaction with osteoclast which affect bone remodeling and may cause decrease in BMD. Further, in animal models, the primary cholesterol metabolite, 27-hydroxycholesterol, interacts with estrogen and liver X-receptors, decreases osteoblast differentiation, and increases osteoclastogenesis, thereby resulting in increased bone resorption and decrease in BMD. BMD at femoral neck showed positive correlation with TG, which was lost when adjusted for various factors including age and BMI. A similar positive association of TG with BMD was reported in men and adolescents, which became insignificant when adjusted for body fat or markers of insulin resistance. However, other small studies have reported both absent and positive correlation of TG with BMD while even after adjustment with body fat. Obesity, weight, and BMI are positively correlated with TC and LDL-c, though it became insignificant when adjusted for body fat or markers of insulin resistance. Hence, it is not surprising to find a positive correlation of TG with BMD, which gets neutralized when adjusted for BMI or fat mass.

HDL-c was not correlated with BMD at any site in the present study, which was also reported previously. Other studies in European men found a negative correlation of HDL-c with BMD at femur and spine, but the relationship was attenuated after adjustment for body fat content in one study. There was no association of BMD at radius with any lipid parameters. A similar finding was reported in a large population based study. On the contrary, a weak negative association of BMD at radius was observed with TC in one population-based study.

**Postmenopausal women**

Serum TC and LDL-c had weak negative correlation with only total femur BMD. Several studies, including large population-based studies, have also reported a negative association of TC and LDL-c with femur, lumbar spine, and radius. In contrast, a positive correlation of TC with hip BMD and total body BMD has also been reported, though in one of these studies, samples for lipid profiles were drawn in a nonfasting state. Few studies have also shown no relationship between TC and LDL-c with BMD at any site. Several of these studies are weakened by either small sample size, selection bias, or inclusion of subjects with comorbidities, as well as and consumption of medication known to affect BMD.

BMD at femoral neck was positively related with TG, which became nonsignificant in multivariate regression analysis after adjustment with various factors. A similar positive association was reported in smaller studies as well large population-based studies. Some studies have reported the association to remain significant even after adjustment for weight.

HDL-c revealed a positive correlation with lumbar spine BMD only in this group, which was maintained in multiple regression analysis. This relation was further confirmed by observation that HDL-c was higher in women with normal bone density compared with those women with low bone density. Several large population based studies and smaller studies also reported a positive association between HDL-c and lumbar spine BMD. However, other studies reported either a negative association or no association of HDL-c and BMD. These differences have been explained by ethnic and racial differences, size of the study population, and inclusion of women on hormone replacement therapy.

**Premenopausal women**

In the present study, BMD at femoral neck and lumbar spine decreased significantly with increasing quartiles of LDL-c, and this weak negative correlation was maintained in multiple regression analysis. Large population based studies also found a negative association of TC and LDL-c with lumbar spine BMD and whole body mineral content, but not with femur in premenopausal women.

After adjustment, no significant correlation was found between TG and BMD at any site. In contrast, a Korean population-based study has reported a negative association of TG with BMD at total hip. However, this study was retrospective and suffers from selection bias.

HDL-c was not correlated with BMD at any site and a similar observation has been reported among Chinese premenopausal women. However, another large population-based study found a positive relation between HDL and BMD at lumbar spine and femur.

The main limitation of the study was absence of longitudinal data. Another limitation was absence of data on dietary habits, smoking, and physical activity, which can adversely affect both BMD and lipid parameters. The strength of
our study was the large sample sizes from healthy Indian population who were free from common morbidities and were not consuming any medication affecting BMD. Further, data on serum 25OHD and iPTH strengthened the study further.

**Conclusion**

While we report a weak correlation between lipid parameters and BMD at various sites in men, pre- and premenopausal women, its clinical significance needs to be elucidated.

**References**

1. Kiel DP, Kaupila LI, Cupples LA, Hannan MT, O’Donnell CJ, Wilson PW. Bone loss and the progression of abdominal aortic calcification over a 25-year period: The Framingham Heart Study. Calcif Tissue Int. 2001;68:271-6.
2. McFarlane SJ, Muniyappa R, Shin JJ, Bahtiyar G, Sowers JR. Osteoporosis and cardiovascular disease: Brittle bones and bone arteries, is there a link? Endocrine 2004;23:1-10.
3. Lawlor DA, Sattar N, Sayers A, Tobias JH. The association of fastig insulin, glucose, and lipids with bone mass in adolescents: Findings from a cross-sectional study. J Clin Endocrinol Metab 2012;97:2068-76.
4. Hernández JL, Olmos JM, Ramos C, Martinez J, de Juan J, Valero C, et al. Serum lipids and bone metabolism in Spanish men: The Camargo cohort study. Endocr J 2010;57:51-60.
5. Dennison EM, Syddall HE, Aihie Sayer A, Martin HJ, Cooper C. The Hertfordshire Cohort Study Group. Lipid profile, obesity and bone mineral density: The Hertfordshire Cohort Study. QJM 2007;100:297-303.
6. Adami S, Braga V, Zamboni M, Gatti D, Rossini M, Bakri J, et al. Relationship between lipid and bone mass in 2 cohorts of healthy women and men. Calcif Tissue Int 2004;74:136-42.
7. Samelson EJ, Syddall HE, Aihie Sayer A, Martin HJ, Cooper C. The Hertfordshire Cohort Study Group. Lipid profile, obesity and bone mineral density: The Hertfordshire Cohort Study. QJM 2007;100:297-303.
8. Wu LY, Yang TC, Kuo SW, Hsiao CF, Hung YJ, Hsieh CH, et al. Correlation between bone mineral density and plasma lipids in Taiwan. Endocr Res 2003;29:317-25.
9. Begen Z, Balic D, Rizanovic M. The association between lipid profile and bone density in postmenopausal women. Med Arch 2012;66:378-81.
10. Malovej J, Chen JS, Hayward C, Williams FM, Sambrook PN. Association between serum cholesterol and bone mineral density. Bone 2009;44:208-13.
11. Sivas F, Alemdaroğlu E, Elverici E, Kulug T, Ozoran K. Serum lipid profile: Its relationship with osteoporotic vertebral fractures and bone mineral density in Turkish postmenopausal women. Rheumatol Int 2009;29:885-90.
12. D’Amelio P, Di Bella S, Tamone C, Ravazzoli MG, Cristofaro MA, Di Stefano M, et al. HDL cholesterol and bone mineral density in normal-weight postmenopausal women: Is there any possible association? Panminerva Med 2008;50:89-96.
13. Afshinnia F, Chacko S, Zahedi T. Association of lower serum cholesterol levels with higher risk of osteoporosis in type 2 diabetes. Endocr Pract 2007;13:620-8.
14. Brownbill RA, Ilich JZ. Lipid profile and bone paradox: Higher serum lipids are associated with higher bone mineral density in postmenopausal women. J Womens Health (Larchmt) 2006;15:261-70.
33. Nelson ER, DuSell CD, Wang X, Howe MK, Evans G, Michalek RD, et al. The oxysterol, 27-hydroxycholesterol, links cholesterol metabolism to bone homeostasis through its actions on the estrogen and liver X receptors. Endocrinology 2011;152:4691-705.

34. Edwards CJ, Hart DJ, Spector TD. Oral statins and increased bone-mineral density in postmenopausal women. Lancet 2002;355:2218-9.

35. Jeon YK, Lee JG, Kim SS, Kim BH, Kim SJ, Kim YK, et al. Association between bone mineral density and metabolic syndrome in pre-and postmenopausal women. Endocr J 2011;58:87-93.

36. Bagger YZ, Rasmussen HB, Alexandersen P, Werge T, Christiansen C, Tankö LB. PERF study group. Links between cardiovascular disease and osteoporosis in postmenopausal women: Serum lipids or atherosclerosis per se? Osteoporos Int 2007;18:505-12.

37. Ackert-Bicknell CL. HDL cholesterol and bone mineral density: Is there a genetic link? Bone 2012;50:525-33.