

DETERMINANTS OF BONE QUALITY: HEREDITY VERSUS LIFESTYLE FACTORS

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INTRODUCTION

One in three women in Canada will suffer an osteoporotic fracture in their lifetime, having serious consequences on quality of life and the Canadian Health Care system. Osteoporosis is a multifactorial disease compromised of genetic, environmental and lifestyle influences. Studies suggest heritability of skeletal traits in parental-offspring pairs is apparent by adolescence or early adulthood. Approximately 40-62% of bone mineral density (BMD) may be determined by genetics [1], but calcium intake and high-impact physical activity have also been shown to increase bone density [2][3]. Therefore, apart from inherited factors, lifestyle influences may be significant contributors to bone quality [4].

To date the research on familial bone health and fracture risk has been acquired using dual x-Ray absorptiometry (DXA). However, this two-dimensional measurement technique cannot account for the structural properties of bone, and over half of fractures occur in women above the osteoporosis threshold for DXA [5]. Recently, high-resolution peripheral quantitative computed tomography (HR-pQCT) has been used in conjunction with finite element analysis (FEA) to estimate the bone's resistance to fracture. These techniques make it possible to explore the familial association of bone microarchitecture and bone strength. Therefore, the purpose of this study was to assess the similarities of lifestyle and bone architecture between mothers and daughters using both DXA and HR-pQCT to better understand the interactions of these elements, and to compare the two scanning modalities.

METHODS

The study included 29 healthy pairs of mature mothers and daughters. HR-pQCT (Scanco Medical) scans at the radius and tibia and DXA (Discovery W, Hologic) scans of the hip and spine were obtained for each participant, and analyzed to determine areal and volumetric BMD, geometric and microstructural indices. FEA was performed to calculate an estimate of bone strength. Information about diet, exercise and health history was collected through questionnaires and a total body DXA scan assessed body composition. T-tests, Chi square and ANCOVAs were performed to compare groups, and intra-class correlation coefficients (ICC) were used to quantify similarities between mothers and daughters. Linear

regression assessed the variance between bone quality, heredity and lifestyle factors.

RESULTS

Initial differences in bone parameters (DXA and HR-pQCT) between mothers and daughters disappear after adjusting for the effects of age, height and weight ($p > 0.05$). ICC revealed low to moderate correlations between mothers and daughters with similar relationships observed by DXA ($r = 0.37$ to 0.38 , $p < 0.05$) and HR-pQCT ($r = 0.36$ to 0.51 , $p < 0.05$). ICC were similar between the radius ($r = 0.374$ to 0.402) and tibia ($r = 0.37$ to 0.51). Cortical porosity ($r = 0.51$) and area ($r = 0.43$) at the tibia were closely related between mothers and daughters, so too was percent body fat ($r = 0.56$). Total calcium intake and the history of physical activity did not correlate. Following linear regression, 75% of tibia cortical area can be explained by lean mass, height, age and physical activity ($p < 0.05$).

DISCUSSION AND CONCLUSIONS

Overall, there was a low to moderate correlation between mothers and daughters, with cortical bone at the tibia being most similar. We found mothers and daughters have comparable body composition; however, calcium intake and physical activity did not correlate. Our preliminary analysis revealed 75% of cortical bone area can be explained by lifestyle factors. This suggests differences in lifestyle may have an impact on the daughter's bones, separate from their mother's influence. However, there are many factors that were not accounted for, and this merits further investigation. In conclusion, DXA and HR-pQCT gave comparable correlations in bone factors between mothers and daughters irrespective of skeletal site, and while heredity relationships existed between mothers and daughters, lifestyle factors appear to be stronger influences in tibia bone quality.

REFERENCES

1. Havill L, et al. *JBMR* **22**(5):737-46 2007.
2. Wizenberg T, et al. *BMJ* **333**(7572):775 2006.
3. Lloyd T, et al. *J Pediatr.* **144**:776-82 2004.
4. Krall EA and Dawson-Hughes B, *JMBR* **8**(1):1-9 1993.
5. Schuit SC, et al. *Bone* **34**(1):195-202 2006.