BONE VOLUMETRIC DENSITY, GEOMETRY AND STRENGTH IN FEMALE AND MALE COLLEGIATE RUNNERS

Amanda J Thieschafer,[1] Julie M Hughes,[1] Kristin L Popp,[1] Rachel J Wetzsteon,[2] Steven D Stovitz,[3] Beth C Kaufman,[1] Mindy S Kurzer, [4] Moira A Petit [1]

[1]School of Kinesiology Laboratory of Musculoskeletal Health, University of Minnesota, Minneapolis, Minnesota USA

[2] Children's Hospital of Philadelphia, Philadelphia, Pennsylvania USA,

[3] Department of Medicine, University of Minnesota, Minneapolis, Minnesota USA

[4] Department of Food Science and Nutrition, University of Minnesota, Minneapolis, Minnesota USA

Abstract

Given the characteristics of the mechanical loads on bone during running, this activity should theoretically have a positive effect on bone strength. However several studies suggest runners have low or normal areal bone mineral density (*a*BMD, g/cm^2) compared to non-running controls. Bone geometry can adapt in ways that improve bone strength with no change in bone density or mass. The purpose of this study was to explore differences in tibial bone geometry, volumetric density (vBMD, mg/mm^3), and estimates of bone strength in runners and healthy, inactive controls. We used peripheral quantitative computed tomography (pQCT, Orthometrix XCT 3000) to assess tibial bone properties in male (n = 21) and female (n = 38) runners and inactive healthy controls (n = 17 males, 32 females) aged 18-35 (mean 22.6$\pm$3.3yrs). We measured vBMD, bone area (ToA, mm^2) and an index of compressive bone strength (bone strength index; BSI, mg^2/mm^4= ToA * ToD^2) at the distal (4%) tibia. At the midshaft sites (50 and 66% tibia) ToA and cortical (CoA, mm^2) bone area, cortical density (CoD, mg/cm^3), cortical thickness (CoTh, mm), estimated bending strength (strength strain index; SSIp, mm^3) and muscle cross-sectional area (MCSA) were assessed. We used analysis of covariance (ANCOVA) adjusting bone outcomes for age, tibia length and body weight. At the distal (4%) tibia, female runners had significantly greater BSI (+19%, $p < 0.05$) due to a larger ToA (+11%, $p < 0.05$), but no difference in vBMD compared to controls. At the proximal sites, female runners also had significantly greater bone strength (SSIp +17-19%, $p < 0.001$) due to a greater ToA (+14%), CoA (+15%), and CoTh (+8-9%) but no difference in vBMD compared to female controls. Male runners, compared to controls had significantly greater CoTh (+8-14%, $p < 0.05$) at both proximal sites as well as a greater CoA (+11%, $p < 0.009$) at the 66% site, but no differences in bone strength or vBMD. Greater bone strength in female runners was attributable to greater bone area rather than density. In contrast, there was no difference in bone strength between male groups; however male runners had favorable bone geometric properties. These data suggest that running may optimize bone geometry resulting in increased bone strength in females.