BONE MINERAL DENSITY OF THE PROXIMAL FEMUR IS NOT RELATED TO DYNAMIC JOINT LOADING DURING LOCOMOTION

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INTRODUCTION Load bearing provides the most potent influence on bone mass and architecture (1). In 2004 Moisio et al. (2) reported that nearly 40% of the variance of proximal femur bone mineral density (BMD) was associated with peak hip joint moments during walking. This result implies that joint moments acquired using gait analysis during a single session conveys meaningful information regarding daily stress and loading history. We considered the possibility that the result could be an analytical artifact, as the relationships reported were based on joint moment calculations that implicitly included the influence of body mass.

We have previously reported the influences of body size variables on bone mineral density (3, 4). In each of these studies we found a significant relationship between muscle strength variables and bone mineral density of the proximal femur in older adults. However, after accounting for the influence of body size on muscle strength variables, the relationship between muscle strength and bone mineral density was reduced to zero. Based on this work we anticipated that the relationship between joint moments measured during locomotion and bone mineral density would be similarly affected.

The purpose of the present study was to characterize the extent to which body mass influences the relationship between hip joint moments during locomotion and bone mineral density of the proximal femur in a homogeneous sample of healthy young women. We hypothesized that BMD would not be significantly associated with hip joint moments during locomotion independently of body mass.

METHODS Twenty-five women (age and mass: 22.96±2.05 years, 66.8±18.04 kg) participated in this institutionally approved study. The BMD (g/cm^2) of the non-dominant femur was determined by Dual Energy X-ray Absorptiometry (DXA) (Hologic QDR 4500 Elite). Subjects performed 10-15 trials during which they walked at a self-selected velocity along a path of approximately 10 meters. An eight-camera motion capture system (Motion Analysis Corporation, Santa Rosa, CA) and two AMTI force plates operating at 60 Hz recorded gait kinematics and kinetics. Univariate Pearson correlations were calculated to determine the relationships between hip joint moments, body mass, and proximal femur BMD. Significant correlations between hip joint moments and proximal femur BMD were subsequently investigated using an allometric scaling procedure (3,4) to determine the extent to which body mass influenced the relationship between hip joint moments and the BMD of specific regions of interest.

RESULTS AND DISCUSSION A potentially important relationship was discovered between only one of the measures of hip joint moment and one of the regions of interest of proximal femur BMD. Specifically, the peak internal rotation moment and the BMD of the intertrochanteric region were

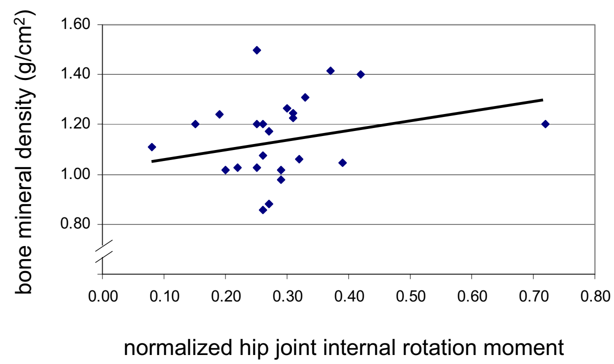

Figure 1: BMD vs. normalized internal rotation hip moment. After removing the influence of body mass on the hip joint moment, the relationship with BMD was not significantly different than zero. The regression equation characterizing the relationship between the peak internal rotation moment normalized to body mass and intertrochanteric BMD: BMD = 1.071 + (.284*normalized internal rotation moment) was not significant (p=0.337). The figure reveals the presence of an apparent outlier on the x-axis. A *post hoc* regression conducted without this data point resulted in an equation that was not significant (p=0.25) and accounted for only 6.3 percent of the shared variance.

significantly correlated (r= 0.475, p = 0.019). The magnitude of the peak internal rotation moment was 19.77±2.2 Nm. The average BMD of the intertrochanteric region was 1.15±0.03 grams/cm^2. However, the relationship between the allometrically scaled peak internal rotation moment and intertrochanteric BMD was not significant (Figure 1). Prior to scaling, the peak internal rotation hip joint moment (unscaled) was strongly associated with the BMD of the intertrochanteric region; accounting for more than 20 percent of the shared variance. However, scaling of the hip joint moments to account for the influence of body mass reduced the relationship between hip joint moment and bone mineral density to essentially zero. As expected, body mass accounted for a significant proportion of the shared variance of proximal femur BMD

In summary, the relationship between bone mineral density of the proximal femur in a sample of young healthy women and peak hip joint moments during locomotion was found to be dependent on the influence of body mass on both variables. After this influence was accounted for, the BMD-hip joint moment relationship disappeared. The results suggest that the dynamic hip joint moments during walking are not independently informative of daily stress stimulus and loading history in young women.

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