GENDER AND AGE SPECIFIC RELATIONSHIPS EXIST BETWEEN WALKING AND BONE DENSITY

Katherine Boyer[2,1], Jonathan Rylander[2,1], B, Jenny Kiratli[1], Thomas Andriacchi[1,2], Gary Beaupre[1,2]
[1]VA Palo Alto Bone and Joint Center, Palo Alto CA
[2]Mechanical Engineering Stanford University, CA
kboyer@stanford.edu

INTRODUCTION

Osteoporosis is a serious public health concern. An estimated 37-50% of women and 13-33% of men over 50 yrs have low bone mineral density and are at risk for fractures[1]. This issue is expected to grow as the population ages. An important mechanical stimulus for maintaining bone mineral balance is provided by weight bearing daily activities, however it is not clear what specific mechanical characteristics of a loading history are necessary to significantly influence bone density, how this translates to loads generated by everyday activities and whether the loading requirements are the same for males and females, or older and younger individuals. Thus the goal of this study was to quantify the habitual walking amounts and gait mechanics in older individuals to investigate the relationship between the loading magnitude and frequency in walking and bone density. Specifically, this study tested the hypothesis that significant correlations between the walking load stimulus and proximal femoral bone density (BMD) exist separately for: younger and older subjects; males and females.

METHODS

Gait mechanics, habitual walking amounts and BMD were quantified for 207 healthy older individuals, (age ≥ 50yrs). Volunteers provided informed consent prior to participation per Stanford University IRB guidelines. Steps per day and walking speed were measured using an activity monitor (AMP231/331 Dynastream Innovations Inc. Canada) worn for five days. Lower extremity kinematics and ground reaction forces (GRF) were collected at 120Hz as subjects walked at three self-selected speeds on a walkway with embedded force-plate. BMD was quantified for the total femur region using DXA (GE/Lunar iDXA). The bone stimulus, BDI was determined using a mathematical model of bone density regulation [2].

$$BDI = \left(n_{steps} \times (\beta \times GRF)^m\right)^{1/2m}$$

where m = 6 is an empirically determined constant; n_{steps} = average steps/day; β=BW/pooled mean BW; the GRF value was estimated for each subject using the activity monitor walking speed history and a linear regression equation determined for walking speed and GRF from the gait analysis.

Statistical methods included one-way ANOVA with Bonferroni post-hoc adjustment, α=0.05 and multiple regression analysis to examine BDI- BMD relationships with adjustments for age and gender.

RESULTS AND DISCUSSION

Subjects were stratified into 4 groups based on age (< 65 yrs & ≥ 65 yrs.) and gender. There were no differences between groups in the average steps per day or average walking velocity (Table 1). BDI explained 11.9% of the variance in BMD (p<0.01). A significant improvement occurred when subject "group" was added to the model, indicating that both age and gender are important co-factors in the this relationship. To investigate further separate regression models were done for each group (Figure 1). BDI explained a significant portion of the variance in BMD for the younger females (YF) (17.6% p<0.01) group only. For the older females (OF) group BDI explained only 4.6% (p=0.15) of the variance in BMD alone, but 15.3 % when age was also entered.

Table 1: Mean (SE) group demographics. *p<0.05 gender

Group	Age [Yr]	BMI [kg/m^2]	Steps/ day	BDI	BMD [g/cm^2]
Younger female YF (n=64)	56.6 (0.5)	23.9 (0.4)	10212 (413)	1.96* (0.02)	0.92* (0.01)
Older female OF (n= 46)	71.3 (0.7)	24.4 (0.4)	9302 (554)	1.92* (0.02)	0.91* (0.02)
Younger male YM (n=37)	57.4 (0.7)	25.3 (0.3)	9015 (581)	2.21* (0.04)	1.00* (0.02)
Older male OM (n=60)	72.3 (0.6)	25.6 (0.3)	8696 (474)	2.16* (0.02)	0.96* (0.01)

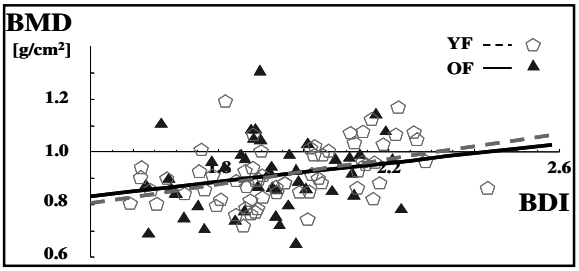

Figure 1: Linear regression between BMD and BDI for the YF and OF groups.

CONCLUSIONS

The study results suggest that a significant gender difference exists for the influence of walking on BMD. This difference might be attributed to the differences in hip BMD heritability between males and females [3]. With advanced age the influence of loading alone on BMD was lessened in females, however the relationship with the age-adjusted BMD was similar to the younger group. These results demonstrate the importance in females of walking activity in preserving bone mass typically lost in normal aging.

ACKNOWLEDGMENTS

Funding VA R R&D Service, merit review grant A4067R. Data collection C.Dairaghi, B.Elspas, J.Guerricabetia, and S.Williams.

REFERENCES

1. Looker,AC et al. *J Bone Miner Res*, **12**, 1761- 1768 1997.
2. Whalen,RT and Breit,GA,(2001), Patent **US 6,183,425 B1**,
3. Tse,KY et al. *J Orthop.Res*, **27**, 150- 154 2009.