

Associations between bone loading due to daily activity and hip bone mass and structure

Tina Smith¹, George Metsios¹, Michael Baker², Richard Foster² and Jin Luo³

¹Faculty of Education, Health & Wellbeing, University of Wolverhampton, Wolverhampton, UK

²Corata Limited, Farnborough, Hampshire, UK

³School of Applied Sciences, London South Bank University, London, UK

Email: Tina.Smith@wlv.ac.uk

Summary

Bone loading due to daily physical activity over one week, was quantified from accelerometer data. Moderate-to-vigorous loading was positively associated with bone health of the left proximal femur. Adopting this level of activity in daily living may have sustained benefits for healthy ageing of bone.

Introduction

Hip fracture is a major health concern. Exercise can improve bone health and reduce fracture risk [1], but the optimal way to achieve this is not clear. In general, physical activities that can load the bone with high strain magnitude and high strain rate (frequency) are most likely to have a positive osteogenic effect [2]. Therefore the assessment of the osteogenic potential of physical activity must incorporate these features.

To determine hip bone health and fracture risk, assessment often focuses on bone mineral content (BMC) or density (BMD). However, bone geometry and mass distribution are also important for bone strength and resistance to fracture [3]. To date appropriate quantification of mechanical loading of bone during daily activity and implications for hip bone health has not been adequately studied. The aim of this study was to examine associations between bone loading due to daily activity and bone mass and structure at the proximal femur.

Methods

Male and female (pre-menopausal) participants (n=27, male=10, 44.3±8.2y, 1.67±0.09m, 71.3±14.7kg) wore a tri-axial strap mounted accelerometer (GENEActiv, Action; 100 Hz) at the 4th lumbar vertebra, for seven consecutive days. The left proximal femur was scanned using dual-energy X-ray absorptiometry (DXA; Hologic, Discovery W QDR series x-ray Bone Densitometer) by a certified radiographer.

The acceleration data were imported into our custom written analysis software (GADget©, v3.4). The magnitude and frequency of the signal was used to estimate loading intensity and dose as both these aspects are important to bone health [2,4]. The data were divided into 5-second segments. Loading intensity was calculated for each segment [4] for the following categories: 5< light activity ≤10 BW/s; moderate-to-vigorous activity >10 BW/s. The weekly loading dose (BW) for each category was calculated across a frequency band of 0.2-6 Hz.

Total hip area, BMC and BMD; and cross-sectional area (CSA), cross sectional moment of inertia (CSMI) and cortical thickness of the narrow neck (NN), intertrochanter (IT) and femoral shaft (FS), were extracted from the DXA scan report. Weekly loading dose and bone parameters data were correlated using Pearson's Correlation Coefficient (p < .05).

Results and Discussion

This study has estimated external mechanical loading due to physical activity using osteogenic specific parameters (magnitude and frequency) to determine loading dose over one week [2,4]. Significant correlations were found between moderate-to-vigorous loading dose and hip bone parameters (Table 1). No significant correlations were found between any of the bone parameters and light physical activity loading dose. This may be due to moderate and vigorous physical activity incorporating more osteogenic features [2,3]. Identifying specific activities contributing to the moderate-to-vigorous loading dose will be beneficial to elicit aspects of lifestyle that have a positive effect on bone health. This can help inform future research on bone health interventions.

All bone geometry and mass distribution parameters at IT and FS were significantly correlated with bone loading, but only CSMI at the NN. This may be related to some moderate and vigorous activities having a lesser influence on the NN. Further research is required to identify activity that can induce changes in bone at specific sites.

Conclusions

Moderate-to-vigorous loading dose of weekly physical activity was positively associated with bone health at the hip. Finding novel ways of incorporating such activity into a person's daily routine may increase adherence and have sustained benefits.

Acknowledgments

Funding was received from the University of Wolverhampton, Early Researcher Award Scheme.

References

- [1] Howe TE et al. (2011). *Cochrane Database Sys Rev*, **7**.
- [2] Turner CH. (1998). *Exerc Sport Sci Rev*, **31**: 45-50.
- [3] Allison SJ et al. (2015). *J Bone Miner Res*, **30**: 1709-16.
- [4] Smith T et al. (2018). *J App Biomech*, **34**: 7-13.

Table 1: Significant correlations between moderate-to-vigorous loading dose and left proximal femur parameters

	Total BMC (g)	NN CSMI (cm ⁴)	IT CSA (cm ²)	IT CSMI (cm ⁴)	IT Cortical Thickness (cm)	FS CSA (cm ²)	FS CSMI (cm ⁴)	FS Cortical Thickness (cm)
Moderate-to-Vigorous Loading Dose (BW)	r = .406 p = .036	r = .407 p = .043	r = .501 p = .011	r = .398 p = .049	r = .425 p = .034	r = .491 p = .013	r = .399 p = .048	r = .421 p = .036