Osteogenic potential of external mechanical loading during walking in sedentary and non-sedentary adults

OSTEOGENIC POTENTIAL OF EXTERNAL MECHANICAL LOADING DURING WALKING IN SEDENTARY AND NON-SEDENTARY ADULTS

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INTRODUCTION

Sedentary behaviour is generally regarded as having deleterious effects on cardiometabolic health, although little is known about its specific association with bone health. Impact forces generated as the foot contacts the ground during activity have the potential to act as a stimulus for bone maintenance and development. Therefore, increased sedentary behaviour may reduce the time available to gain osteogenic benefits from impact-based activity.

Peak ground reaction force is commonly used as an estimate of loading intensity when determining the osteogenic potential of activity [1]. Dynamic, high impact, high frequency activities have been shown to be most effective at applying an osteogenic stimulus [1], although low level impacts have been shown to beneficially modify bone geometry [2]. Therefore, differences in the characteristics of low impact activity have potential to influence bone health.

As impact forces are attenuated as they travel up the body, exploration of mechanical loading at regions such as the spine, require further investigation. External force due to impact is related to acceleration; therefore an accelerometer attached to the spine can provide an estimation of the mechanical loading. The aim of this study, therefore, was to investigate associations between sedentary and non-sedentary behavior on the osteogenic potential of walking, and bone mineral density (BMD) of the lumbar spine.

METHODS

Ten sedentary (Female = 9; 43.06 ± 7.91 yrs; 1.62 ± 0.06 m; 66.82 ± 14.51 kg) and ten non-sedentary (Female = 8; 45.30 ± 6.54 yrs; 1.65 ± 0.08 m; 73.19 ± 17.00 kg) adults, who engaged in low levels of physical activity, participated in the study. The International Physical Activity Questionnaire - Short Form (IPAQ-SF) was used to classify sedentary behavior (≥ 8 hours spent sitting on a week-day) and activity levels (low = IPAQ-SF category 1 or 2).

Walking data were collected via a force platform (Bertec, 4060-10; 1000 Hz) mounted along a 10 m runway, and an accelerometer (Biometrics, ACL300; 1000 Hz) attached to the skin at the 4th lumbar vertebrae (L4). Participants walked at a self-selected pace so their dominant foot landed on the force platform, while timing gates recorded velocity.

Vertical force (cut-off 50 Hz) and accelerometer data (cut-off 46 – 63 Hz) were filtered using a 4th order, low pass, Butterworth, zero phase filter. Peak vertical force during the loading response of walking (Fz1 peak) was extracted along with peak vertical acceleration of the corresponding phase of the same step. Force data was normalised to body weight (BW). Data processing was carried out using Matlab 2015a. BMD of the lumbar spine was measured using dual-energy X-ray absorptiometry (Hologic, Discovery W QDR series x-ray Bone Densitometer) by a certified radiographer. Data were analysed using an independent t-test (SPSS, v20).

RESULTS AND DISCUSSION

No significant differences were found between groups for the external mechanical loading measures or DXA data (Table 1). As both groups had similar walking velocity it is likely this contributed to the similarities found in force and accelerometer data, indicating both groups experience similar amounts of whole body and L4 external mechanical loading, and osteogenic benefit from the activity.

Table 1: Kinematic and kinetic variables and 4th lumbar vertebrae bone mineral density (Mean ± SD).

	Sedentary	**Non-sedentary**	***p*-value**
Velocity ($m \cdot s^{-1}$)	1.49 ± 0.12	1.72 ± 0.23	0.11
Fz1 Peak (BW)	1.21 ± 0.11	1.27 ± 0.23	0.37
Acceleration Peak (g)	0.76 ± 0.35	1.07 ± 0.34	0.06
L4 BMD ($g \cdot cm^{-2}$)	1.07 ± 0.18	1.10 ± 0.16	0.71
Lumbar spine total BMD ($g \cdot cm^{-2}$)	1.05 ± 0.14	1.11 ± 0.13	0.31

Acceleration levels recorded at the lumbar spine during walking were low for both groups and below the threshold associated with positive changes in BMD [3]. This indicates higher impact activities may be necessary for improvements in BMD at that site. However, as we still continue to investigate the most effective daily activity regimes on overall bone health it is important studies continue to analyse low impact activities [2] as they may be able to improve BMD and bone strength in other body locations [1].

CONCLUSIONS

In the absence of participation in high levels of physical activity, differences in amounts of daily sedentary behavior are not associated with external loading during walking and BMD at the lumbar spine.

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