Supplementary Data

Introduction

1.4 million vertebral fractures were related to osteoporosis in 2005 worldwide [4]. Bone loss initially affects the surface of vertebrae and then osteoporosis affects trabecular bone to a greater extent [27].

Methods

Data were analyzed using custom made scripts in Matlab® (R2010b, Mathworks Inc.). Raw acceleration and angular rate signals (sampled at 110 Hz) were low pass filtered at 20 Hz with a zero phase 5th order Butterworth algorithm [28]. Raw acceleration was subjected to three corrections: inclination of the sensor to the vertical (gravity) using a cosine function, removing the frequency components of skin movement and removing the effect of gravity [12].

Participants characteristics:

Table 1 Characteristics of groups according to their T-score

Characteristics	Groups according to BMD		
	YH	**OH**	**OO**
Age	28.94 (3.76)	64.05(7.44)	67.27(7.63)
Weight (kg)	63.32(5.86)	66.79(7.71)	64.76(8.32)
Height (m)	1.63(0.06)	1.64(0.07)	1.60(0.06)
BMI (kg/m^2)	23.69(2.59)	24.70(2.68)	24.98(2.72)
T-score	-0.07(0.51)	-0.44(0.42)	-1.77(0.8)
Number of individuals (n)	16	19	41
Straight walking speed (m/s)	1.66(0.19)	1.73(0.21)	1.66(0.26)

Mean (SD), Body mass index (BMI), bone mineral density (BMD), young and healthy (YH), older healthy (OH), older osteoporotic (OO)

Discussion

It has been suggested that thoracic kyphosis has a strong linear relationship with spinal load profiles [29, 30], thus changes in curvature may also alter the transmission of signals in the spine. Moreover, it is shown that voluntary periodic movement and muscle contractions of the trunk may alter the stiffness of the spine when exposed to low frequency vibration [25]. These are factors which are also likely to affect vibration transmission.

This study explored vibration transmission up to 8 Hz due to the natural frequency of the skin-sensor interface of the participants. The calculation of vibration transmissibility is based on skin-mounted sensors involving correction for soft tissue interface movement [31]. The data obtained over the skin surface has been shown to be very close to that which has been measured by inserting pins directly to bone [32, 33], and the method has been found to provide highly reliable data. The vibration transmission observed in this study relates to a defined walking distance (33 meters). It is not known if the vibration characteristics will be similar with a longer distance walked. Further research is suggested to demonstrate the contribution of muscular contraction to either attenuation or amplification of vibration during walking by combining the vibration measurements with electromyography. RMSa measurement provides the magnitude of vibration transmitted to locations of the spine at all frequencies and up to 20 Hz. Previous studies have reported that low frequency mechanical loading is effective at simulating bone but no agreement has been achieved regarding the magnitude of that stimulation [34]. Animal studies have demonstrated that peak bone loading occurs at relatively low frequency (1-3 Hz) [35]. Therefore we believe that RMSa measurement provides a tool to characterize the intensity of physical activity which will potentially to stimulate bone growth. Previous studies have investigated the effect of mechanical stress on bones and the stimulus is often characterized in terms of micro strains (µs), loading force (N) and acceleration (g forces and ms^{-2}). These dynamic parameters have been shown to be related to changes in either BMD or bone metabolism biochemical markers [36-39]. The results of this study provide independent observations on the differences in vibration transmission due to osteoporosis and ageing. Future research could help elucidate these relationships. Finally, a greater sample of the population is needed to account for variability between subjects as well as other possible factors such as risk of fracture determined by FRAX [40].

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