Walking for fitness: is it enough to maintain both heart and bone health?


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**Abstract.** Exercising at levels of whole body accelerations exceeding 3.6 g has been shown to have positive effects on cardiovascular fitness, bone density and balance. This pilot research project evaluated the whole body accelerations and cardiovascular challenge provided by selected walks in the Canberra region of Australia to determine if walks could be ranked according to potential level of impact on both cardiovascular fitness and bone health. Nine participants, who described themselves as walking at least 3 km, three times per week, wore a data logging device recording heart rate, acceleration and GPS position while walking three outdoor tracks: (1) the running track of an athletics stadium; (2) on a hill climb path through bushland; and (3) on a route through suburban streets. There was a significant difference ($P<0.05$) for heart rate, distribution of whole body accelerations and average walking speed between track 2 and tracks 1 and 3. There was a significant difference for heart rate, distribution of whole body accelerations and average walking speed between the walks. The running track and the suburban walk provide a moderate exercise challenge, with the hill climb walk providing progressively greater vertical height challenge, resulting in an increased cardiovascular exercise challenge. No participant effectively exceeded the threshold for achieving a positive impact on bone density (100 or more accelerations/day >3.6 g) on track 1, and only two of the nine participants intermittently achieved this threshold on tracks 2 and 3.

**Additional keywords:** accelerations, cardiovascular fitness.

**Introduction**

The benefits of physical activity in the promotion and maintenance of cardiovascular health and associated chronic diseases such as Type 2 diabetes are well established (Astrand *et al*. 2003). Impact exercise has been reported to have positive effects on bone mass in adolescents, has been implicated in the reduction of bone loss in ageing and, by improving strength and motor control in the elderly, has been associated with the incidence of reduced falls (Greendale *et al*. 1995; Gregg *et al*. 2000; NIH Consensus Development Panel on Osteoporosis Prevention Diagnosis and Therapy 2001). A systematic review of randomised controlled trials by Wallace and Cumming (2000) indicates that high-impact activities are the most effective in inducing positive changes in femoral neck bone density, lowering the associated risk of fracture.

Exercising that incorporates levels of whole body accelerations exceeding 3.9 g at a frequency of 100 per day has been shown to have positive effects on cardiovascular fitness, femoral bone density and balance (Jämsä *et al*. 2006; Vainionpää *et al*. 2006; Heikkinen *et al*. 2007). These acceleration levels are normally reported in activities such as running or jumping, which may be appropriate for middle aged and younger individuals, but may be more difficult for many older people or those with chronic lower limb injuries to achieve.

Vainionpää and co-workers (2007) suggest that although the most significant positive association between exercise impact and increased mid-femoral bone thickness occurred with impacts of 3.9 g or more, the notable effect on bone strength indices commenced from accelerations of ~1.1 g and above. The intensity, duration, frequency and type of exercise that best promotes positive bone strength change is unclear (Vainionpää *et al*. 2007). There is a need for further studies in the area of human *in vivo* exercise impact assessment. New technology in wearable accelerometer systems provides enhanced capacity for examining exercise environments outside the laboratory.

Wearable accelerometer systems have been used successfully for analysis of *‘in the field’* walking and running activities for some time (Collins and Whittle 1989; Kavanagh and Menz 2008). However, this is the first study to use a data logging system combining 3-D accelerations, heart rate measurement and terrain variations in the one compact system (SPI Elite, GPSports, Canberra, Australia). By recording both heart rate and acceleration data, without the need for telemetry, the effect of walking on different types of walking tracks on both heart rate and...
response and 3D accelerations can be examined in more natural environments, away from the limitations of telemetry range restrictions.

The aim of this pilot research project was to evaluate whole body accelerations and the cardiovascular challenge provided by selected walks in the Canberra, Australian Capital Territory region of Australia, to determine if walking trails could be ranked to:

1. Evaluate the cardiovascular challenge (i.e. heart rate expressed as a percentage of maximum predicted heart rate), for individuals over 65 years of age, of the different walking tracks.
2. Determine if whole body accelerations experienced by the participants were associated with the type of track (i.e. smooth, flat surface athletic track versus concrete footpath versus elevated vertical height uneven surface track).

If walking a more challenging track in terms of vertical rise and surface irregularity affords a higher cardiovascular challenge and greater impact accelerations, this may be of benefit to older individuals seeking activities to maintain both cardiovascular and bone health.

**Method**

Participants responded to an advertisement inviting people walking at least 3000 m, three times a week to participate in the project. Ten individuals satisfying the criteria were enrolled; however, one individual dropped out due to personal commitments before the first session. Nine participants (three men, six women, 75 ± 9 years) wore a data logging device (SPI Elite, GPSports) recording heart rate, acceleration and global positioning system (GPS) position and completed all three walks. The data logger devices were worn in a purpose designed backpack harness centred over the upper thoracic spine (T1, T2) while the participants undertook self-determined ‘brisk walks’ on each of three outdoor tracks. The maximum heart rate for each participant was calculated using the method described by Robergs and Landwehr (2002): heart rate maximum = 205.8 – (0.685 × age).

The tracks were: (1) the Australian Institute of Sport (AIS) athletics track, for five laps of the standard 400 m international level athletics running track with 0 m vertical rise; (2) the Mount Ainsley Walk, a 2000 m formed walking track with moderate walking surface irregularities and ~200 m vertical rise (1 lap); and (3) the Narrabundah Community Walk, a designated 2900 m urban walk consisting of concrete footpaths and occasional bitumen road crossings with 2 m vertical rise (1 lap).

A repeated-measures design was used with all participants completing walks on all three tracks. Allocation to order of setting out for participants walking the selected tracks was randomised by the toss of a coin. The participants were instructed to undertake all the walks at a self-selected ‘brisk but comfortable’ walking pace. Data from the logging device was downloaded to a laptop and proprietary software (Team AMS GPSports) was used to compare steady-state exercise performance, number of maximum accelerations (number of accelerations exceeding 2 g) and GPS position and velocity between each of the walks. A repeated-measures analysis of variance was undertaken on each measure to examine differences between the three tracks, using two planned contrasts that first compared the steep bush track with the other two tracks combined, then compared between the two flat surface tracks.

**Results**

The accelerometer raw data graph outputs were used to visually compare accelerations achieved on different walks and to cross check activities such as crossing roads with the GPS track output. An example of the raw acceleration data for one participant indicating where the participant stopped before crossing a roadway while completing a walking track is displayed in Fig. 1.

The participants were instructed to undertake all the walks at a self-selected ‘brisk’ walking pace, which was reflected in that the average %Maximum Heart Rate (%MHR) achieved on the non-elevated walks was 72%MHR and on the elevated vertical height uneven surface track it was 85%MHR. As the recommended %MHR to achieve a training effect is exercising at greater than 65%MHR, the participants could be expected to achieve a cardiovascular training benefit from all three walks.

All participants walked significantly more slowly ($F_{1,8} = 120.5$, $P < 0.001$) on the inclined Mt Ainsley track (mean 3.2 kph, s.e. 0.137 and confidence interval (CI) 2.9–3.5) compared with both the relatively flat AIS track (mean 5.2 kph, s.e. 0.27 and CI 4.6–5.8) and the Narrabundah Community Walk (mean 4.9 kph, s.e. 0.19 and CI 4.4–5.3), where speeds were not significantly different ($F_{1,8} = 3.3$, $P = 0.11$).

The participants experienced higher levels of mean cardiovascular challenge on the Mt Ainsley walk (85%MHRpred = 132 bpm, s.e. 4.3, CI 122–142) than the AIS athletics track (72%MHRpred = 112 bpm, s.e. 4.7, CI 99–120) and the Narrabundah Community Walk (72%MHRpred = 112 bpm, s.e. 4.5, CI 102–122) ($F_{1,8} = 21.9, P = 0.002$); however, cardiovascular challenge was not significantly different on the flat tracks ($F_{1,8} = 0.3$, $P = 0.63$).

To allow comparison with previously published data for accelerations recorded at the hip/pelvis, 1 g was subtracted from

![Fig. 1. Accelerometer data output with minimal activity in the acceleration output data (indicated by an arrow) showing where the participant stopped before crossing a roadway while completing a walking track.](image-url)
the acceleration data recorded at the upper thoracic spine and the result then corrected for attenuation from the hip/pelvis to the thoracic spine by a factor of 1.6. This correction factor was determined from the representative plots of shank, trunk, neck and head accelerations of 15 strides over 10 trials reported in Kavanagh et al. (2006). Participants experienced higher mean maximum accelerations on the Narrabundah Community Walk (mean maximum accelerations exceeding \(2\text{ g} = 15.9\), s.e. 4.0, CI 6.5–25.3) than the AIS athletics track (mean maximum accelerations exceeding \(2\text{ g} = 11.3\), s.e. 4.9, CI 0.1–22.7), followed by the Mt Ainsley Walk (mean maximum accelerations exceeding \(2\text{ g} = 0.6\), s.e. 0.3, CI –0.1–1.3). Although the mean maximum accelerations did not differ between the flat tracks \((F_1,8 = 1.25, \ P = 0.30)\), these two tracks combined showed significantly more mean maximum acceleration than was recorded on the Mt Ainsley Walk \((F_1,8 = 11.39, \ P < 0.01)\).

No trips or falls were reported by the participants while undertaking the walking trails.

Discussion

There was a significant difference for heart rate, distribution of whole body accelerations and average walking speed between the walks. The AIS athletics track and the Narrabundah Community Walk provide a moderate exercise challenge, with the Mt Ainsley Walk providing progressively greater vertical height challenge, resulting in an increased cardiovascular exercise challenge.

The maximal accelerations recorded by the SPI Elite System at the upper thoracic spine are comparable with those determined from the representative plots of shank, trunk, neck and head accelerations of 15 strides over 10 trials reported in Kavanagh et al. (2006) for the upper trunk (C7 region), suggesting that the SPI Elite System is a valid measure of upper trunk accelerations. When compared with the published data for upper body accelerations, no participant effectively exceeded the threshold for achieving a positive impact on femoral bone density (100 or more accelerations/day >3.9 g) on the AIS athletics track and only two of the nine participants intermittently achieved the threshold on the Narrabundah Community Walk or the Mt Ainsley Walk.

Overall, the participants walked at a lower velocity on the irregular surface and elevated Mt Ainsley (3.2 kph) walk, which was most likely due to the greater cardiovascular load afforded by this track. This lead to lower accelerations being experienced for this walk than the accelerations experienced on the two less cardiovascular challenging walks (AIS 5.2 kph and Narrabundah Community Walk 4.9 kph).

Conclusions

- The use on a data-logging device recording accelerations, heart rate and GPS coordinates, such as the SPI Elite System, worn at the upper thoracic spine is a valid tool as a measure of accelerations in vivo at the upper trunk.
- Self-determined ‘brisk walking’ in all three walking environments included in the trial achieved a heart rate consistent with that required to achieve a cardiovascular training effect.
- Accelerations experienced by the participants were associated with the type of track. Highest accelerations were experienced by participants walking on conventional concrete footpaths (Narrabundah Community Walk). This was followed by the athletic track surface (AIS athletics track) and then the irregular surface, elevated vertical height uneven surface track (Mt Ainsley track).
- The ‘take home message’ from this study is that to achieve whole body acceleration levels that have been associated with a positive bone growth effect, further research is necessary to determine safe mechanisms for including activities such as small jumps/hops in the walking activities of older people to maximise the effect of their exercise.

Conflicts of interest

None declared.

References


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