

## Patterns of physical activity and ultrasound attenuation by heel bone among Norfolk cohort of European Prospective Investigation of Cancer (EPIC Norfolk): population based study

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### Abstract

**Objectives** To study associations between patterns of physical activity and ultrasound attenuation by the heel bone in men and women.

**Design** Cross sectional, population based study.

**Setting** Norfolk.

**Participants** 2296 men and 2914 women aged 45-74 registered with general practices participating in European Prospective Investigation into Cancer (EPIC Norfolk).

**Results** Self reported time spent in high impact physical activity was strongly and positively associated with ultrasound attenuation by the heel bone, independently of age, weight, and other confounding factors. Men who reported participating in  $\geq 2$  hours/week of high impact activity had 9.5% higher ultrasound attenuation than men who reported no activity of this type. Women who reported any high impact activity had 3.4% higher ultrasound attenuation than those who reported none. In women this effect was similar in size to that of an age difference of four years. Moderate impact activity had no effect. However, climbing stairs was strongly independently associated with ultrasound attenuation in women. There was a significant negative association in women between time spent watching television or video and heel bone ultrasound attenuation.

**Conclusions** High impact physical activity is independently associated with ultrasound attenuation by the heel bone in men and women. As low ultrasound attenuation has been shown to predict increased risk of hip fracture, interventions to promote participation in high impact activities may help preserve bone density and reduce the risk of fracture. However, in older people such interventions may be inappropriate as they could increase the likelihood of falls.

### Introduction

Physical activity has been shown to be associated with bone density,<sup>1-4</sup> but it is uncertain how the different aspects of this complex and multidimensional activity

affect achievement of peak bone mass or its rate of decline in later life. Identifying the components of physical activity that are beneficial for a particular outcome is essential when designing preventive interventions, but the process is complicated by the difficulty of measuring the subdimensions of activity in epidemiological studies.<sup>5-7</sup> Interventions aimed at increasing activity may not produce the benefits predicted from observational studies if they focus on the wrong type of physical activity. We studied the cross sectional association between patterns of physical activity in an adult population and ultrasound attenuation by the heel bone. Low ultrasound attenuation by heel bone, which is associated with low bone mineral density, has been shown to be a predictor of higher risk of hip fracture.<sup>8</sup>

### Participants and methods

The European Prospective Investigation of Cancer (EPIC) study is a prospective cohort study designed to investigate the aetiology of major chronic diseases. The Norfolk cohort was recruited between 1993 and 1997 and comprised 25 633 men and women aged 45 to 74 years identified from participating general practice lists. From January 1998 we invited the cohort for a second health check; the study group for this analysis is the 5210 participants who had complete data entry by May 1999. Tests at the second check included ultrasound measurements of the calcaneus.

Volunteers also completed the EPIC physical activity questionnaire (EPAQ2), which is a self completed questionnaire that collects self reported physical activity behaviours. For this analysis the reported recreational activities were classified beforehand into four groups according to the level of impact (box).

### Results

A total of 2296 men and 2914 women had a heel ultrasound measurement at the second health check and had complete data entry by May 1999. Participants who had experienced any fracture (142 men, 236 women) or who reported having had osteoporosis

diagnosed by their doctor (11 men, 47 women) before the second health check were excluded from subsequent analysis due to potential bias in reporting physical activity. The table shows the characteristics of the remaining 2143 men and 2631 women available for analysis.

Figure 1 shows the patterns of physical activity. The mean times spent participating in recreational activity were 9.8 (SD 12.6) hours/week for men and 6.2 (7.0) hours/week for women. Moderate impact activity accounted for most time in men and women (mean 7 (11.4) and 3.4 (4.5) hours/week respectively). Mean participation in high impact activity was identical in men and women (0.2 (1.5) hours/week), although the proportion of men who participated in any high impact activity was greater (292 (13.6%) in men *v* 244 (9.3%) in women). For men, 91% of time spent in high impact activity was accounted for by tennis and badminton (50%), competitive running and jogging (29%), and squash (12%). In women, 94% of time in high impact activity was spent participating in tennis and badminton (66%), step aerobics (16%), and competitive running and jogging (12%).

Mean time spent watching television or video was 21.9 (9.9) hours/week for men and 22.6 (10.0) hours/week for women. The median category for frequency

Characteristics of 2143 men and 2631 women with no history of osteoporosis or fracture, 1998-9. Values are mean (SD) unless stated otherwise

	Men	Women	P value*
Age (years)	64.6 (8.3)	62.9 (8.4)	<0.0001
Height (m)	1.74 (0.07)	1.61 (0.07)	<0.0001
Weight (kg)	81.2 (11.3)	69.1 (11.7)	<0.0001
No (%) ever smoked	1396/2123 (66)	1000/2604 (38)	<0.0001
No (%) stopped menstruating	—	1891/2552 (75)	—
No (%) ever used hormone replacement therapy	—	826/2584 (32)	—
Ultrasound attenuation (dB/MHz)	89.5 (17.5)	71.4 (16.5)	<0.0001
Speed of sound (m/s)	1645 (41)	1624 (41)	<0.0001

\*Test for heterogeneity between men and women by analysis of variance for means or  $\chi^2$  for proportions.

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#### Classification of recreational physical activity

##### No impact

Swimming (competitive or leisure)  
Fishing  
Snooker  
Playing musical instrument

##### Low impact

Racing or rough terrain cycling  
Cycling for pleasure  
Weeding, pruning  
Conditioning exercises  
Floor exercises  
Rowing  
Horse riding  
Sailing, wind surfing, boating

##### Moderate impact

Backpacking or mountain climbing  
Walking for pleasure  
Mowing lawn  
Watering lawn or garden in summer  
Digging, shovelling, or chopping wood  
Do it yourself  
Other types of aerobics  
Exercises with weights  
Dancing  
Bowling  
Table tennis  
Golf  
Cricket  
Ice skating  
Winter sports—for example, skiing  
Martial arts, boxing, wrestling

##### High impact

High impact aerobics, step aerobics  
Competitive running  
Jogging  
Tennis or badminton  
Squash  
Football, rugby, or hockey  
Netball, volleyball, basketball

of stair climbing was 1-5 flights a day for both men and women. More women than men reported climbing more than 10 flights a day (378 (14.4%) *v* 218 (10.2%).

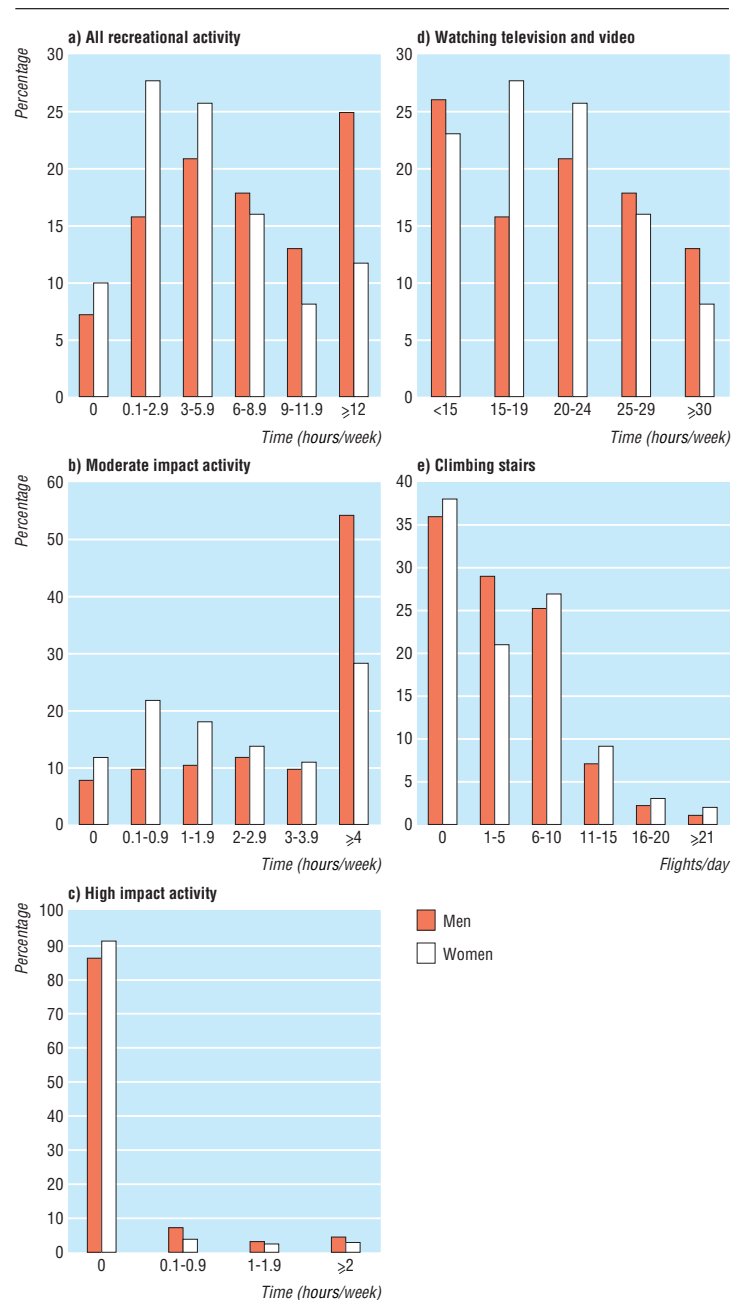
Men who reported participating in high impact activity reported climbing more stairs and watching less television or video than those who reported no such participation. However, there was no difference in time spent in other groups of recreational physical activity. In women, those who reported participation in high impact activities reported spending more time in total recreational activity, more time in moderate impact activities, climbing more stairs, and watching less television or video (data not shown).

After age, weight, height smoking, use of hormone replacement therapy, and menopausal status were adjusted for, only type of recreational activity positively associated with ultrasound attenuation was high impact. In men there was a significant linear relation between increasing hours of participation in high impact activity and ultrasound attenuation ( $\beta$  coefficient 2.97 dB/MHz/hour/week high impact activity,  $P < 0.001$ ). In women, however, there was no significant dose-response relation, and the association was confined to some participation versus none ( $\beta$  coefficient 2.36 dB/MHz,  $P = 0.02$ ). The association between high impact activity and ultrasound attenuation was unaffected by adjustment for climbing stairs and watching television or video. After people who participated in high impact activity were excluded, no association was found between time spent in moderate impact activity and ultrasound attenuation. Nor was there any association with time spent in total recreational, non-impact, or low impact activity (data available on *BMJ's* website).

In women, but not in men, we found a significant negative association between the amount of time spent watching television or video and ultrasound attenuation (fig 2). In women, a positive and significant association was also found between number of flights of stairs climbed and ultrasound attenuation (fig 3). The associations of ultrasound attenuation with stair climbing and television viewing were independent of each other and of participation in high impact activity.

## Discussion

Lower ultrasound attenuation by heel bone is associated with lower bone mineral density at the heel

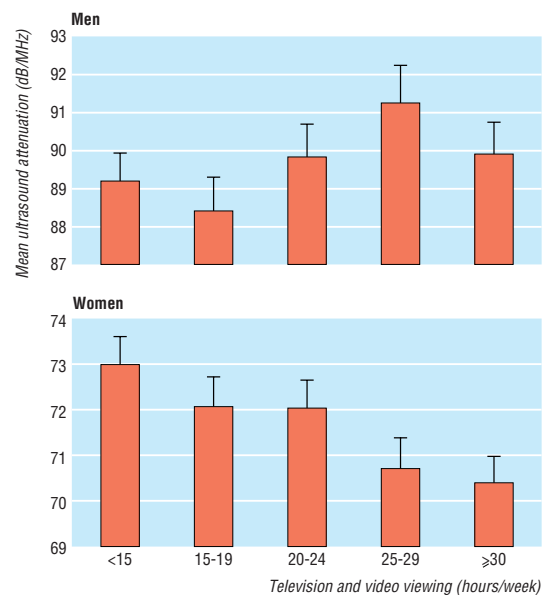


**Fig 1** Self reported physical activity among men and women aged 45-74 in EPIC Norfolk cohort

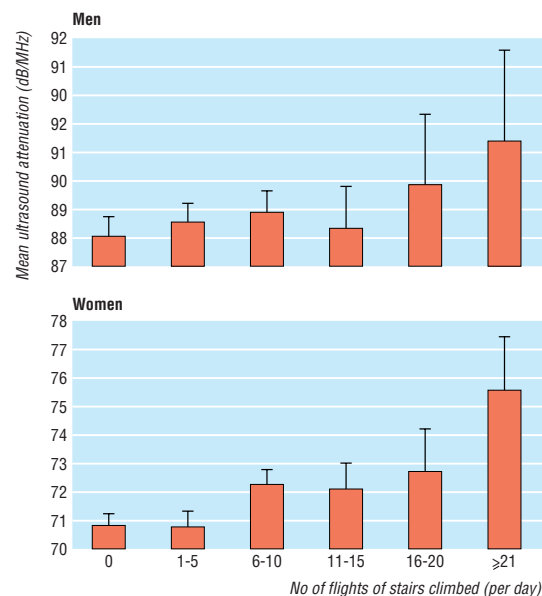
and at the hip.<sup>9,10</sup> Low ultrasound attenuation is an independent predictor of higher risk of hip fracture.<sup>8,11</sup> This cross sectional study supports the hypothesis that specific physical activities help maintain bone density and that physical inactivity, measured in this study by television viewing, has an adverse effect. The study design does not allow us to determine whether the relation between high impact physical activity and ultrasound attenuation reflects a higher peak bone density achieved in early adulthood or a slower rate of decline in later life. However, if our results are substantiated by prospective studies, they are likely to result in recommendations on the type of physical activity best able to slow the rate of bone loss in middle aged people. Prescribing high impact activities for older people

with established osteoporosis would probably do more harm than good.

The biological basis of the association we have observed is supported by animal studies showing that activities which create diverse and unusual loading have potent osteogenic potential.<sup>12-14</sup> Similar studies are difficult in human populations because of the problems of measuring loading at the site of interest. However, activities such as running and landing from a jump generate external loads on the body of 3-10



**Fig 2** Mean (SE) ultrasound attenuation according to hours of television and video viewing adjusted for age, weight, smoking history, and ultrasound machine for men and women plus menopausal status and hormone replacement therapy for women



**Fig 3** Mean (SE) ultrasound attenuation according to frequency of climbing stairs adjusted for age, weight, smoking history, and ultrasound machine for men and women plus menopausal status and hormone replacement therapy for women

### What is already known on this topic

Low ultrasound attenuation at the heel is associated with low bone mineral density at the heel and the hip and is associated with a higher risk of hip fracture

Physical activity is associated with bone density, but it is unclear which aspects of this complex multidimensional exposure are most important

### What this study adds

Participation in high impact recreational activity was independently associated with higher ultrasound attenuation at the heel

There was no association with moderate or low impact physical activity

Women who reported watching more television had lower ultrasound attenuation

times body weight,<sup>15</sup> and such external loads have been correlated with internal forces in the femur.<sup>16</sup>

### Implications

The association that we observed was large. In men, an additional hour per week doing high impact activity had the same effect on ultrasound attenuation as an extra 3 kg in body weight. For women the effect of regular participation in high impact activity was the same as the effect of a difference in age of four years. The association is important because it may reflect the future risk of fracture. In prospective studies, a 1 SD higher ultrasound attenuation by the heel bone was associated with a reduction in relative risk of future hip fracture of about a half.<sup>8</sup> In our study, the difference in ultrasound attenuation in men who participated in  $\geq 2$  hours per week of high impact activity compared with those who did none was 0.48 of 1 SD, which might be translated into a 33% reduction in risk of hip fracture. Among women, the difference between those who did and did not participate in high impact activity was 0.15 of 1 SD, which would translate to a relative risk reduction of 12%.

These results support the development of preventive physical activity interventions that have an element of airborne projection and impact. Such interventions are inappropriate in an elderly cohort because they require a level of activity that might be poorly tolerated and have detrimental health effects at a population level.<sup>17</sup> However, if these interventions were aimed at a population with an adequate degree of muscle strength and balance, such as younger women,<sup>18</sup> they could reduce the rate of bone loss.

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Contributors: K-TK, NED, and SB originated and designed the EPIC-Norfolk population study. K-TK and JR introduced ultrasound measurement of the heel bone. ND contributed to data collection and quality assurance for ultrasound measurements in collaboration with JR. NJW introduced the assessment of physical activity. SO is study coordinator and organised data collection and measurement procedures. AW contributed to

data collection. RL is responsible for data management and computing overall and assisted with analyses. RWJ conceived and conducted the data analysis with NJW. RWJ wrote the paper with NJW, who is the guarantor.

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### Endpiece

#### The best physician

And this is what the physician has to do, and in this the art of medicine consists: for medicine may be regarded generally as the knowledge of the loves and desires of the body, and how to satisfy them or not; and the best physician is he who is able to separate fair love from foul, or to convert one into the other; and he who knows how to eradicate and how to implant love, whichever is required, and can reconcile the most hostile elements in the constitution and make them loving friends, is a skilful practitioner.

Plato, 427-347 BC

Submitted by Ashley Liston, general practitioner, Newcastle upon Tyne