that reduce the need for a mouse—designed to aid arthritis sufferers—allowing the webpage to be controlled by the keyboard alone. High-visibility keyboards may also be useful for the visually impaired. A cheaper alternative is to purchase high-visiblilty stickers which can be attached to an existing standard keyboard (for examples of the BrowseAloud interface and magnifying application, see Figures 4–6 in Appendix 1 in the Supplementary data available in *Age and Ageing* online). In a recent survey conducted by the ONS in 2011, individuals were asked why they did not own an Internet connection within their home. The most common response by 50% said they did not need it, but 21% said a lack of skills prevented them from having it [4]. This is likely to be very prevalent in the older population. To encourage computer literacy, Age UK organises promotional weeks with events nationwide to help older people develop IT skills (http://www.ageuk.org.uk/work-and-learning/technology-and-internet/events/). They organise the delightfully titled 'itea and biscuits week' to help people learn about computers and modern technology and also 'myfriends online week' to help teach about the social side of the Internet. Although there are a number of books designed to teach older people basic computer skills, it seems a paradox that most IT courses are advertised online. This may be useful if friends or family can help but is of no use to someone starting off using a computer. Maybe GP practices and elderly care departments could offer these services.

In conclusion, although lower than other age groups, Internet use is common among the over-65's and this will only increase in the future. As a group they are interested in health information and we should ensure that we not only have suitable content for them but also ensure our websites are accessible and readable.

Key points

- In the UK there are 38.3 million Internet users representing 77% of the population.
- Websites offer an easy way of disseminating information both to other health-care professionals and patients.
- In our survey, the likelihood of never using the Internet increased with age from 5% for ages of 4–49 to 45% for ages of 80 and over.
- Seventy-two per cent of patients in the age range 60–69 and 55% of over-80 year olds do have the Internet at home.
- All departments should look at their web presence and consider someone as a web editor/web lead for that area.

Conflicts of interest

None declared.

Supplementary data

Supplementary data mentioned in the text is available to subscribers in *Age and Ageing* online.

References

1. Office for National Statistics. *Statistical Bulletin*. Internet Access 2010.
2. Internet Access 2010. *Statistical Bulletin from the Office for National Statistics* (http://www.statistics.gov.uk/pdfdir/iahi0810.pdf).
3. Garthwaite M, Bultitude MF. Urology NHS WebPages: a review of English NHS Trusts. BJMSU 2011; 4: 182–6.
4. Office for National Statistics. *Statistical Bulletin*. Internet Access 2011.

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Vitamin D and orthostatic hypotension

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Abstract

Introduction: we aimed to investigate on the potential relationship between vitamin D and orthostatic hypotension (OH) in a case–control model in older adults.
Methods: all participants were community-dwelling adults who were not taking vitamin D supplements. Cases were subjects aged 64 or older who were diagnosed with OH at a Falls and Blackout Unit. Controls were age- (within 5 years) and gender-matched subjects who had no history of blackouts, falls or orthostatic dizziness in the preceding year. OH was defined according to standard criteria and was diagnosed with an active stand test. Serum vitamin D [25(OH)D] was measured by radioimmunoassay.
Results: seventy-six subjects were included in the analysis (38 controls and 38 cases). Twenty-four in each group were female and mean age was between 78 and 79 years. Subjects with OH had lower serum 25(OH)D compared to controls (mean difference = 20.6 nmol/l, $P = 0.0002$). Lower vitamin D status was associated with an increased risk of OH after adjustment for season, body mass index, presence of stroke, diabetes and angina ($P = 0.035$) but not with impaired orthostatic haemodynamics.
Discussion: findings suggest that vitamin D may play a role in the aetiology of OH. Further studies will be required to explore on this relationship.

Keywords: *vitamin D, orthostatic hypotension, orthostatic haemodynamics, older people*

Orthostatic hypotension (OH) is common in the elderly and is associated with falls, fractures and significant morbidity and mortality [1]. Vitamin D supplementation has been shown to reduce risk of falls that may be mediated by it's effect on muscle strength and balance [2–4]. However, other potential mechanisms for this fall reduction are unclear. It is possible that vitamin D may also play a role in orthostatic hypotension, though evidence is lacking. Vitamin D has been implicated in both systolic and diastolic blood pressure, as well cardiovascular and cerebrovascular disease [5–9]. Vitamin D receptors are found in vascular smooth muscle, endothelial and cardiac cells suggesting that vitamin D could affect vasomotor and cardiac response during orthostasis [10].

We aimed to investigate the hypothesis that lower vitamin D status is associated with orthostatic hypotension in a case–control model involving community-dwelling older adults.

Methods

All participants were community-dwelling adults who were not taking vitamin D supplements. Cases were subjects aged 64 or older who were diagnosed with orthostatic hypotension at the Falls and Blackout Unit at St James's Hospital, Dublin and were consecutively recruited between January and February 2009. Those unwilling or unable to give consent or who had an illness in the past month were excluded.

Controls were age- (within 5 years) and gender-matched subjects who had no history of blackouts, falls or orthostatic dizziness in the preceding year and who were participants of the Dublin Healthy Ageing Study (DHAS), details of which have been previously described [11]. This is a community-based study examining physical, psychiatric, cognitive and social health care characteristics of non-demented older people. Subjects in the DHAS who met our criteria were randomly selected from this study database. Blood samples and clinical data from the DHAS were used for comparison with the OH group who attended the Falls and Blackout Unit.

Assessments

Orthostatic hypotension was diagnosed with the use of an active stand test and was defined according to the consensus criteria as a reduction in systolic or diastolic blood pressure of ≥20 and 10 mmHg respectively, within 3 min of assuming an erect posture [12].

The active stand test involves measuring haemodynamic variables while the patient moved from a horizontal to a standing position with or without assistance. Noninvasive continuous plethysmographic measurements of beat-to-beat blood pressure and heart rate were recorded with the use of a standardized device (Finometer®). This converts finger arterial pressures to brachial arterial pressures by a method of brachial reconstruction. Measurements were taken after lying supine for 5 min and then on standing up quickly and continuing to stand for 3 min. Blood pressure and heart rate were noted every 30 s from baseline until the manoeuvre was complete.

All subjects had their height (m) and weight (kg) measured and body mass index calculated by standard formula (weight/height^2). The Mini-Mental State Examination (MMSE) was administered as a screen of global cognitive function [13]. Non-fasting vitamin D blood samples were

drawn, centrifuged within two hours and stored at −20°C until later analysed at St James's Hospital Biochemistry laboratory. 25-Hydroxyvitamin D status was determined using a chemiluminescence assay performed on a liaison immunoassay analyser (Diasorin Inc., Stillwater. MN, USA).

All participants gave informed consent and ethical approval was granted by the Research Ethnics Committee of St James's Hospital.

Statistical analysis

All data were analysed with the statistical software program JMP© version 8.0 (SAS Institute Inc., Cary, NC, USA). Mean and standard deviation were used as descriptive statistics. Serum 25(OH)D was not normally distributed in the OH group and was logarithmically transformed. Differences in vitamin D status and baseline characteristics between both cohorts were analysed with the unpaired *t*-test, Mann–Whitney and Fisher's exact test. The relationship between vitamin D, OH and haemodynamic parameters on the active stand was explored in logistic and multiple linear regression models. Analysis for outliers was performed graphically and with the Cook's *D* test and any identified were excluded as appropriate. Statistical significance was accepted when $P < 0.05$.

Results

Seventy-six subjects were included in the analysis (38 controls and 38 cases). Twenty-four subjects in each group were females and had a mean age of between 78 and 79 years. Two subjects had Parkinson's disease, though their exclusion in an analysis did not change the study findings. Baseline characteristics were otherwise similar in both groups though participants with OH had a higher baseline systolic blood pressure (mean difference 9.9 mmHg, $P = 0.03$; Table 1).

In the combined group ($n = 76$), an inverse association was found between serum 25(OH)D and baseline diastolic blood pressure before and after adjustment for season and body mass index ($\beta = -0.13$, $P = 0.03$). While there was a trend for higher systolic blood pressure in those with lower 25(OH)D this was not statistically significant ($\beta = -0.18$, $P = 0.08$).

Subjects with orthosthatic hypotension (OH) who were age- and gender-matched had a significantly lower 25(OH)D than controls (mean difference = 20.6 nmol/l, $P = 0.0002$). In a logistic regression model incorporating 25(OH)D as a continuous variable, an increased risk of OH was found in those with lower levels after adjusting for season, body mass index, history of diabetes, stroke and ischaemic heart disease (β coefficient −0.03, $P = 0.035$).

However, lower 25(OH)D in those with OH was not associated with any drops in systolic or diastolic blood pressure, either before or after adjustment for covariates. In fact, those with a greater fall in systolic blood pressure had higher vitamin D status. In addition, no association was found between 25(OH)D and resting heart rate or changes in heart rate in the OH group (Table 2).

Table 1. Study group characteristics

Characteristics (mean ± SD)	Cases	Controls	*P* value
Age (years)	79.0 ± 6.8	78.2 ± 5.8	0.65[a]
Body mass index (kg m^{-2})	25.5 ± 4.0	25.1 ± 3.4	0.66[a]
Systolic blood pressure (mmHg)	154.6 ± 22.6	144.7 ± 19.3	0.03[a]
Diastolic blood pressure (mmHg)	77.1 ± 11.3	72.6 ± 10.6	0.07[a]
Diabetes (%)	2 (5.3)	6 (15.8)	0.26[b]
Stroke (%)	7 (18.4)	2 (5.3)	0.15[b]
Angina (%)	4 (10.5)	7 (18.4)	0.51[b]
MMSE	26.4 ± 2.9	27.2 ± 2.3	0.26[c]
25(OH)D (nmol^{-1})	40.5 ± 22.2	61.1 ± 23.1	0.0002[a]

[a]Unpaired *t*-test.
[b]Fisher's exact test.
[c]Mann–Whitney test.

Discussion

To our knowledge, this is the first study that has investigated on a relationship between serum 25(OH)D and orthostatic hypotension. The finding that vitamin D levels were lower in subjects with OH raises the possibility that it may play an aetiological role. There is a good biological plausibility underlying the potential affect of vitamin D on blood pressure control and intravascular volume, mechanisms by which it could contribute to OH. Vitamin D has been shown to down-regulate the renin–angiotensin aldosterone system in rodent models and this also appears to be up-regulated in human subjects who have vitamin D deficiency [14, 15]. In addition, it has also been associated with endothelial dysfunction and hence may have the potential to affect vasopressor response [16–18].

We also found a significant association between 25(OH)D and diastolic blood pressure which has been identified in other studies [5, 19]. While no association was found between lower vitamin D status and blood pressure drops or changes in heart rate, the study number was small and

Table 2. Relationship between serum 25(OH)D (log-transformed) and haemodynamic parameters in the OH group ($n = 38$)*

	β-Coefficient	*P* value
ΔSBP (mmHg)	36.26	0.03
ΔDBP (mmHg)	17.17	0.10
ΔHR	−4.97	0.47

ΔSBP, systolic blood pressure change; ΔDBP, diastolic blood pressure change; ΔHR, heart rate change.
*Model adjusted for age, gender, season and body mass index.

so wider conclusions on this cannot be drawn. However, 25 (OH)D has been inversely associated with resting heart rates in a large study of community dwelling US adults, raising the possibility that it may have an affect on autonomic function [20].

Orthostatic haemodynamics appears to be impaired in frailty in older adults and frailty is also associated with lower vitamin D levels [21, 22]. It is possible that frailty and antihypertensive use, which were not adjusted for, may have changed the study findings.

Given that vitamin D deficiency is prevalent in the older population [10] and supplementation is inexpensive, it may provide a practical alternative strategy for treating other non-skeletal conditions like OH. Further larger observational studies and randomised controlled trials will be required to explore on this relationship.

Key points

- Vitamin D levels were significantly lower in patients with OH.
- Lower vitamin D status was not associated with impaired orthostatic haemodynamics.
- Further studies are needed to explore this relationship.

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References

1. Gupta V, Lipsitz LA. Orthostatic hypotension in the elderly: diagnosis and treatment. Am J Med 2007; 120: 841–47.
2. Bischoff-Ferran H, Dawson-Hughes B, Staehelin HB *et al*. Fall prevention with supplemental and active forms of vitamin D: a meta-analysis of randomised controlled trials. B Med J 2009; 339: b3692.
3. Kalyani RR, Stein BB, Valiyil R, Manno R, Maynard JW, Crews DC. Vitamin D treatment for the prevention of falls in older adults: systematic review and meta-analysis. J Am Geriatr Soc 2010; 58: 1299–310.
4. Muir SW, Montero-Odasso M. Effect of vitamin D supplementation on muscle strength, gait and balance in older adults: a systematic review and meta-analysis. J Am Geriatr Soc 2011; 59: 2291–300.
5. Pilz S, Tomaschitz A, Ritz E, Pieber TR. Vitamin D status and arterial hypertension: a systematic review. Nature Rev Cardiol 2009; 6: 621–30.
6. Wang TJ, Pencina MJ, Booth SL *et al*. Vitamin D deficiency and risk of cardiovascular disease. Circulation 2008; 117: 503–11.
7. Buell JS, Dawson Hughes B, Scott ML *et al*. 25-Hydroxyvitamin D, dementia and cerebrovascular pathology in elders receiving home services. Neurology 2010; 74: 18–26.
8. Wu SH, Ho SC, Zhong L. Effects of vitamin D supplementation on blood pressure. South Med J 2010; 103: 729–37.
9. Witham MD, Nadir MA, Struthers AD. Effect of vitamin D on blood pressure: a systematic review and meta-analysis. J Hypertens 2009; 27: 1948–954.
10. Holick MF. Vitamin D deficiency. N Engl J Med 2007; 357: 266–81.
11. Chin AV, Robinson DJ, O'Connell H *et al*. Vascular biomarkers of cognitive performance in acommunity-based elderly population: the Dublin Healthy Ageing Study. Age Ageing 2008; 37: 559–64.
12. The Consensus Committee of the American Autonomic Society and the American Academy of Neurology. Consensus statement on the definition of orthostatic hypotension, pure autonomic failure, and multiple system atrophy. Neurology 1996; 46: 1470.
13. Folstein FM, Folstein SE, McHugh PR. Mini Mental State: a practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975; 12: 189–98.
14. Li YC, Kong J, Wei M *et al*. 1,25-Dihydroxyvitamin D3 is a negative endocrine regulator of the renin – angiotensin system. J Clin Invest 2002; 110: 229–38.
15. Forman JP, Williams JS, Fisher ND *et al*. Plasma 25-hydroxyvitamin D and regulation of the renin-angiotensin system in humans. Hypertension 2010; 55: 1283–8.
16. Witham MD, Dove FJ, Sugden JA, Doney AS, Struthers AD. The effect of vitamin D replacement on markers of vascular health in stroke patients—a randomized controlled trial. Nutr Metab Cardiovasc Dis 2010; [Epub ahead of print] Published online 03 Jan 2011.
17. Harris RA, Pederson-White J, Guo DH *et al*. Vitamin D(3) supplementation for 16 weeks improves flow-mediated dilation in overweight African-American adults. J Hypertension 2011; 24: 557–62.
18. Sugden JA, Davies JI, Witham MD *et al*. Vitamin D improves endothelial function in patients with Type 2 diabetes mellitus and low vitamin D levels. Diabet Med 2008; 25: 320–25.
19. Almirall J, Vaquerlo M, Bare ML, Anton E. Association of low serum 25-hydroxyvitamin D levels and high arterial blood pressure in the elderly. Nephrol Dial Transplant 2010; 25: 503–9.
20. Scragg RK, Camargo CA Jr, Simpson RU. Relation of serum 25-hydroxyvitamin D to heart rate and cardiac work (from the National Health and Nutrition Examination Surveys). Am J Cardiol 2010; 105: 122–82.
21. Romero Ortuno R, Cogan L, O'Shea D, Lawlor BA, Kenny RA. Orthostatic haemodynamics may be impaired in frailty. Age Ageing 2011; 40: 576–83.
22. Wilhelm-Leen ER, Hall YN, Deboer IH, Chertow GM. Vitamin D deficiency and frailty in older Americans. J Intern Med 2010; 268: 171–80.

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