Age and Ageing 2010; **39:** 699–704
doi: 10.1093/ageing/afq101
Published electronically 4 September 2010

Effects of height loss on morbidity and mortality in 3145 community-dwelling Chinese older women and men: a 5-year prospective study

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Abstract

Background: height loss beginning in mid-life and post-menopausal period was associated with adverse health outcomes. However, height loss occurring after old age has been little studied. We examined how height loss was related to bone mineral density (BMD) change, fracture incidence and cause-specific mortality in older adults.
Methods: the stature and BMD of 3145 community-dwelling men and women aged ≥65 were measured at baseline and after 4 years. All fracture and cause-specific mortality events were searched in a territory-wide clinical information database and death registry.
Results: twenty-five (1.6%) men and 64 (4.0%) women lost >2 cm after 4 years. In women, the BMD decline was faster in the rapid height losers (adjusted difference = 4.18%, $P < 0.001$). There was no corresponding difference observed in men. Rapid height loss was associated with excess all fractures and hip fractures (adjusted HR for all fractures = 2.86, $P < 0.001$; adjusted HR for hip fractures = 4.74, $P < 0.01$) in women but only hip fractures (adjusted HR = 4.93, $P < 0.05$) in men. The all-cause (adjusted HR = 3.43, $P < 0.01$) and respiratory disease mortality (adjusted HR = 5.64, $P < 0.05$) were higher in men with rapid height loss, whereas those in women were insignificant.
Conclusions: modest height loss occurring after old age, >2 cm in 4 years, was associated with excess hip fracture, total and respiratory disease mortality in older men. In women, it was associated with excess BMD decline, all fractures and hip fractures but not mortality. Further research is needed to determine the usefulness of regular stature measurement as an indicator of bone health in the primary-care setting in older adults.

Keywords: *height loss, mortality, fractures, osteoporosis, elderly*

Introduction

Height loss occurs with ageing [1] which is related to inter-vertebral disc shrinkage [2], senile postural change [2] and vertebral compression fractures [3–6]. Furthermore, past studies reported that age-related stature decline was associated with bone loss [5, 7–9], fragility fractures [3–5, 7, 10] and other adverse health outcomes including poor quality of life [5, 6], the incidence of cardiovascular diseases [11] and even total mortality [11].

Previous studies recruited subjects in mid-life alone [8, 11] or from mid-life to late life [3–7, 9, 12]. It is unclear whether the measurement of stature decline entirely in old age only may be able to detect such similar associations. This may be possible as height decline accelerates in old age, which contributes to the major portion of height loss [1]. We therefore postulated that starting to measure height serially in old age would not be too late to observe the relationship between stature decline and adverse health outcomes.

Not all the previous reports included both men and women [5, 7, 10, 12], and some examined only post-menopausal women [3, 4, 8], whereas one studied only men [11]. Two isolated reports [5, 7] included both bone loss and fragility fractures as adverse outcomes, whereas others reported either the bone mineral density (BMD) changes

[8, 9, 12] or the occurrence of fractures alone [3, 4, 10], using either measured [4, 5, 7, 8] or recalled height loss [3, 9, 10, 12]. To the best of our knowledge, only one single study in men observed mortality and the incidence of cardiovascular disease [11]. However, in this study, no BMD changes or the occurrence of fractures was reported.

In the present study, we therefore attempted to examine how the magnitude of prospectively measured height loss occurring within old age might be related to the concurrent change in BMD, and the adverse clinical outcomes of fragility fracture, all-cause and disease-specific mortality, in a large cohort of older men and women.

Methods

Four thousand community-dwelling men and women aged 65 or over were invited to attend a health check carried out in the School of Public Health of The Chinese University of Hong Kong between August 2001 and December 2003 by placing recruitment notices in community centres for the elderly and housing estates. This project was designed primarily to examine the BMD of older Chinese adults prospectively for 4 years. Written informed consents were obtained. Only ethnic Chinese subjects were recruited. We excluded those who (i) were unable to walk without assistance of another person; (ii) had had a bilateral hip replacement because that would have affected the BMD measurement; (iii) were not competent to give informed consent; (iv) had medical conditions which, in the judgement of the study physicians made it unlikely that they would survive the duration of the primary study. The subjects were recruited in three age strata so that approximately 33% were in each of the stratum: 65–69 years, 70–74 years and 75 years and over. The study was approved by the Clinical Research Ethics Committee of The Chinese University of Hong Kong.

A questionnaire containing information regarding demographics, smoking habit, alcohol intake, physical activity score for the elderly (PASE) [13] and medical history was administered by trained interviewers. The presence or absence of the disease was based on the subjects' report of their physician's diagnoses, supplemented by the identification of drugs brought to the interviewers.

The stature measurements were undertaken by four trained research staff, who were graduates in biomedical sciences. The subjects attended our research centre in the morning from 9 to 11 a.m. They were asked to stand upright without shoes and look straight ahead and their standing heights were measured by the Holtain Harpenden Stadiometer (Holtain Ltd, Crosswell, UK). The measurements were conducted at the first visit and 4 years later. Body weight was measured, with the subjects wearing a light gown, by the Physician Balance Beam Scale (Healthometer, IL, USA). The inter-observer reliability of stature measurement has been tested on 2 observers and 15 subjects. The intra-class correlation coefficients was 1.0, 95% CI (1.0, 1.0).

We measured BMD at the total hip by dual-energy x-ray absorptiometry (DXA), using a Hologic QDR 2000 densitometer (Hologic, Waltham, WA, USA; Hologic Delphi, software version 11.2). The coefficient of variation (*in vivo*) was 0.9% at the total hip. Calibration with a Hologic body composition step phantom was performed at least three times per week. All subjects underwent the same stature and BMD measurements at baseline and 4 years afterwards. The last fourth year assessment was undertaken on 30 November 2007.

All fragility fractures and hip fractures were searched annually by the Hong Kong Hospital Authority Clinical Management System, a territory-wide central clinical information database that recorded all clinic attendance and hospital episodes. Mortality status was ascertained annually by registration search in the Death Registry of the Hong Kong Government on 31 March each year. The last search was undertaken on 31 March 2008. The causes of death were defined according to the International Classification of Diseases (ICD 10) coding in the death certificates.

Statistical Methods

For analysis purpose, past studies have employed cut-off values of height loss ranged from 2 to 7.5 cm [3, 4, 6–9, 11, 12] depending on whether it was measured [4, 7, 8] or recalled maximal height loss [3, 9, 12] and on the interval in between the measurements. We followed the International Society of Clinical Densitometry recommended cut-off value of >2 cm loss of measured height to define rapid height loss in the present study [14]. The change of total hip BMD, the incidence of all fragility fractures and hip fractures, the total, cardiovascular and respiratory disease mortality between the two groups were compared by unpaired *t*-test and Cox regression whichever appropriate. Further adjustment for possible confounders, which we have identified in this cohort [15], including age, weight, smoking habit, alcohol intake, physical activity score, grip strength, calcium intake, chronic obstructive airway disease, gastrectomy, thyroid disease, diabetes mellitus, fracture after age 50, treatment with angiotensin-conversion enzyme inhibitors (ACEIs), inhaled steroid and anti-osteoporosis drugs, was carried out by multivariate analysis. All tests were two-sided and $P < 0.05$ were taken as statistically significant. All analyses were undertaken using SPSS version 10.0.1 (SPSS Inc., 1999)

Results

A total of 2000 men and 2000 women were recruited and assessed at baseline. The mean age of the cohort was 72.5 $\pm$ 5.2 (standard deviation) years (in men, 72.3 $\pm$ 5.0 years; in women, 72.5 $\pm$ 5.3 years) and the participants were followed up beyond the fourth-year assessment for fragility fractures and mortality outcomes. The median follow-up period was 5.33 years.

One hundred and thirty-seven (6.8%) men and 58 (2.9%) women died in between this 4-year period and therefore no prospective height loss measurement was possible. Excluding the defaulters due to mortality, 301 (15.0%) men and 359 (17.7%) women did not attend the fourth-year assessment. Out of the participants who survived at the fourth year and attended the fourth-year assessment, 25 (1.6%) men and 64 (4.0%) women lost >2 cm in height in the previous 4 years. The baseline characteristics at the first visit of these male and female participants (Table 1) and the rapid and slow height losers (Table 2) were tabulated. Since the two genders differed significantly in various baseline characteristics that were possibly related to adverse health outcome (Table 1), all subsequent analyses were undertaken separately for men and women. In comparing the rapid to the slow height losers (Table 2), in men, the rapid height losers were older and had weaker grip strength, whereas in women, the rapid height losers were older, shorter, had lower BMD and less active in daily activity at baseline (Table 2). Sixty-eight fracture events occurred in men and 132 fracture events occurred in women from the time of first assessment and 93 men and 21 women died after the fourth-year assessment.

In women, after 4 years, the percentage BMD loss was faster in the rapid height losers than the slow height losers (adjusted difference = 4.18%, $P < 0.001$). However, there was no corresponding BMD decline difference observed in men (Table 3).

In men with rapid height loss, there was excess risk of hip fractures before and after adjustment (crude HR = 10.03, $P < 0.01$ and adjusted HR = 4.93, $P < 0.05$) (Table 3). In women, the excess risk of all fractures and hip fractures also existed before (crude HR for all fractures = 3.43, $P < 0.001$; crude HR for hip fractures = 6.88, $P < 0.001$, Table 3) and persisted after adjustment (adjusted HR for all fractures = 2.86, $P < 0.001$; adjusted HR for hip fractures = 4.74, $P < 0.01$, Table 4).

The all-cause mortality was higher in men with rapid height loss (crude HR = 4.57, $P < 0.001$ and adjusted HR = 3.43, $P < 0.01$, Table 4). Respiratory disease mortality was significantly higher in the rapid height losers before and after adjustment (crude HR = 7.27, $P < 0.01$; adjusted HR = 5.64, $P < 0.05$, Table 4). In women, no equivalent association between mortality and height loss was observed (Table 4).

Table 1. Comparison of baseline characteristics between male and female

	Mean (SD)/freq (%)		*P*-value
	Male	Female	
	$N = 1562$	$N = 1583$	
Age (year)	71.77 (4.67)	72.02 (5.06)	0.1471
Height (cm)	163.25 (5.68)	151.08 (5.25)	<0.0001*
Weight (kg)	62.71 (9.16)	54.72 (8.35)	<0.0001*
Grip strength (kg)	31.89 (6.22)	20.51 (4.17)	<0.0001*
PASE	100.67 (50.69)	87.01 (33.33)	<0.0001*
Baseline hip BMD (g/cm^2)	0.87 (0.12)	0.72 (0.11)	<0.0001*
Current smoker	169 (10.8%)	26 (1.6%)	<0.0001*
Alcohol use	380 (24.3%)	43 (2.7%)	<0.0001*
COPD	157 (10.1%)	75 (4.7%)	<0.0001*
Gastrectomy	152 (9.7%)	98 (6.2%)	0.0002*
Thyroid disease	31 (2.0%)	102 (6.4%)	<0.0001*
Diabetes	221 (14.2%)	218 (13.8%)	0.7602
Fracture after 50 years	97 (6.2%)	268 (16.9%)	<0.0001*
Taking ACEI	213 (13.6%)	125 (7.9%)	<0.0001*
Taking inhaled corticosteroid	10 (0.6%)	10 (0.6%)	0.9761
Taking osteoporosis drugs	3 (0.2%)	26 (1.6%)	<0.0001*
Cancer history	63 (4.0%)	67 (4.2%)	0.7791

*$P < 0.05$.

Table 2. Comparison of baseline characteristics between slow and rapid height losers

	Mean (SD)/freq (%)		*P*-value
	Slow height losers	Rapid height losers	
Male	$n = 1529$	$n = 25$	
Age (year)	71.70 (4.64)	75.56 (5.23)	<0.0001*
Height (cm)	163.23 (5.69)	164.05 (5.26)	0.4749
Weight (kg)	62.73 (9.11)	61.76 (11.93)	0.5977
Grip strength (kg)	31.94 (6.20)	29.16 (7.02)	0.0265*
PASE	100.76 (50.65)	98.85 (59.39)	0.8523
Baseline hip BMD (g/cm^2)	0.87 (0.12)	0.83 (0.16)	0.0917
Current smoker	163 (10.7%)	5 (20.0%)	0.1358
Alcohol use	370 (24.2%)	7 (28.0%)	0.6601
COPD	154 (10.1%)	3 (12.0%)	0.7510
Gastrectomy	148 (9.7%)	3 (12.0%)	0.6976
Thyroid disease	31 (2.0%)	0 (0.0%)	0.4720
Diabetes	219 (14.3%)	2 (8.0%)	0.3693
Fracture after 50 years	92 (6.0%)	3 (12.0%)	0.2155
Taking ACEI	209 (13.7%)	3 (12.0%)	0.8094
Taking inhaled corticosteroid	10 (0.7%)	0 (0.0%)	0.6850
Taking osteoporosis drugs	3 (0.2%)	0 (0.0%)	0.8246
Female	$n = 1519$	$n = 64$	
Age (year)	71.84 (4.93)	75.98 (6.47)	<0.0001*
Height (cm)	151.16 (5.25)	149.15 (4.91)	0.0033*
Weight (kg)	54.81 (8.40)	52.87 (6.87)	0.0745
Grip strength (kg)	20.57 (4.17)	19.21 (3.69)	0.0124*
PASE	87.86 (33.47)	71.75 (24.50)	0.0002*
Baseline Hip BMD (g/cm^2)	0.72 (0.11)	0.66 (0.11)	0.0002*
Current smoker	23 (1.5%)	2 (3.3%)	0.2867
Alcohol use	42 (2.8%)	1 (1.6%)	0.5872
COPD	71 (4.7%)	1 (1.6%)	0.2591
Gastrectomy	94 (6.3%)	4 (6.6%)	0.9258
Thyroid disease	97 (6.5%)	4 (6.6%)	0.9764
Diabetes	209 (13.9%)	9 (14.8%)	0.8545
Fracture after 50 years	246 (16.4%)	15 (24.6%)	0.0924
Taking ACEI	115 (7.7%)	8 (13.1%)	0.1211
Taking inhaled corticosteroid	10 (0.7%)	0 (0.0%)	0.5225
Taking osteoporosis drugs	25 (1.7%)	0 (0.0%)	0.3096

*$P < 0.05$.

Discussion

In older women, we observed a more rapid BMD loss and excess risk of all fractures and hip fractures in those losing height more than 2 cm in 4 years. This illustrated that height loss could serve as a surrogate marker of the underlying osteoporosis process and the associated fracture risk.

Table 3. Hip BMD percentage change in 4 years and comparison between slow and rapid height losers

% change of BMD (SE)		Crude difference	Adjusted difference
Slow losers	Rapid losers	(95% CI)	(95% CI)
Men			
0.91 (0.09)	1.35 (0.67)	0.44 (−0.88, 1.77)	−0.13 (−1.43, 1.17)
Women			
2.27 (0.12)	7.11 (0.59)	4.85 (3.67, 6.03)‡	4.18 (3.00, 5.35)‡

‡$P < 0.001$.

SE, standard error; CI, confidence interval; % change BMD = (baseline BMD − 4-year follow-up BMD)/baseline BMD × 100%; adjusted difference, adjusted for age, weight, smoking, alcohol, grip strength, PASE, COPD, gastrectomy, thyroid disease, diabetes, fracture after 50 years, on ACE, inhaled corticosteroid and osteoporosis medications.

Table 4. All fractures, hip fractures and mortality in rapid and slow height losers

	Number of events (%)	Crude HR (95%CI)	Adjusted HR (95%CI)
Men			
All fractures			
Slow losers	68 (4.4%)	1.0	1.0
Rapid losers	3 (12.0%)	2.86 (0.90, 9.08)	1.82 (0.56, 5.98)
Hip fractures			
Slow losers	13 (0.9%)	1.0	1.0
Rapid losers	2 (8.0%)	10.03 (2.26, 44.43)†	4.93 (1.05, 23.30)*
All-cause mortality			
Slow losers	87 (5.7%)	1.0	1.0
Rapid losers	6 (24.0%)	4.57 (2.00, 10.47)‡	3.43 (1.47, 8.00)†
Cardiovascular disease mortality			
Slow losers	29 (2.0%)	1.0	1.0
Rapid losers	0 (0.0%)	—	—
Respiratory disease mortality			
Slow losers	18 (1.2%)	1.0	1.0
Rapid losers	2 (9.5%)	7.27 (1.68, 31.53)†	5.64 (1.21, 26.33)*
Women			
All fractures			
Slow losers	120 (7.9%)	1.0	1.0
Rapid losers	16 (25.0%)	3.43 (2.04, 5.78)‡	2.86 (1.65, 4.96)‡
Hip fractures			
Slow losers	19 (1.3%)	1.0	1.0
Rapid losers	5 (7.8%)	6.88 (2.56, 18.47)‡	4.74 (1.61, 13.95)†
All-cause mortality			
Slow losers	19 (1.3%)	1.0	1.0
Rapid losers	2 (3.1%)	2.82 (0.66, 12.12)	1.52 (0.32, 7.33)
Cardiovascular disease mortality			
Slow losers	4 (0.3%)	1.0	1.0
Rapid losers	1 (1.6%)	6.93 (0.77, 62.43)	4.67 (0.37, 59.73)
Respiratory disease mortality			
Slow losers	3 (0.2%)	1.0	1.0
Rapid losers	0 (0.0%)	—	—

HR, hazard ratio, CI, confidence interval; adjusted HR, adjusted for age, weight, smoking, alcohol, grip strength, PASE, COPD, gastrectomy, thyroid disease, diabetes, fracture after 50 years, on ACE, inhaled corticosteroid and osteoporosis medications.

*$P < 0.05$.

†$P < 0.01$.

‡$P < 0.001$.

In older men, although an excess risk of hip fracture was observed, stature decline was not related to excess BMD decline in contrary to what has been observed in older women. This observation suggests that osteoporosis may not be the most important risk factor of fracture in older men. The stature decline in older men could have resulted from other causes such as senile kyphosis, other than subclinical osteoporotic vertebral compression fractures [16]. In addition, hyperkyphotic posture has been identified as an independent risk factor for injurious falls in older men, with the association being less pronounced in women [17]. That hyperkyphotic older men being more prone to injurious falls may explain the excess risk of hip fractures in the absence of any concurrent acceleration of BMD decline. Alternatively, the small number of men having height loss (1.6%) may explain the absence of association between height loss and BMD decline in men. The current study may not have sufficient power to examine the association between height loss and BMD decline in older men.

Similar to the work of Wannamethee *et al.* [11], which demonstrated the association between height loss, total mortality and increased incidence of coronary heart disease, we have also observed a higher total mortality in the rapid height losers in older men. However, the major associated cause of mortality in our cohort was respiratory rather than cardiovascular diseases. Chronic obstructive pulmonary disease (COPD) was common (10.1%) in the male participants. At baseline, the prevalence of COPD and inhaled corticosteroid therapy did not differ significantly between the rapid and slow height losers. Despite this observation, respiratory disease mortality has been adjusted for these two potential confounding variables, and height loss was observed to be associated with respiratory disease mortality independent of COPD and inhaled corticosteroid therapy. Kyphosis in old age has been demonstrated to be associated with ventilatory dysfunction [18–20]. Whether this may singly account for the excess respiratory disease mortality in the presence of other co-existing chronic lung diseases remains to be elucidated.

The mortality events in women were fewer than those in men (21 women died versus 93 men died), probably because of the difference in co-morbidities and life-style factors. There were fewer female smokers, drinkers and fewer women suffering from COPD and taking ACEI (Table 1). The mortality rate observed in women might be too low to demonstrate the association between height loss and mortality. This may explain why we did not observe an equivalent association between mortality and height loss similar to that in men.

The default rate of our cohort was not low, 15.0% in men and 17.7% in women, which probably resulted from their poorer health. *Post hoc* analysis (results not shown) demonstrated that the defaulters were older, weaker in grip strength and less active in daily activities at baseline and that these characteristics were also similar to the rapid height losers. Since they defaulted the fourth-year assessment, we could not classify whether they were rapid height

losers or not. If they had attended the fourth-year assessment, they might have been classified as such and the prevalence of rapid height losers might have been higher than that observed. Nevertheless, a very modest decline in stature, 2 cm in 4 years, in older adults was already associated with significant adverse health outcomes: excess mortality and hip fractures in older men and excess bone loss and all fractures and hip fractures in older women.

A considerable proportion of mortality events (6.9% in men and 2.8% in women) had occurred before the fourth-year assessment. It was possible that mortality might have started to increase earlier with lesser extent of height loss than we had defined (more than 2 cm in 4 years). Future studies are warranted to explore the earlier adverse events associated with smaller magnitude of height loss.

The defaulters and the mortalities occurred before the fourth-year assessment had reduced the final number of participants considerably. The absence of association between height loss and BMD decline in men and that of height loss and mortality in women might have resulted from an inadequate sample size. In addition, the small number of height losers and outcome events together with multiple statistical testing could give rise to aberrant results, which have to be interpreted and considered with cautions.

The majority of the height losers were older than 70 years of age and most of the events also occurred in this age group. Perhaps our survey had been biased towards this age range and our results should be more applicable to this older old group.

We have attempted to incorporate recalled height loss as an alternative case definition for rapid height loss. Unfortunately, a considerable proportion of our participants, because of cognitive impairment, could not recall their maximal height at the age of 25 years [21]. As such, we have not analysed our data using recalled height loss.

Conclusion

Modest height loss occurring after old age, greater than 2 cm in 4 years, was associated with excess risk of hip fracture, total and respiratory disease mortality in older men. In women, it was associated with excess BMD decline, risk of all fractures and hip fractures but not mortality. Serial measurement of stature in older adults is feasible to record this accelerated phase of height loss and further research is needed to determine the usefulness of regular stature measurement as an indicator of bone health in the primary-care setting in older adults.

Key points

- Modest height loss occurring after old age, >2 cm in 4 years, was associated with excess hip fractures, total and respiratory disease mortality in older men.
- In older women, it was associated with concurrent acceleration of BMD decline, all fractures, hip fractures but not mortality.
- Further research is needed to determine the usefulness of regular stature measurement as an indicator of bone health in the primary-care setting in older adults.

Funding

This study was supported by Hong Kong Research Council Grant and National Institute of Health Grant (5R01 R049439-02).

Conflicts of interest

All the authors have no other conflicts of interest to disclose.

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Received 10 December 2009; accepted in revised form 14 May 2010

Age and Ageing 2010; **39:** 704–710
doi: 10.1093/ageing/afq096
Published electronically 7 September 2010

A multicentre randomised controlled trial of day hospital-based falls prevention programme for a screened population of community-dwelling older people at high risk of falls

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Abstract

Objective: to determine the clinical effectiveness of a day hospital-delivered multifactorial falls prevention programme, for community-dwelling older people at high risk of future falls identified through a screening process.
Design: multicentre randomised controlled trial.
Setting: eight general practices and three day hospitals based in the East Midlands, UK.
Participants: three hundred and sixty-four participants, mean age 79 years, with a median of three falls risk factors per person at baseline.
Interventions: a day hospital-delivered multifactorial falls prevention programme, consisting of strength and balance training, a medical review and a home hazards assessment.