Observational Study

Medicine® OPEN

Gender differences in the relationship between socioeconomic status and height loss among the elderly in South Korea

Korean National Health and Nutrition Examination Survey 2008–2010

Yang-Hyun Kim, MD, PhD[a], Kyung-Sik Ahn, MD, PhD[b], Kyung-Hwan Cho, MD, PhD[a,*], Chang Ho Kang, MD, PhD[b], Sung Bum Cho, MD, PhD[b], Kyungdo Han, PhD[c], Yong-Kyun Rho, MD, PhD[d], Yong-Gyu Park, PhD[c]

Abstract

This study aimed to examine average height loss and the relationship between height loss and socioeconomic status (SES) among the elderly in South Korea.

Data were obtained from the Korean National Health and Nutrition Examination Survey 2008–2010. A total of 5265 subjects (2818 men and 2447 women) were included. Height loss was calculated as the difference between the subject's self-reported maximum adult height and their measured current height. The height loss values were divided into quartiles (Q1–Q4) for men and women. SES was determined using a self-reported questionnaire for education level, family income, and occupation.

Height loss was associated with SES in all age groups, and mean height loss increased with age. In the relationship between education level and maximum height loss (Q4), men with ≤6, 7–9, or 10–12 years of education had higher odds ratios for the prevalence of height loss (Q4) than men with the highest education level (≥13 years). With regard to the relationship between the income level and height loss (Q4), the subjects with the lowest income had an increased prevalence of maximum height loss (Q4) than the subjects with the highest income (odds ratios = 2.03 in men and 1.94 in women). Maximum height loss (Q4) was more prevalent in men and women with a low SES and less prevalent in men with a high SES than in men with a middle SES.

Height loss (Q4) was associated with education level in men and with income level (especially low income) in men and women. Height loss was also associated with a low SES in men and women.

Abbreviations: BMI = body mass index, BP = blood pressure, CI = confidence interval, HDL-C = high-density lipoprotein cholesterol, KNHANES = Korean National Health and Nutrition Examination Survey, OR = odds ratio, SES = socioeconomic status, WC = waist circumference.

Keywords: elderly, gender, height loss, Korean National Health and Nutrition Examination Survey, socioeconomic status

1. Introduction

Height is an indicator of population health[1] and is representative of childhood health and nutritional status, despite the related genetic component after the adolescent growth spurt.[2,3] Adult height decreases as part of the aging process. The exact mechanisms of this height loss have not been fully elucidated; nonetheless, the phenomenon is associated with several biological and pathophysiological changes, including increased fat mass, decreased fat-free mass, and reduced bone mineral density.[4] Furthermore, degenerative changes in the intervertebral discs, vertebral deformity or fracture, and senile kyphosis can cause height loss.[5–7] In some studies, height loss has also been associated with clinical issues such as decreased cognitive function and self-reported health status, depression, and illness.[8–11] Indeed, 1 cohort study found that an annual height loss of >1 cm per year increased the risk of bone fracture;[12] another found that a height loss of >3 cm over 20 years increased both mortality and the incidence of coronary heart disease.[13] In addition to these medical issues, several investigations have found an effect of childhood socioeconomic status (SES) on adult health status, as it relates to height.[14–18]

In general, the prevalence and mortality of chronic diseases are negatively associated with SES,[19–24] and several Chinese studies found that height loss was negatively associated with SES in both adulthood[25] and childhood.[26] However, this relationship has not been investigated in the South Korean population. Therefore, we examined the average height loss and relationship between height loss and SES among the elderly in South Korea using representative sample data from the Korean National Health and Nutrition Examination Survey (KNHANES).

Editor: Luis Mauricio Pinet Peralta.

YH-K and KS-A equally contributed to this study.

The authors have no funding and conflicts of interest to disclose.

[a] Department of Family Medicine, [b] Department of Radiology, Korea University College of Medicine, [c] Department of Biostatistics, Catholic University College of Medicine, Seoul, [d] Department of Family Medicine, Hallym University College of Medicine, Chunchon, Republic of Korea.

[*] Correspondence: Kyung-Hwan Cho, Department of Family Medicine, Korea University Anam Hospital, Korea University College of Medicine, Seongbuk-gu, Seoul, Republic of Korea (e-mail: vornfree@gmail.com).

Medicine (2017) 96:34(e7131)

Received: 20 February 2016 / Received in final form: 10 December 2016 / Accepted: 18 May 2017

http://dx.doi.org/10.1097/MD.0000000000007131

2. Methods

2.1. Survey overview

The KNHANES has been conducted by the Division of Chronic Disease Surveillance at the Korean Center for Disease Control and Prevention since 1998. It surveys the health and nutrition of the population at a national level and is divided into 3 parts: a health interview, physical examination, and nutritional survey.[27] We used data from the KNHANES conducted between 2008 and 2010. A representative sample of noninstitutionalized civilians was obtained from all geographic regions in the country; subjects were selected using a cluster sampling design, stratified into multiple stages, and prorated by age as stated in the 2005 National Census Registry. Trained interviewers performed face-to-face interviews.

2.2. Subjects

In total, 29,235 subjects participated in the 2008–2010 KNHANES. We enrolled men >50 years old and postmenopausal women (n=7564) and excluded those who had not answered the questions concerning medical history or had not fasted for >8 hours before the measurement (n=2299). Finally, 5265 subjects (2818 men and 2447 women) were included in the study. The institutional review board of the Korean Center for Disease Control and Prevention approved the study protocol. Written informed consent forms were obtained from all subjects.

2.3. Anthropometric and biochemical measurements

Current height and weight were measured without shoes and with only light clothes to the nearest 0.1 cm and 0.1 kg, respectively, by a trained examiner using quality-controlled measuring instruments. The subjects' lifetime maximum height was determined using the self-reported questionnaire. Height loss was calculated as the difference between the maximum height and current height. Then, subjects were divided into 4 quartiles on the basis of their height loss: Q1 (<0.1 cm), Q2 (0.1–1.2 cm), Q3 (1.2–2.6 cm), and Q4 (≥2.6 cm) for men and Q1 (<0.9 cm), Q2 (0.9–2.3 cm), Q3 (2.3–3.9 cm), and Q4 (≥3.9 cm) for women. After normal expiration, waist circumference (WC) was measured to the nearest 0.1 cm on a horizontal plane at the mid-point between the lower costal margin and the iliac crest. Weight (kg) was divided by height squared (m^2) to calculate the body mass index (BMI). Blood pressure (BP) was measured 3 times at 5-min intervals using a standard mercury sphygmomanometer (Baumanometer; W.A. Baum Co., New York), with the subject seated. The mean of the second and third measurements was calculated and used in the analysis. Blood samples were collected after the subject had fasted for ≥8 hours. The fasting serum levels of glucose, triglyceride, and high-density lipoprotein cholesterol (HDL-C) were measured enzymatically using a Hitachi Automatic Analyzer 7600 (Hitachi, Tokyo, Japan).

2.4. Socio-demographic variables

Socio-demographic variables (age, sex, education level, family income level, and occupation) were surveyed with the self-reported questionnaire. We divided subjects into 3 groups according to the education level and the income: low [income (iQ1) and education ≤6 years], middle [income (iQ2–3) and education 7–12 years], and high [income (iQ4) and education ≥13 years].

2.5. General health behaviors

Those who drank ≥30 g/day of alcohol were classified as heavy drinkers. Current smokers were defined as those who currently smoked and had smoked at least 100 cigarettes in their whole life. Physical activity was determined using the International Physical Activity Questionnaire (8). The "regular exercise" group included those who exercised ≥3 times/week for ≥20 min/session (in the case of intense exercise), or for ≥30 min/session.

2.6. Definition of metabolic syndrome

Metabolic syndrome was defined using the American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement (AHA/NHLBI) for Asians.[28,29] Subjects who had more than 3 of the following components were defined as having metabolic syndrome: high WC (≥90 cm in men or ≥80 cm in women), high fasting blood glucose level (≥100 mg/dL) or use of a hypoglycemic drug, high BP (≥130/85 mmHg) or use of an antihypertensive drug, low HDL-C level (<40 mg/dL in men or <50 mg/dL in women) or use of an antidyslipidemic drug, and high triglyceride level (≥150 mg/dL) or use of an antidyslipidemic drug.

2.7. Statistical analyses

Data are presented as mean ± standard error (SE) for continuous variables and as percentages (SE) for categorical variables. To analyze the subjects' general characteristics, Student's *t*-test was used for continuous variables, and the Chi-square test was used for categorical variables. Analysis of covariance was used to examine height loss among the 3 SES groups and among the 3 age groups (50–59 years, 60–69 years, and ≥70 years). Three multivariable-adjusted logistic regression analysis models were performed to determine the odds ratios (ORs) and 95% confidence intervals (CIs) of the prevalence of maximum (Q4) height loss in each quartile of education level and income. More specifically, model 1 was adjusted for age, and model 2 was adjusted for age, BMI, smoking, drinking, regular exercise, occupation, and metabolic syndrome. We also examined the OR and 95% CI for height loss (Q4) in each of the 3 SES groups, in both men and women, after adjusting for all covariates. We used the SAS software package version 9.2 for Windows (SAS Institute Inc., Cary, NC) to provide approximations for the whole Korean population and to account for the complex sampling design. All statistical tests were 2-tailed, and *P*-values <.05 were considered statistically significant.

3. Results

3.1. General characteristics of the subjects

In both men and women, we compared the general characteristics of the subjects divided into two groups: "less height loss" (Q1–3) and "maximum height loss" (Q4) (Table 1). Both men and women in the Q4 group were older than those in the Q1–3 group (both $P<.001$). The mean height, weight, BMI, WC, and occupation rate were higher in the Q1–3 group in men. In women, mean height, weight, BMI, and regular exercise were higher, but WC and the prevalence of metabolic syndrome were lower in the Q1–3 group than in the Q4 group (all $P<.05$). In men, the mean maximum height in the Q1–3 group was 168.8 ± 0.1 cm and in the Q4 group was 168.0 ± 0.2 cm ($P=.016$), and the mean height loss was 0.5 ± 0.0 cm in the Q1–3 group and

Table 1

General characteristics of the subjects from the KNHANES.

	Men			Women		
Height loss	**Q1–3**	**Q4**	***P****	**Q1–3**	**Q4**	***P****
Unweighted, n	2113	705		1841	606	
Age, years	59.1 ± 0.2	65.7 ± 0.4	<.001	59.3 ± 0.2	65.2 ± 0.5	<.001
Height, cm	168.4 ± 0.1	163.8 ± 0.2	<.001	155.6 ± 0.1	151.3 ± 0.2	<.001
Weight, kg	68.3 ± 0.3	63.0 ± 0.5	.007	58.1 ± 0.2	56.8 ± 0.4	<.001
BMI, kg/m^2	24.8 ± 0.2	24.0 ± 0.1	<.001	24.1 ± 0.1	23.5 ± 0.2	<.001
Maximum height, cm	168.8 ± 0.1	168.0 ± 0.2	.016	157.1 ± 0.1	157.7 ± 0.2	.004
Height loss, cm	0.5 ± 0.0	4.3 ± 0.1	<.001	1.5 ± 0.0	6.4 ± 0.1	<.001
WC, cm	85.9 ± 0.2	84.4 ± 0.4	.003	81.5 ± 0.3	83.2 ± 0.5	.002
Current smoking, yes, %	34.8 (1.3)	34.3 (2.3)	.853	4.7 (0.8)	5.1 (1.0)	.746
Heavy drinking, yes, %	18.3 (1.1)	17.1 (1.8)	.555	1.1 (0.3)	1.0 (0.7)	.929
Regular exercise, yes, %	29.2 (1.3)	25.9 (1.9)	.147	25.7 (1.3)	20.6 (1.9)	.029
Metabolic syndrome, yes, %	39.5 (1.2)	39.4 (2.5)	.982	44.4 (1.4)	53.2 (2.5)	.003
Occupation, yes, %	72.7 (1.2)	60.0 (2.4)	<.001	42.2 (1.6)	36.9 (2.6)	.069

Data are presented as mean ± standard error (SE) or percentages (SE).

* Obtained using *t*-tests or chi-square tests.

BMI = body mass index, KNHANES = Korean National Health and Nutrition Examination Survey, Q1–3 = lower 3 quartiles of height loss, Q4 = highest quartile of height loss, WC = waist circumference.

4.3 ± 0.1 cm in the Q4 group (*P* < .001). In women, the mean maximum height was 157.1 ± 0.1 cm in the Q1–3 group and 157.7 ± 0.2 in the Q4 group (*P* = .004), and the mean height loss was 1.5 ± 0.0 cm in the Q1–3 group and 6.4 ± 0.1 cm in the Q4 group (*P* < .001).

3.2. Proportions of each SES group in the Q1–3 and Q4 groups

Table 2 shows the proportions of the Q1–3 and Q4 groups in each SES group, in men and women. The proportions of the subjects in each SES group were significantly different between the Q1–3 and Q4 groups in men and women (all *P* < .001). In the Q1–3 groups, a higher proportion of subjects had ≥13 years of education than in the Q4 groups (men: 22.4% vs 11.0% and women: 7.3% vs 3.3%). Conversely, a lower proportion of subjects in the Q1–3 groups had ≤6 years of education than in the Q4 groups (men: 25.8% vs 41.4% and women: 48.2% vs 69.4%). A similar proportional distribution was observed in both men and women with regard to the income level. In the Q1–3 groups, a higher proportion of subjects had the highest income level (iQ4) than in the Q4 groups (men: 32.1% vs 18.6% and women: 24.8% vs 14.1%). In the Q4 groups, a higher proportion of subjects had the lowest income level (iQ1) than in the Q1–3 groups (men: 17.2% vs 36.7% and women: 21.9% vs 44.8%).

3.3. Mean height loss among the 3 SES groups according to the 3 age groups

In both men and women, mean height loss increased as the age increased, and mean height loss was higher in the low SES group than in the high SES group among all 3 age groups (50–59 years, *P* = .006; 60–69 years, *P* = .004; and ≥70 years, *P* = .002 in men and 50–59 years, *P* = .005; 60–69 years, *P* = .004; and ≥70 years: *P* < .001 in women) (Fig. 1).

3.4. Prevalence of maximum height loss (Q4) according to SES

Table 3 shows the prevalence of maximum height loss (Q4) according to SES. Compared with the highest education level (≥13 years; reference group), the prevalences of maximum height loss (Q4) were 2.16, 1.83, and 1.49 times more prevalent in the men with ≤6 years, 7–9 years, or 10–12 years of education, respectively, after adjustment for all covariates. These ORs for the prevalence of height loss (Q4) tended to increase as the

Table 2

Proportions of men and women in each education and income group, in the Q1–3 and Q4 groups for height loss.

	Men			Women		
Height loss	**Q1–3**	**Q4**	***P****	**Q1–3**	**Q4**	***P****
Education level, years			<.001			<.001
≤6	25.8 (1.3)	41.4 (2.5)		48.2 (1.6)	69.4 (2.3)	
7–9	21.5 (1.1)	23.7 (2.0)		20.4 (1.0)	14.9 (1.8)	
10–12	30.4 (1.3)	23.9 (2.2)		24.2 (1.3)	12.3 (1.7)	
≥13	22.4 (1.4)	11.0 (1.6)		7.3 (0.8)	3.3 (1.0)	
Income level			<.001			<.001
iQ1	17.2 (1.0)	36.7 (2.1)		21.9 (1.3)	44.8 (2.5)	
iQ2	25.5 (1.1)	27.7 (2.0)		27.0 (1.4)	24.9 (1.9)	
iQ3	25.2 (1.1)	17.0 (1.8)		26.3 (1.3)	16.1 (1.8)	
iQ4	32.1 (1.3)	18.6 (1.9)		24.8 (1.5)	14.1 (1.8)	

Data are presented as percentage (standard error).

* Obtained using chi-square tests.

iQ = income quartiles, Q1–3 = lower 3 quartiles of height loss, Q4 = highest quartile of height loss.

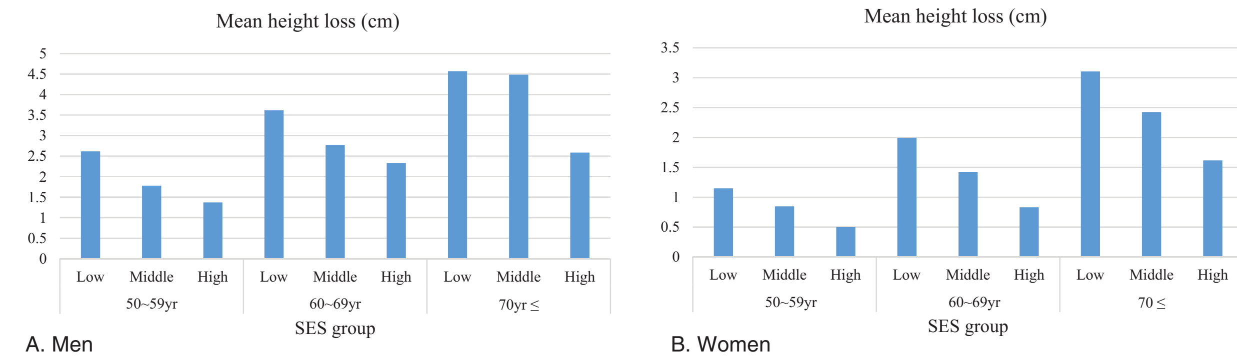

Figure 1 (A). Mean height loss in the 3 socioeconomic status (SES) groups according to the age group in men: 50–59 years, $P=.006$; 60–69 years, $P=.004$; and ≥70 years, $P=.002$. SES groups: low (income iQ1 and ≤6 years of education), middle (income iQ2–3 and 7–12 years of education), and high (income iQ4 and ≥13 years of education). (B) Mean height loss in the 3 socioeconomic status (SES) groups according to age group in women: 50–59 years, $P=.005$; 60–69 years, $P=.004$; and ≥70 years: $P<.001$. SES groups: low (income iQ1 and ≤6 years of education), middle (income iQ2–3 and 7–12 years of education), and high (income iQ4 and ≥13 years of education). iQ = income quartiles, SES = socioeconomic status.

education level decreased ($P<.001$). The prevalence of height loss (Q4) was not associated with education level in women; however, there was a tendency for the ORs for the prevalence of height loss (Q4) to increase as the education level decreased ($P<.001$).

In the relationship between the income level and the maximum height loss (Q4), the subjects with the lowest income level (iQ1) were 2.03 and 1.94 times more likely to have maximum height loss (Q4) than the subjects with the highest income level (iQ4) in men and women, respectively, after adjusting for all covariates. Moreover, in both men and women, as the income level decreased, the ORs for the prevalence of maximum height loss (Q4) increased (P-value for both trends <.001).

3.5. Prevalence of maximum height loss (Q4) among the 3 SES groups

Using multivariable-adjusted logistic regression analysis, we additionally analyzed the ORs and 95% CIs for the prevalence of maximum height loss (Q4) in the 3 SES groups in men and women (Fig. 2). After adjustment for all covariates, maximum height loss (Q4) was 1.705 times more prevalent in the men in the low SES group and 0.330 times less prevalent in the men in the high SES group than men in the middle SES group. In women, maximum height loss (Q4) was 1.537 times more prevalent in the women in the low SES group than in the women in the middle SES group after adjustment for all covariates.

4. Discussion

In the present study, height loss was associated with SES level among all age groups, and mean height loss increased as age increased. In the relationship between the education level and the maximum height loss (Q4), men with ≤6, 7–9, or 10–12 years of education had a higher prevalence of maximum height loss (Q4) overall than men with the highest education level. Regarding the relationship between the income level and maximum height loss (Q4), the men and women with the lowest income level were 2.03 and 1.94 times more likely, respectively, to have maximum height loss (Q4) than the subjects with the highest income level.

Height loss is associated with overall mortality independent of vertebral fracture.[5,7,13] Wannamethee et al[13] found that elderly

Table 3

Multivariable-adjusted logistic regression analysis of the prevalence of maximum height loss (Q4) according to socioeconomic status in men and women.

	Men		Women	
	Model 1	Model 2	Model 1	Model 2
Education level, y			Height loss (Q4)	
≤6	2.27 (1.57–3.26)	2.16 (1.49–3.14)	2.0 2 (1.01–4.03)	1.63 (0.80–3.32)
7–9	1.63 (1.11–2.38)	1.83 (1.27–2.64)	1.16 (0.55–2.42)	1.52 (0.73–3.19)
10–12	2.06 (1.45–2.93)	1.49 (1.02–2.17)	1.67 (0.81–3.42)	1.14 (0.53–2.46)
≥13	1	1	1	1
P-value for trend	<.001	<.001	<.001	.031
Income level				
iQ1	1.96 (1.41–2.74)	2.03 (1.41–2.92)	2.01 (1.35–2.99)	1.94 (1.27–2.96)
iQ2	1.38 (0.99–1.93)	1.36 (0.96–1.92)	1.42 (0.95–2.11)	1.33 (0.88–2.01)
iQ3	1.01 (0.71–1.45)	1.00 (0.68–1.46)	1.00 (0.66–1.50)	0.87 (0.56–1.34)
iQ4	1	1	1	1
P-value for trend	<.001	<.001	<.001	<.001

Odds ratios and 95% confidence intervals were obtained using multivariable-adjusted logistic regression.
Model 1 was adjusted for age.
Model 2 was adjusted for age, body mass index, smoking, drinking, regular exercise, occupation, and metabolic syndrome.
iQ = income quartiles, Q1–3 = lower 3 quartiles of height loss, Q4 = highest quartile of height loss.

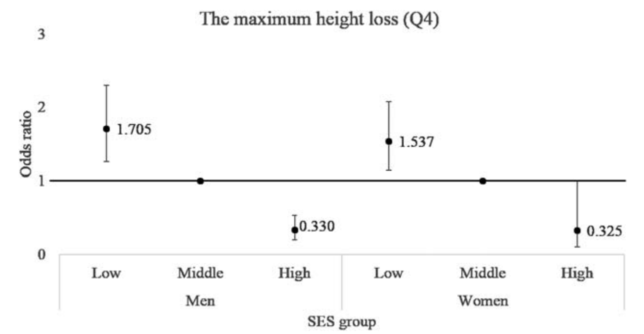

Figure 2. Prevalence of maximum (Q4) height loss among the 3 socioeconomic status (SES) groups in men and women. Odds ratios and 95% confidence intervals (CIs) were obtained using multivariable-adjusted logistic regression, adjusted for age, body mass index, smoking, drinking, regular exercise, occupation, and metabolic syndrome. *P* value for trend <.001 in both men and women. Q4: the highest quartile of height loss. SES groups: low (income iQ1 and ≤6 years of education), middle (income iQ2–3 and 7–12 years of education), and high (income iQ4 and ≥13 years of education). CIs = confidence intervals, iQ = income quartiles, Q4 = highest quartile of height loss, SES = socioeconomic status.

men with a height loss ≥3 cm were at an increased risk of all-cause mortality and coronary heart disease. Another study found that women with height loss >5 cm had poor health outcomes,[7] because height loss might compress internal organs, such as those in the respiratory, cardiovascular, and gastrointestinal systems, resulting in decreased function, early satiety, and consequent weight loss.[30]

Although controversies exist regarding the relationship between height loss and bone mineral density, several studies have suggested that height loss is associated with decreased bone mineral density and osteoporosis.[4,31,32] Moreover, Kantor et al[32] found that height loss ≥2 inches was a strong predictor of osteoporosis at the hip. In addition to height loss, SES is also a risk factor for osteoporosis. A higher education level has a protective effect on bone mineral density, although no linear relationship was found in a population-based study involving women.[33] The exact mechanism of this is not known; it is possible that people with a higher education level are more likely to exercise and use nutritional supplementation than people with a lower education level.[34] Moreover, social position during childhood might affect bone mineral density as well as height in adulthood.[18] Studies that analyzed the relationship between SES and bone mineral density screening found that subjects with lower income were less likely to undergo bone mineral density screening.[35,36] This might delay the diagnosis and treatment of osteoporosis and fracture and subsequently result in height loss. Other studies have emphasized a cumulative effect of bone health from childhood or pre-birth; in subjects with low SES, these effects may deteriorate bone health.[37–40]

Issues in the cartilage and joints of the spine might cause height loss. Indeed, 25% of the spinal column height comprises intervertebral discs; therefore, a degenerative change in the discs would result in height loss, especially in the elderly.[41,42] Because the diagnosis and treatment of degenerative diseases may also be delayed in subjects with low SES, these degenerative changes are more prevalent in these subjects.[43,44] Therefore, these changes in the musculoskeletal system may result in height loss in subjects with low SES. However, the relationship between height loss and the musculoskeletal system by sex remains controversial. In some studies, including the current study, height loss was greater in women than in men.[45,46] Some studies of women found that kyphosis was associated with an increased risk of fracture,[47] and self-reported height loss (2.4 cm) has been observed in elderly women with severe kyphosis.[48] However, another study proposed that the prevention of osteoporosis and fracture using medical treatment and intervention might reduce height loss in women more effectively than in men, especially in women with a height loss >5 cm.[49] Although the cause of height loss in men has not yet been reported, Szulc et al[50] found an association between sarcopenia and poor bone structure and between sarcopenia and bone loss in elderly men.

Height loss may be associated with SES, independent of other factors. In the China Longitudinal Healthy Longevity Study, SES was an important predictor of height loss,[25] and both education level and income were negatively associated with height loss. The authors suggested that subjects with a high SES had better health behaviors than those with a low SES. Moreover, subjects with a high SES would be more likely to use medical care facilities to maintain and improve their health and to ensure that they maintain a good nutritional status than subjects with a low SES.[25,51] Occupational type was also associated with height loss. Men aged ≥60 years employed in housework or agriculture showed greater height loss than men in high-skilled occupations; however, this association was not present in women.[25]

This study had some limitations. First, owing to its cross-sectional design, it was not possible to ascertain a causal relationship between SES and height loss. Second, we did not collect data regarding the SES of the subjects in their youth, and the SES in childhood may be associated with adult bone structure and height loss. Third, we did not assess the history of osteoporosis, fracture, or treatment, which are the causes of height loss, although this is controversial. Fourth, because we only included Korean subjects, our results might not be generalizable to other ethnic groups. Fifth, we only assessed the subjects' peak (maximum) height using a self-reported questionnaire, not by reference to written data; memory bias may have occurred. Nonetheless, Hiller et al[7] found that self-reported maximum height is useful as a surrogate for baseline height.

However, this study had some strengths. To the best of our knowledge, it is the first study to examine height loss and the association between height loss and SES in Korean elderly. Therefore, the results of this study could be widely used in various clinical studies as basic data regarding height loss in the Korean elderly, especially as it relates to osteoporosis or treatment. Second, this study analyzed data for a sample representative of the Korean population. Third, measurement of height is easy and cost-free in almost any clinical setting. Therefore, it may be used widely as an indicator of related health problems.

In conclusion, height loss was associated with ≤6, 7–9, or 10–12 years of education in men and with low income level (iQ1) in both men and women. Height loss was more prevalent in men and women with low SES and less prevalent in men with a high SES than in men with a middle SES. Because height loss can be a predictor of poor health outcomes, physicians should monitor patients' height loss, especially in men with a low SES. Further prospective studies are needed to reveal the causal pathways between SES and height loss.

Acknowledgments

The authors wish to thank the participants of this study for their dedication.

References

[1] Steckel RH. Biological measures of the standard of living. J Econ Perspect 2008;22:129–52.
[2] Adair LS, Fall CH, Osmond C, et al. Associations of linear growth and relative weight gain during early life with adult health and human capital in countries of low and middle income: findings from five birth cohort studies. Lancet 2013;382:525–34.
[3] Stein AD, Wang M, Martorell R, et al. Growth patterns in early childhood and final attained stature: data from five birth cohorts from low- and middle-income countries. Am J Hum Biol 2010;22:353–9.
[4] Thornton MJ, Sedlak CA, Doheny MO. Height change and bone mineral density: revisited. Orthop Nurs 2004;23:315–20.
[5] Auyeung TW, Lee JS, Leung J, et al. Effects of height loss on morbidity and mortality in 3145 community-dwelling Chinese older women and men: a 5-year prospective study. Age Ageing 2010;39:699–704.
[6] Hannan MT, Broe KE, Cupples LA, et al. Height loss predicts subsequent hip fracture in men and women of the Framingham Study. J Bone Miner Res 2012;27:146–52.
[7] Hillier TA, Lui LY, Kado DM, et al. Height loss in older women: risk of hip fracture and mortality independent of vertebral fractures. J Bone Miner Res 2012;27:153–9.
[8] Leoncini E, Ricciardi W, Cadoni G, et al. Adult height and head and neck cancer: a pooled analysis within the INHANCE Consortium. Eur J Epidemiol 2014;29:35–48.
[9] Osika W, Montgomery SM. Economic disadvantage modifies the association of height with low mood in the US, 2004: the disappointment paradox. Economics Hum Biol 2008;6:95–107.
[10] Case A, Paxson C. Height, health, and cognitive function at older ages. Am Econ Rev 2008;98:463–7.
[11] Batty GD, Shipley MJ, Gunnell D, et al. Height, wealth, and health: an overview with new data from three longitudinal studies. Econ Hum Biol 2009;7:137–52.
[12] Moayyeri A, Luben RN, Bingham SA, et al. Measured height loss predicts fractures in middle-aged and older men and women: the EPIC-Norfolk prospective population study. J Bone Mineral Res 2008;23: 425–32.
[13] Wannamethee SG, Shaper AG, Lennon L, et al. Height loss in older men: associations with total mortality and incidence of cardiovascular disease. Arch Intern Med 2006;166:2546–52.
[14] Nash SD, Cruickshanks KJ, Klein R, et al. Socioeconomic status and subclinical atherosclerosis in older adults. Prev Med 2011;52:208–12.
[15] Tomfohr LM, Ancoli-Israel S, Dimsdale JE. Childhood socioeconomic status and race are associated with adult sleep. Behav Sleep Med 2010; 8:219–30.
[16] Cohen S, Janicki-Deverts D, Chen E, et al. Childhood socioeconomic status and adult health. Ann N Y Acad Sci 2010;1186:37–55.
[17] Smith JP, Shen Y, Strauss J, et al. The effects of childhood health on adult health and SES in China. Econ Dev Cult Change 2012;61:127–56.
[18] Clark EM, Ness A, Tobias JH, et al. Social position affects bone mass in childhood through opposing actions on height and weight. J Bone Miner Res 2005;20:2082–9.
[19] Adler NE, Boyce T, Chesney MA, et al. Socioeconomic status and health. The challenge of the gradient. Am Psychol 1994;49:15–24.
[20] Antonovsky A. Social class, life expectancy and overall mortality. Milbank Mem Fund Q 1967;45:31–73.
[21] Christiansen M, Hansen CD, Glasscock D, et al. Social inequality and health in adolescents. Ugeskrift Laeger 2010;172:857–63.
[22] Sorlie PD, Backlund E, Keller JB. US mortality by economic, demographic, and social characteristics: the National Longitudinal Mortality Study. Am J Public Health 1995;85:949–56.
[23] Vafaei A, Rosenberg MW, Pickett W. Relationships between income inequality and health: a study on rural and urban regions of Canada. Rural Remote Health 2010;10:1430.
[24] Kington RS, Smith JP. Socioeconomic status and racial and ethnic differences in functional status associated with chronic diseases. Am J Public Health 1997;87:805–10.
[25] Huang W, Lei X, Ridder G, et al. Health, height, height shrinkage, and SES at older ages: evidence from China. Am Econ J Appl Econ 2013; 5:86–121.
[26] Yi Z, Gu D, Land KC. The association of childhood socioeconomic conditions with healthy longevity at the oldest-old ages in China. Demography 2007;44:497–518.
[27] Park HA. The Korea national health and nutrition examination survey as a primary data source. Korean J Fam Med 2013;34:79.
[28] Grundy SM, Cleeman JI, Daniels SR, et al. Diagnosis and management of the metabolic syndrome an American Heart Association/National Heart, Lung, and Blood Institute scientific statement. Circulation 2005;112: 2735–52.
[29] Alberti K, Eckel RH, Grundy SM, et al. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation 2009;120:1640–5.
[30] Ross PD. Clinical consequences of vertebral fractures. Am J Med 1997;103:30S–42S. discussion 42S–43S.
[31] Twiss JJ, Dillon AL, Konfrst JM, et al. The relationship of actual height loss with health-seeking behaviors and risk factors in perimenopausal and menopausal women. J Am Acad Nurse Pract 2002;14:131–7.
[32] Kantor SM, Ossa KS, Hoshaw-Woodard SL, et al. Height loss and osteoporosis of the hip. J Clin Densitom 2004;7:65–70.
[33] Brennan SL, Henry MJ, Wluka AE, et al. BMD in population-based adult women is associated with socioeconomic status. J Bone Miner Res 2009; 24:809–15.
[34] Di Thiene D, Marceca M. Closing the gap in a generation: health equity through action on the social determinants of health. A challenge for the international community [Italian]. Ann Ig 2008;20:595–601.
[35] Neuner JM, Zhang X, Sparapani R, et al. Racial and socioeconomic disparities in bone density testing before and after hip fracture. J Gen Intern Med 2007;22:1239–45.
[36] Demeter S, Leslie WD, Lix L, et al. The effect of socioeconomic status on bone density testing in a public health-care system. Osteoporos Int 2007;18:153–8.
[37] Nabulsi M, Mahfoud Z, Maalouf J, et al. Impact of maternal veiling during pregnancy and socioeconomic status on offspring's musculoskeletal health. Osteoporos Int 2008;19:295–302.
[38] Fehily AM, Coles RJ, Evans WD, et al. Factors affecting bone density in young adults. Am J Clin Nutr 1992;56:579–86.
[39] Moreno Villares JM, Galiano Segovia MJ. Influence of nutrition and social environment on bone maturation in children [Spanish]. Nutr Hosp 2007;22:726–7. author reply 727–729.
[40] Oliver H, Jameson KA, Sayer AA, et al. Growth in early life predicts bone strength in late adulthood: the Hertfordshire Cohort Study. Bone 2007; 41:400–5.
[41] Baron YM, Brincat MP, Galea R, et al. Intervertebral disc height in treated and untreated overweight post-menopausal women. Hum Reprod 2005;20:3566–70.
[42] Martin MD, Boxell CM, Malone DG. Pathophysiology of lumbar disc degeneration: a review of the literature. Neurosurg Focus 2002;13:E1.
[43] Ji GY, Oh CH, Jung NY, et al. Interference of detection rate of lumbar disc herniation by socioeconomic status. Asian Spine J 2013;7:14–9.
[44] Katz JN. Lumbar disc disorders and low-back pain: socioeconomic factors and consequences. J Bone Joint Surg Am 2006;88(suppl 2):21–4.
[45] Sorkin JD, Muller DC, Andres R. Longitudinal change in height of men and women: implications for interpretation of the body mass index: the Baltimore Longitudinal Study of Aging. Am J Epidemiol 1999;150: 969–77.
[46] Sorkin JD, Muller DC, Andres R. Longitudinal change in the heights of men and women: consequential effects on body mass index. Epidemiol Rev 1999;21:247–60.
[47] Huang MH, Barrett-Connor E, Greendale GA, et al. Hyperkyphotic posture and risk of future osteoporotic fractures: the Rancho Bernardo study. J Bone Miner Res 2006;21:419–23.
[48] Ettinger B, Black DM, Palermo L, et al. Kyphosis in older women and its relation to back pain, disability and osteopenia: the study of osteoporotic fractures. Osteoporos Int 1994;4:55–60.
[49] Abdou CM, Dunkel Schetter C, Campos B, et al. Communalism predicts prenatal affect, stress, and physiology better than ethnicity and socioeconomic status. Cultur Divers Ethnic Minor Psychol 2010;16: 395–403.
[50] Szulc P, Beck TJ, Marchand F, et al. Low skeletal muscle mass is associated with poor structural parameters of bone and impaired balance in elderly men—the MINOS study. J Bone Miner Res 2005;20:721–9.
[51] Kim J. The mediating effects of lifestyle factors on the relationship between socioeconomic status and self-rated health among middle-aged and older adults in Korea. Int J Aging Hum Dev 2011;73:153–73.