American Journal of Epidemiology

Vol. 158, No. 5
Printed in U.S.A.
DOI: 10.1093/aje/kwg173

Adult Height and Cause-specific Mortality: A Large Prospective Study of South Korean Men

Yun-Mi Song[1], George Davey Smith[2], and Joohon Sung[3]

[1] Department of Family Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Republic of Korea.
[2] Department of Social Medicine, University of Bristol School of Medicine, Bristol, United Kingdom.
[3] Department of Preventive Medicine, Kangwon National University College of Medicine, Kangwon-Do, Republic of Korea.

Received for publication April 30, 2002; accepted for publication March 4, 2003.

To examine the relation of adult height with mortality, the authors conducted a cohort study of 386,627 middle-aged South Korean male civil servants from 1992 to 1998. An inverse association between height and all-cause mortality (14,003 deaths) was observed after adjustment for socioeconomic position and major behavioral risk factors. The adjusted relative risk for all-cause mortality associated with a 5-cm increment in height was 0.97 (95% confidence interval: 0.95, 0.98). There was little evidence of associations for coronary heart disease or overall cancer mortality. However, stomach cancer showed a weak inverse association that was attenuated after adjustment. Strong inverse associations with death from stroke, respiratory disease, and external causes were observed. The association with stroke mortality was specific for hemorrhagic stroke. The inverse associations observed between height and mortality suggest a possible effect of childhood environment on health. Variations in the associations by cause of death indicate that specific processes are involved. These data are consistent with those of other studies in suggesting that risk of hemorrhagic stroke is particularly influenced by adversity in early life. The lack of an association between height and coronary heart disease suggests that additional factors are required for short stature to translate into increased coronary heart disease risk.

body height; cerebrovascular accident; coronary disease; men; mortality; neoplasms

Both genetic and environmental factors influence height. Social conditions are important among environmental factors, and height is partly a surrogate marker for conditions in early life (1–6). Over the past several decades, many investigators have examined the height-mortality relation as a way of exploring whether early life and childhood factors directly influence mortality in adulthood. Although some studies did not consider adulthood socioeconomic position and known cardiovascular disease risk factors, short stature has generally been found to have inverse relations with all-cause, cardiovascular, and respiratory mortality after these other factors are taken into account (3, 7–11). However, conflicting associations have been found for some specific causes of death, and previous studies of height and mortality were restricted to Western populations.

Therefore, we analyzed data from a large cohort of middle-aged South Korean men to examine the relation between height and mortality from a range of specific causes. This study provides data that allow examination of the generalizability of the height-mortality association. Thus, it identifies causes of death that might be closely linked by biologic processes to height.

MATERIALS AND METHODS

Study participants and variables

Study participants were South Korean male public servants and teachers aged 40–64 years who were insured by the Korean Medical Insurance Corporation and underwent a health examination in 1992. Details on this study population have been presented previously (12). Among the initial 386,824 men, 18 men whose height data were not obtainable and 179 men who died during the health examination period in 1992 were excluded from the study. Thus, 386,627 men were finally included in the study.

During the health examination in 1992, height (in centimeters), body weight (in kilograms), blood pressure, and fasting serum glucose and cholesterol levels were measured, and

Reprint requests to Dr. Yun-Mi Song, Department of Family Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, 50 Irwon-Dong, Gangnam-Gu, Seoul 135-710, Republic of Korea (e-mail address: ymsong@smc.samsung.co.kr).

information on health-related behaviors, including smoking, alcohol intake, and exercise, was obtained from a self-administered questionnaire. No specific guidelines were used to measure height. We examined the reliability of measured heights by comparing heights measured in 1992 with heights measured in 1994 for the 349,672 subjects who had measurements taken in both years. The coefficient for correlation between the two measures was 0.97.

The average height of the study participants was 168.3 cm (standard deviation, 5.07 cm). We divided the participants into six height categories based on the upper and lower deciles of the distribution and quartiles of the intermediate 80 percent, as follows: ≤162, 163–165, 166–168, 169–171, 172–174, and ≥175 cm. Body mass index was calculated as weight in kilograms divided by the square of height in meters.

We classified the subjects into four groups according to their smoking habits in 1992: never smoker, former smoker, light smoker (<20 cigarettes/day), and heavy smoker (≥20 cigarettes/day). We categorized alcohol consumption into three classes according to frequency of alcohol drinking: none, one or two times per week, and three or more times per week. According to the subjective judgment of study participants, two classes were used for exercise: engaging in regular exercise or not. We examined the test-retest validity of the question about exercise habits using the data from 1992 and 1994. The kappa value was 0.47, reflecting moderate agreement. Subjects were classified into four levels of socioeconomic position based on the quartile distribution of their monthly salaries (<$979, $979–$1,241, $1,242–$1,569, and ≥$1,570). Area of residence was categorized as large city, medium/small city, or county, according to the administrative division. Occupations were categorized into a high occupational group and a low occupational group. Educational, administrative, professional, and executive occupations were regarded as higher-level occupations, whereas manual, semiskilled, and unskilled occupations and police work were placed in the lower occupational group.

Mortality follow-up

The vital status of study subjects between October 1992 and December 1998 was completely ascertained through data linkage with nationwide death report data from the South Korean National Statistical Office based on personal identification numbers. The following codes in the Tenth Revision of the *International Classification of Diseases* were utilized to classify specific causes of death as follows: all cancer (C00–C97), hepatobiliary cancer (C22–C24), stomach cancer (C16), respiratory tract cancer (C30–C34), colorectal cancer (C18–C20), esophageal cancer (C15), pancreatic cancer (C25), hematopoietic cancer (C81–C96), brain cancer (C71 and C72), urinary tract cancer (C64–C68), cerebrovascular disease (I60–I69), ischemic stroke (I63), hemorrhagic stroke (I61 and I62), coronary heart disease (I20–I25), respiratory disease (J00–J99, A15, A16, and A19), all external causes (S00–T98), suicide (X60–X84), and undetermined causes (Y10–Y34). Most of the undetermined causes of death would have been suicide, and henceforth this category is referred to as suicide.

Statistical analysis

Analysis of covariance was used to obtain age-adjusted average levels of diastolic and systolic blood pressure, body mass index, and serum cholesterol. Age-adjusted baseline characteristics according to the six height groups were obtained using direct standardization. The South Korean male population structure in 1992 was used as a standard. Age-adjusted rates of mortality (per 100,000 person-years) from specific causes were also calculated through direct standardization.

Relative risks for the six height groups were estimated using Cox proportional hazards regression analysis. The lowest height group was used as the reference level in estimating relative risks. To examine the confounding effects of socioeconomic factors on the relation between height and mortality, we repeated the analysis with and without controlling for these factors.

RESULTS

During the follow-up period between October 1992 and December 1998, a total of 14,003 deaths occurred. Of these, 5,781 deaths (41.3 percent) were from cancer. Another 1,267 deaths (9.1 percent) were attributable to stroke, 652 (4.7 percent) to coronary heart disease, 399 (2.8 percent) to respiratory disease, and 2,235 (16.0 percent) to external causes. Of cancers, hepatobiliary cancer was the most frequent, with 2,040 cases, followed by stomach cancer (1,201 cases), respiratory tract cancer (1,024 cases), colorectal cancer (301 cases), pancreatic cancer (276 cases), hematopoietic cancer (233 cases), esophageal cancer (178 cases), urinary tract cancer (94 cases), and brain cancer (84 cases).

The age-adjusted baseline characteristics of the study subjects are presented by height in table 1. Because greater height was associated with younger age at baseline examination, we adjusted other factors for age. Taller subjects were likely to have higher diastolic and systolic blood pressures and a higher body mass index. Frequent drinking was more common among taller men. Greater proportions of taller men reported engaging in regular physical exercise. Heavy smoking was more prevalent among taller men. The proportions of men who had a higher salary, had an occupation in the higher occupational group, and lived in a large city were greater among taller men. All differences were small, however, with the exception of salary and occupational level.

Figure 1 shows age-adjusted mortality from all causes and some specific causes. Relative risks and 95 percent confidence intervals for all-cause and cause-specific mortality are presented by height in table 2. There was an inverse trend in age-adjusted all-cause mortality with increasing height. The tallest group (≥175 cm) had an approximately 10 percent lower risk of all-cause mortality in comparison with the shortest group (≤162 cm), even after adjustment for socioeconomic and health risk factors. When height was considered as a continuous variable, the relative risks for all-cause mortality for a 5-cm increment in height before and after additional adjustment for socioeconomic factors were 0.92 and 0.97, respectively. There was little evidence of a relation

TABLE 1. Age-adjusted characteristics of men aged 40–64 years at the baseline examination, by height, South Korea, 1992–1998

Variable	No. of subjects	Height (cm)					
		≤162 (*n* = 49,546)	163–165 (*n* = 68,966)	166–168 (*n* = 77,866)	169–171 (*n* = 89,005)	172–174 (*n* = 57,846)	≥175 (*n* = 43,398)
Mean age (years)	386,627	50.1 (0.03)*	49.5 (0.02)	49.3 (0.02)	48.5 (0.02)	48.7 (0.03)	48.3 (0.03)
Mean diastolic blood pressure (mmHg)	386,509	82.5 (0.05)	82.6 (0.04)	82.8 (0.04)	82.9 (0.04)	83.1 (0.05)	83.3 (0.05)
Mean systolic blood pressure (mmHg)	386,510	126.8 (0.07)	126.7 (0.06)	126.9 (0.06)	126.8 (0.05)	127.0 (0.07)	127.3 (0.08)
Mean fasting serum glucose level (mg/dl)	386,627	95.3 (0.12)	95.1 (0.11)	95.2 (0.10)	95.3 (0.09)	95.1 (0.11)	95.3 (0.13)
Mean serum cholesterol level (mg/dl)	386,445	196.3 (0.17)	197.0 (0.15)	196.9 (0.14)	197.0 (0.13)	196.2 (0.16)	195.6 (0.18)
Mean body mass index†	386,319	23.3 (0.01)	23.4 (0.01)	23.5 (0.01)	23.5 (0.01)	23.6 (0.01)	23.7 (0.01)
Frequency of alcohol drinking per week (%)	377,320						
None		37.7	35.1	33.4	32.6	31.8	31.5
One or two times		37.3	40.2	41.1	41.9	42.1	41.5
Three or more times		25.0	24.7	25.5	25.6	26.1	27.1
Smoking habits (%)	369,033						
Never smoker		24.2	22.7	21.3	20.6	19.9	19.4
Ex-smoker		20.4	22.2	23.0	23.6	24.3	24.7
Current smoker							
Light (<20 cigarettes/day)		40.0	39.2	39.3	38.6	38.0	37.7
Heavy (≥20 cigarettes/day)		15.4	16.0	16.4	17.3	17.7	18.1
Engaging in regular exercise (%)	367,456	33.1	34.5	34.7	35.1	35.8	36.7
Monthly salary (%)	386,627						
<$979		40.3	29.6	25.9	22.1	20.5	18.3
$979 –$1,241		15.6	17.4	19.7	20.7	20.6	20.7
$1,242–$1,569		20.2	24.7	25.2	26.3	26.9	27.6
≥$1,570		23.9	28.4	29.2	30.9	32.0	33.4
Area of residency (%)	371,415						
Large city		50.0	51.8	52.9	55.4	55.3	55.8
Medium/small city		29.5	30.0	30.2	29.3	29.4	29.7
County		20.5	18.2	16.9	15.3	15.4	14.5
"High" occupational group‡ (%)	371,415	32.9	38.8	38.4	40.4	41.5	43.4

* Numbers in parentheses, standard error.
† Weight (kg)/height (m)^2.
‡ Educational, administrative, professional, and executive occupations were regarded as "high" occupational groups.

for overall cancer mortality (table 2). Stomach cancer showed a weak inverse association with height that was attenuated upon adjustment.

There was no strong relation between height and death from coronary heart disease. Inverse relations between height and death from stroke, respiratory disease, and external causes were observed, even after adjustment for socioeconomic and health risk factors. Within stroke subtypes, hemorrhagic stroke showed strong inverse associations with height, whereas ischemic stroke showed essentially no association.

DISCUSSION

In this analysis, we found an inverse relation between height and all-cause mortality, which is consistent with previous studies (3, 11, 13). The relation between height and mortality could be confounded by socioeconomic factors (13, 14). In many previous studies, low adult height was found to be associated with indicators of low socioeconomic position and high levels of both biologic and behavioral risk factors (8, 10, 11, 15–21). Similarly, people with more favorable socioeconomic circumstances have been shown to be taller and to have lower levels of blood pressure and smoking than those with less favorable circumstances (12, 22–24). However, many previous investigations (7, 9–11) found that an inverse association between height and mortality remained even after results were controlled for health risk factors and socioeconomic characteristics in adulthood. Furthermore, height has been found to be inversely related to cardiorespiratory disease mortality in a population that was universally of privileged socioeconomic position in adulthood (25). The present study, in which the relation between height and health risk factors was different from that of many previous studies, also showed an inverse relation between height and mortality that remained after data were controlled for socioeconomic and health risk factors. Therefore, the relation between height and mortality does not seem to be fully explained by the confounding effect of factors associated with adulthood socioeconomic position.

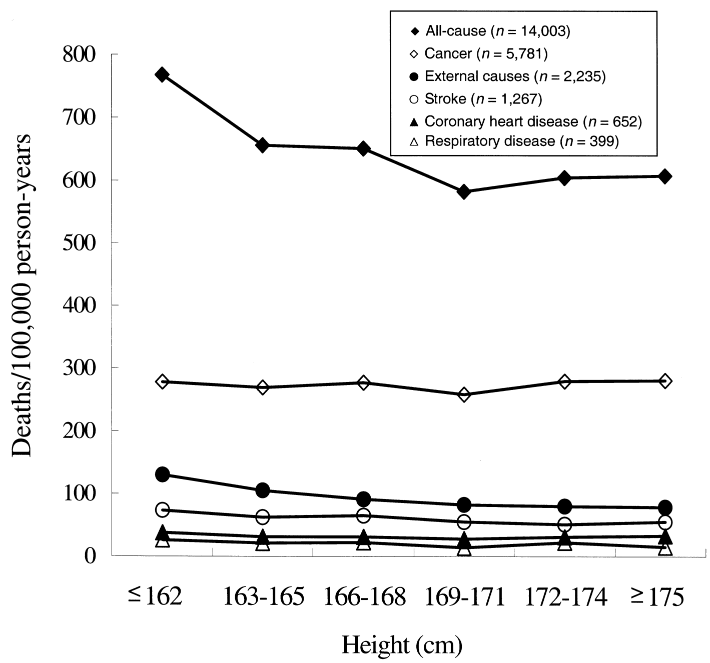

FIGURE 1. Age-adjusted rate of cause-specific mortality among 386,627 men aged 40–64 years, by height, South Korea, 1992–1998.

Allebeck and Bergh (13) found that the association between height and mortality could be explained almost entirely by social background and behavioral characteristics in childhood. In a previous study in Scotland, father's social class was related to death from all causes and some specific causes, even after adjustment for social class in adulthood (26). It is noticeable that the causes of death related to adverse social circumstances in childhood include stroke, stomach cancer, and respiratory disease, the risks of which were found to be inversely related to height in the present study and a previous study (10). Father's social class is closely associated with social environment in childhood and with height in childhood (1, 5) and adulthood (17, 26). Assuming that childhood environment is an important determinant of adult stature, it seems likely that factors related to growth during childhood play a role in health outcomes in adulthood.

There have been many studies of height and cancer risk, but the findings have not been consistent across studies (9–11, 15, 27, 28). The most common cancers in the present study were hepatobiliary, stomach, and lung cancers. Only one previous study has reliably analyzed data on hepatobiliary cancer (29); it found a weak positive association, with wide confidence intervals compatible with our null finding. Height has generally been found to be inversely associated with stomach cancer risk (9, 10, 30), while no consistent association between height and lung cancer has been seen (30). Our large study adds considerable data on these associations and is consistent with previous work. Our population had characteristics very different from those of most participants in previous reports, reflected by a greater frequency of stomach and hepatobiliary cancer in comparison with colorectal and prostate cancer. Therefore, our essentially null findings with respect to several non-smoking-related cancers—including colorectal, hematopoietic, and prostate cancer—are imprecise, with wide confidence intervals compatible with the generally positive associations seen in other studies (30).

Usually, height is considered not a causal factor that directly influences health but a marker of genotype, in-utero and childhood exposures, and the timing of puberty. The positive relation that has sometimes been found between height and risk of some cancers (10, 15, 27, 30) has been taken to indicate that genetic or hormonal factors, such as insulin-like growth factors, are associated with height and also influence susceptibility to cancer (30–34). Infection with *Helicobacter pylori*, which is implicated in the etiology of stomach cancer (35), generally occurs in childhood. Infection risk is increased by adverse childhood social circumstances and is associated with poor childhood growth (36). This could explain the inverse relation between height and death from stomach cancer.

The evidence for an inverse association between height and risk of stroke has been thought to be weaker than that for coronary heart disease (18, 37), although several recent studies have found an inverse relation (9–11, 25, 38–41). We observed that stroke had an inverse relation with height independently of known risk factors and socioeconomic factors. In the tallest men (≥175 cm) as compared with the shortest men (≤162 cm), the risk of stroke death was 23 percent lower. In studies that have shown a relation between height and stroke, blood pressure is generally not strongly related to height (11, 38); thus, blood pressure may not fully account for the relation. A recent study in Scotland found, as we did,

TABLE 2. Multivariate-adjusted relative risks for cause-specific mortality among 386,627 men aged 40–64 years, by height, South Korea, 1992–1998

Cause of death	Model	Height* (cm): 163–165 (*n* = 68,966) RR†	163–165 95% CI†	166–168 (*n* = 77,866) RR	166–168 95% CI	169–171 (*n* = 89,005) RR	169–171 95% CI	172–174 (*n* = 57,846) RR	172–174 95% CI	≥175 (*n* = 43,398) RR	≥175 95% CI	Risk for a 5-cm increment in height RR	Risk for a 5-cm increment in height 95% CI
All causes (13,966)‡	1§	0.86	0.81, 0.91	0.83	0.79, 0.88	0.77	0.73, 0.82	0.78	0.73, 0.83	0.77	0.72, 0.83	0.92	0.91, 0.94
	2¶	0.92	0.87, 0.97	0.91	0.86, 0.96	0.87	0.82, 0.92	0.89	0.83, 0.94	0.89	0.84, 0.96	0.97	0.95, 0.98
Stroke (1,263)	1	0.81	0.68, 0.98	0.85	0.71, 1.02	0.77	0.64, 0.92	0.69	0.56, 0.85	0.69	0.55, 0.86	0.89	0.85, 0.94
	2	0.86	0.72, 1.04	0.92	0.77, 1.10	0.85	0.71, 1.02	0.78	0.63, 0.96	0.78	0.62, 0.98	0.93	0.88, 0.98
Hemorrhagic stroke (636)	1	0.79	0.61, 1.01	0.73	0.57, 0.94	0.65	0.50, 0.83	0.61	0.46, 0.82	0.64	0.47, 0.87	0.86	0.80, 0.93
	2	0.82	0.64, 1.06	0.77	0.60, 0.99	0.70	0.54, 0.90	0.67	0.50, 0.89	0.70	0.51, 0.96	0.88	0.82, 0.96
Ischemic stroke (262)	1	0.83	0.55, 1.26	1.05	0.71, 1.54	0.94	0.64, 1.40	0.65	0.40, 1.05	0.77	0.46, 1.28	0.92	0.82, 1.03
	2	0.92	0.60, 1.39	1.18	0.80, 1.75	1.11	0.75, 1.66	0.78	0.48, 1.26	0.94	0.56, 1.57	0.98	0.87, 1.10
Coronary heart disease (649)	1	0.85	0.65, 1.10	0.87	0.67, 1.13	0.81	0.63, 1.05	0.85	0.64, 1.13	0.91	0.67, 1.23	0.97	0.90, 1.04
	2	0.87	0.67, 1.14	0.91	0.70, 1.17	0.86	0.66, 1.11	0.90	0.68, 1.20	0.97	0.71, 1.31	0.99	0.91, 1.06
Respiratory disease (396)	1	0.90	0.66, 1.23	0.86	0.64, 1.17	0.61	0.44, 0.86	0.75	0.52, 1.07	0.60	0.39, 0.91	0.85	0.77, 0.93
	2	0.97	0.71, 1.32	0.95	0.70, 1.30	0.71	0.51, 0.99	0.87	0.61, 1.25	0.70	0.46, 1.08	0.90	0.82, 0.99
All external causes# (2,230)	1	0.82	0.72, 0.94	0.71	0.62, 0.82	0.65	0.57, 0.74	0.62	0.54, 0.73	0.62	0.53, 0.73	0.84	0.81, 0.88
	2	0.91	0.80, 1.05	0.82	0.72, 0.94	0.78	0.68, 0.90	0.77	0.66, 0.90	0.78	0.66, 0.93	0.91	0.87, 0.95
Suicide (281)	1	0.80	0.54, 1.18	0.80	0.55, 1.17	0.71	0.49, 1.04	0.64	0.41, 0.99	0.49	0.30, 0.83	0.83	0.74, 0.93
	2	0.91	0.61, 1.35	0.94	0.64, 1.38	0.89	0.61, 1.30	0.81	0.52, 1.26	0.65	0.39, 1.09	0.90	0.80, 1.01
Cancers of all sites (5,769)	1	0.94	0.86, 1.03	0.94	0.86, 1.03	0.91	0.83, 0.99	0.96	0.88, 1.06	0.96	0.87, 1.07	0.99	0.97, 1.02
	2	0.98	0.90, 1.08	1.00	0.92, 1.09	0.99	0.90, 1.08	1.05	0.95, 1.16	1.06	0.95, 1.18	1.02	1.00, 1.05
Hepatobiliary cancer (2,036)	1	0.93	0.80, 1.08	0.86	0.74, 1.00	0.87	0.75, 1.01	0.94	0.80, 1.10	0.89	0.75, 1.06	0.98	0.94, 1.02
	2	0.98	0.84, 1.14	0.91	0.79, 1.06	0.95	0.82, 1.10	1.03	0.88, 1.21	0.98	0.82, 1.17	1.01	0.96, 1.05
Stomach cancer (1,198)	1	0.84	0.69, 1.02	0.94	0.78, 1.13	0.83	0.68, 1.00	0.80	0.65, 0.98	0.82	0.65, 1.03	0.95	0.89, 1.00
	2	0.89	0.73, 1.08	1.01	0.84, 1.22	0.91	0.75, 1.10	0.88	0.71, 1.09	0.92	0.73, 1.16	0.98	0.93, 1.04
Respiratory tract cancer (1,022)	1	0.92	0.74, 1.14	0.95	0.77, 1.17	0.98	0.80, 1.20	0.88	0.70, 1.11	1.01	0.79, 1.28	1.00	0.94, 1.06
	2	0.98	0.80, 1.22	1.03	0.84, 1.27	1.10	0.89, 1.35	1.00	0.79, 1.26	1.15	0.90, 1.48	1.04	0.98, 1.11
Colorectal cancer (301)	1	1.03	0.68, 1.57	1.09	0.73, 1.63	1.22	0.83, 1.80	1.04	0.67, 1.61	1.15	0.72, 1.82	1.07	0.96, 1.19
	2	1.01	0.67, 1.53	1.06	0.71, 1.58	1.17	0.79, 1.73	0.99	0.64, 1.55	1.09	0.68, 1.74	1.05	0.94, 1.18
Pancreas cancer (276)	1	1.20	0.78, 1.86	1.13	0.74, 1.75	1.08	0.70, 1.66	1.72	1.12, 2.64	1.08	0.65, 1.81	1.07	0.95, 1.20
	2	1.21	0.78, 1.87	1.14	0.74, 1.77	1.09	0.70, 1.69	1.74	1.13, 2.68	1.09	0.65, 1.84	1.07	0.95, 1.20
Hematopoietic cancer (231)	1	1.51	0.95, 2.43	1.41	0.88, 2.25	1.08	0.66, 1.75	1.11	0.66, 1.89	1.26	0.72, 2.18	0.97	0.86, 1.10
	2	1.60	1.00, 2.56	1.51	0.94, 2.41	1.18	0.72, 1.92	1.23	0.72, 2.09	1.40	0.80, 2.45	1.00	0.88, 1.14
Esophageal cancer (177)	1	0.95	0.56, 1.60	1.22	0.75, 1.98	0.71	0.41, 1.22	1.01	0.58, 1.76	1.42	0.82, 2.47	1.03	0.90, 1.19
	2	1.07	0.63, 1.81	1.43	0.87, 2.33	0.89	0.51, 1.54	1.30	0.74, 2.27	1.84	1.05, 3.22	1.12	0.97, 1.30
Urinary tract cancer (94)	1	0.76	0.37, 1.56	0.74	0.37, 1.51	0.94	0.49, 1.84	1.01	0.49, 2.06	1.12	0.52, 2.40	1.13	0.93, 1.38
	2	0.76	0.37, 1.56	0.74	0.36, 1.50	0.94	0.48, 1.84	1.00	0.49, 2.07	1.12	0.52, 2.42	1.14	0.93, 1.40
Brain cancer (84)	1	1.74	0.72, 4.23	1.38	0.56, 3.42	2.14	0.92, 4.99	2.10	0.86, 5.17	1.75	0.65, 4.71	1.21	0.98, 1.49
	2	1.76	0.72, 4.28	1.40	0.56, 3.48	2.16	0.92, 5.07	2.13	0.86, 5.27	1.77	0.65, 4.82	1.21	0.98, 1.50

* Reference category: ≤162 cm (*n* = 49,546).
† RR, relative risk; CI, confidence interval.
‡ Numbers in parentheses, number of cases with nonmissing values for all variables in model 2.
§ Adjusted for age, diastolic blood pressure, glucose, cholesterol, body mass index, alcohol drinking habits, smoking habits, and exercise.
¶ Adjusted for monthly salary, area of residency, occupation, and all variables in model 1.
\# Including injury, poisoning, and certain other consequences of external causes of death.

that height was strongly inversely associated with hemorrhagic stroke but less strongly related to ischemic stroke (41). Hemorrhagic stroke shares many characteristics with stomach cancer. Both declined dramatically in incidence during the 20th century in countries such as the United Kingdom and the United States, both are related to adverse social circumstances in childhood, and both are related to the number of siblings in the family of origin (42). The similarity of associations with height in the present study adds to this evidence and raises the intriguing possibility that adverse social circumstances and possibly concomitant infections in childhood increase the risk of hemorrhagic stroke in later life.

A large number of studies have found height to be inversely related to risk of coronary heart disease, and the few exceptions (14) have been considered chance outliers. The lack of association between height and coronary heart disease in the present study and in a recent study of Israeli men (39) raises the possibility that height, and the factors it indexes, is only related to coronary heart disease risk in combination with another factor—possibly atherogenic diet.

An inverse relation between low height and death from respiratory disease (9–11) has been observed in many studies. The inverse relation between height and death from respiratory disease does not seem to be entirely due to smoking or other factors related to socioeconomic position. Some researchers, but not all, have suggested that the height-disease relation might be explained by differences in lung function (8, 16, 17, 43). Whether lung function or height is the primary factor in the association remains controversial.

Strong inverse relations between height and death from external causes were observed in this study. Although there have been conflicting findings (44), an inverse trend was reported by other investigators (11, 13). Taller men had a lower risk of violent death than shorter men when results were controlled for health risk factors and socioeconomic factors. Shortness has been associated with psychological and cognitive factors that may increase the risk of suicide and other forms of violent death (45, 46). An alternative explanation is that unmeasured socioeconomic and psychosocial factors in adulthood confound the association between height and violent death. We argued previously that the association between smoking and suicide (and smoking and homicide) observed in a US prospective study reflected such confounding (47). The same might apply to the height-violent death associations seen in the present study. However, height was not related to lung cancer in the present population, although socioeconomic factors were related to lung cancer (12). Thus, the lack of a general association between height and socially patterned causes of death argues against residual confounding of the height-violent death association by adult socioeconomic position. Rather, psychosocial factors, perhaps factors originating in childhood, may be important.

Some potential limitations of this study should be considered. Measurement of height was not guided by any specific measuring method. This will have resulted in misclassification, which would have attenuated the height-mortality associations. We could not directly investigate the role of childhood environment. The many different outcomes analyzed in this study could have caused a significant finding by chance; however, if we consider the high precision of the effect estimates ($p < 0.001$) for common causes of death, this is not likely.

In conclusion, in this study we confirmed previous findings of a consistent inverse relation between height and mortality from all causes, respiratory disease, and external causes. Death from stroke was found to have a strong inverse relation with height; the association was confined to hemorrhagic stroke. Coronary heart disease mortality was not related to height in the present study, perhaps because of the low prevalence of an additional factor with which height interacts. Even though height is a risk factor that cannot be modified once a person becomes an adult, the observed association between height and mortality suggests a possible influence of modifiable early-life environmental factors on health.

ACKNOWLEDGMENTS

This study was supported by the South Korean Ministry of Health and Welfare (grant 01-PJ1-PG1-01CH10-0007).

REFERENCES

1. Rona RJ, Swan AV, Altman DG. Social factors and height of primary schoolchildren in England and Scotland. J Epidemiol Community Health 1978;32:147–54.
2. Rona RJ. Genetic and environmental factors in the control of growth in childhood. Br Med Bull 1981;37:265–72.
3. Marmot MG, Shipley MJ, Rose G. Inequalities in death—specific explanations of a general pattern? Lancet 1984;1:1003–6.
4. Arnesen E, Forsdahl A. The Tromsø Heart Study: coronary risk factors and their association with living conditions during childhood. J Epidemiol Community Health 1985;39:210–14.
5. Kuh DL, Power C, Rodgers B. Secular trends in social class and sex differences in adult height. Int J Epidemiol 1991;20: 1001–9.
6. Sørensen HT, Sabroe S, Rothman KJ, et al. Birth weight and length as predictors for adult height. Am J Epidemiol 1999;149: 726–9.
7. Nystrom Peck AM, Vågerö DH. Adult body height, self perceived health and mortality in the Swedish population. J Epidemiol Community Health 1989;43:380–4.
8. Cook NR, Hebert PR, Satterfield S, et al. Height, lung function, and mortality from cardiovascular disease among the elderly. Am J Epidemiol 1994;139:1066–76.
9. Leon DA, Davey Smith G, Shipley M, et al. Adult height and mortality in London: early life, socioeconomic confounding, or shrinkage? J Epidemiol Community Health 1995;49:5–9.
10. Davey Smith G, Hart C, Upton M, et al. Height and risk of death among men and women: aetiological implications of associations with cardiorespiratory disease and cancer mortality. J Epidemiol Community Health 2000;54:97–103.
11. Jousilahti P, Tuomilehto J, Vartiainen E, et al. Relation of adult height to cause-specific and total morality: a prospective follow-up study of 31,199 middle-aged men and women in Finland. Am J Epidemiol 2000;151:1112–20.
12. Song YM, Byeon JJ. Excess mortality from avoidable and non-avoidable causes in men of low socioeconomic status: a prospective study in Korea. J Epidemiol Community Health 2000; 54:166–72.
13. Allebeck P, Bergh C. Height, body mass index and mortality: do social factors explain the association? Public Health 1992; 106:375–82.
14. Liao Y, McGee DL, Cao G, et al. Short stature and risk of mortality and cardiovascular disease: negative findings from the NHANES I Epidemiologic Follow-up Study. J Am Coll Cardiol 1996;27:678–82.
15. Albanes D, Jones DY, Schatzkin A, et al. Adult stature and risk of cancer. Cancer Res 1988;48:1658–62.

16. Walker M, Shaper AG, Phillips AN, et al. Short stature, lung function and risk of a heart attack. Int J Epidemiol 1989;18:602–6.
17. Yarnell JW, Limb ES, Layzell JM, et al. Height: a risk marker for ischaemic heart disease: prospective results from the Caerphilly and Speedwell Heart Disease Studies. Eur Heart J 1992;13:1602–5.
18. Rich-Edwards JW, Manson JE, Stampfer MJ, et al. Height and the risk of cardiovascular disease in women. Am J Epidemiol 1995;142:909–17.
19. Nwasokwa ON, Weiss M, Gladstone C, et al. Higher prevalence and greater severity of coronary disease in short versus tall men referred for coronary arteriography. Am Heart J 1997;133:147–52.
20. Davey Smith G, Hart C, Watt G, et al. Individual social class, area-based deprivation, cardiovascular disease risk factors, and mortality: The Renfrew and Paisley Study. J Epidemiol Community Health 1998;52:399–405.
21. Hebert PR, Rich-Edwards JW, Manson JE, et al. Height and incidence of cardiovascular disease in male physicians. Circulation 1993;88:1437–43.
22. Millar WJ, Wigle DT. Socioeconomic disparities in risk factors for cardiovascular disease. Can Med Assoc J 1986;134:127–32.
23. Jacobsen BK, Thelle DS. Risk factors for coronary heart disease and level of education: The Tromsø Heart Study. Am J Epidemiol 1988;127:923–32.
24. Greiser E, Joeckel KH, Giersiepen K, et al. Cardiovascular disease risk factors, CHD morbidity and mortality in the Federal Republic of Germany. Int J Epidemiol 1989;18(suppl 1):S118–24.
25. McCarron P, Okasha M, McEwen J, et al. Height in young adulthood and risk of death from cardiorespiratory disease: a prospective study of male former students of Glasgow University, Scotland. Am J Epidemiol 2002;155:683–7.
26. Davey Smith G, Hart C, Blane D, et al. Adverse socioeconomic conditions in childhood and cause specific adult mortality: prospective observational study. BMJ 1998;316:1631–5.
27. Hebert PR, Ajani U, Cook NR, et al. Adult height and incidence of cancer in male physicians (United States). Cancer Causes Control 1997;8:591–7.
28. Davey Smith G, Shipley M, Leon DA. Height and mortality from cancer among men: prospective observational study. BMJ 1998;317:1351–2.
29. Robsbahm TE, Tretli S. Height, weight and gastrointestinal cancer: a follow-up study in Norway. Eur J Cancer Prev 1999;8:105–13.
30. Gunnell D, Okasha M, Davey Smith G, et al. Height, leg length, and cancer risk: a systematic review. Epidemiol Rev 2001;23:313–42.
31. Cats A, Dullaart RP, Kleibeuker JH, et al. Increased epithelial cell proliferation in the colon of patients with acromegaly. Cancer Res 1996;56:523–6.
32. Chan JM, Stampfer MJ, Giovannucci E, et al. Plasma insulin-like growth factor I and prostate cancer risk: a prospective study. Science 1998;279:563–6.
33. Hankinson SE, Willett WC, Colditz GA, et al. Circulating concentrations of insulin-like growth factor I and risk of breast cancer. Lancet 1998;351:1393–6.
34. Davey Smith G, Gunnell D, Holly J. Cancer and insulin-like growth factor I: a potential mechanism linking the environment with cancer risk. (Editorial). BMJ 2000;321:847–8.
35. Forman D, Newell DG, Fullerton F, et al. Association between infection with *Helicobacter pylori* and risk of gastric cancer: evidence from a prospective investigation. BMJ 1991;302:1302–5.
36. Perri F, Pastore M, Leandro G, et al. *Helicobacter pylori* infection and growth delay in older children. Arch Dis Child 1997;77:46–9.
37. Håheim LL, Holme I, Hjermann I, et al. Risk factors of stroke incidence and mortality: a 12-year follow-up of the Oslo Study. Stroke 1993;24:1484–9.
38. Njølstad I, Arnesen E, Lund-Larsen PG. Body height, cardiovascular risk factors, and risk of stroke in middle-aged men and women: a 14-year follow-up of the Finnmark Study. Circulation 1996;94:2877–82.
39. Goldbourt U, Tanne D. Body height is associated with decreased long-term stroke but not coronary heart disease mortality? Stroke 2002;33:743–8.
40. McCarron P, Greenwood R, Ebrahim S, et al. Adult height is inversely associated with ischaemic stroke: the Caerphilly and Speedwell collaborative studies. J Epidemiol Community Health 2000;54:239–40.
41. McCarron P, Hart CL, Hole D, et al. The relation between adult height and haemorrhagic and ischaemic stroke in the Renfrew/Paisley Study. J Epidemiol Community Health 2001;55:404–5.
42. Hart CL, Davey Smith G. The relation between number of siblings and adult mortality and stroke risk: 25 year follow up of men in the Collaborative Study. J Epidemiol Community Health 2003;57:385–91.
43. Strachan DP. Ventilatory function, height, and mortality among lifelong non-smokers. J Epidemiol Community Health 1992;46:66–70.
44. Stack S, Wasserman I. Height and risk of suicide. J Soc Psychol 1996;136:255–6.
45. Jiang GX, Rasmussen F, Wasserman D. Short stature and poor psychological performance: risk factors for attempted suicide among Swedish male conscripts. Acta Psychiatr Scand 1999;100:433–40.
46. Tuvemo T, Jonsson B, Persson I. Intellectual and physical performance and morbidity in relation to height in a cohort of 18-year-old Swedish conscripts. Horm Res 1999;52:186–91.
47. Davey Smith G, Phillips AN, Neaton JD. Smoking as "independent" risk factor for suicide: illustration of an artifact from observational epidemiology? Lancet 1992;340:709–12.