International Differences in Body Height and Weight and Their Relationship to Cancer Incidence

Demetrius Albanes and Philip R. Taylor

Abstract

The relationship between body size (adult height and weight) and cancer incidence was investigated in an international ecological study of 24 populations. Site-specific and total cancer incidence rates (age standardized) from 1973 to 1977 were correlated with body size data generally obtained between 1954 and 1974. All-sites cancer incidence was highly correlated with height among both men ($r = 0.50$; $p \leq 0.01$) and women ($r = 0.70$; $p \leq 0.001$). Among men, there were significant correlations between height and cancers of the central nervous system ($r = 0.72$), prostate ($r = 0.66$), bladder ($r = 0.65$), pancreas ($r = 0.59$), lung ($r = 0.47$), and colon ($r = 0.46$). Significant correlations were observed for cancers of the rectum ($r = 0.76$), pancreas ($r = 0.75$), ovary ($r = 0.73$), central nervous system ($r = 0.68$), breast ($r = 0.65$), uterine corpus ($r = 0.50$), and bladder ($r = 0.48$) in women. Adjustment for weight altered these correlations only minimally. Weight was significantly correlated to all-sites cancer only among women ($r = 0.44$; $p < 0.05$), and site-specific correlations were significant for the same sites as for height, but the magnitude of the correlation coefficients was somewhat diminished. In addition, adjustment for height greatly reduced the correlations with weight. These findings support previously observed associations between height and specific cancers (e.g., breast and colon) and identify several additional cancer sites that may be similarly related.

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Introduction

There has been increasing interest in the relationship between anthropometric dimensions and the development of cancer in humans. Beginning with earlier investigations such as those of de Waard and co-workers (1), body weight and fatness have received greater attention in this regard, than, for example, frame size or body height. Increased weight has been associated with increased risk of cancer, although negative and conflicting studies also exist

D. Albanes and P.R. Taylor are affiliated with the Cancer Prevention Studies Branch, Division of Cancer Prevention and Control, National Cancer Institute, National Institutes of Health, Bethesda, MD 20892.

(see Ref. 2 for review). A large number of these investigations concern breast cancer specifically (e.g., 1, 3–5). Most recently, increased height has also been implicated as a risk factor for several cancers, including large bowel and breast (6,7), with previous investigations supporting a positive height-cancer association (e.g., 8–10). With few exceptions, however, these investigations and others like them have been case-control or cohort studies conducted within single western industrialized countries.

In contrast, the relation between anthropometry and cancer has seldom been examined through cross-national comparisons. Such geographic correlation studies in theory offer greater diversity of both the anthropometric dimensions, which are determined by hereditary and environmental factors, and cancer incidence than would most of the analytic studies mentioned above. While a variety of environmental factors—most notably, per capita food "consumption"—have been correlated with incidence and mortality rates (11,12), height or weight has been investigated in this way only with respect to cancer of the breast (13–15). The latter studies provide evidence supportive of a positive body size-breast cancer association and suggest that international variation in height or weight may contribute to the observed differences in incidence of this particular cancer. Although similar ecological investigations of other cancer sites would be useful, they have not been previously reported.

For this reason, and to specifically evaluate the recently reported association between height and cancer of several sites, we studied the relationship between body weight and height and cancer incidence in 24 populations.

Materials and Methods

Data concerning height and weight were taken from the published volume of Eveleth and Tanner (16). This compilation of a large number of growth and anthropometry surveys conducted throughout the world includes both random and representative study samples of up to 1,000 subjects (most involved 100–500). With the exception of the New Zealand Maoris (1930) and Iowa, United States (1946), the anthropometric measurements were obtained between 1954 and 1974, the majority taken in the 1960s. Although anthropometric data for children and adolescents were available for the present investigation, we used only information reported for "young adults," whose ages were usually given as being in the range of 18–39 years. These populations would, therefore, have reached maturity and attained adult height. In the few instances where "young adult" data were not available, information for the next youngest, single age group (i.e., 18 yr olds) was used. Data for body weight were not reported for one male and two female populations, and these were excluded from the correlations involving weight. Because information concerning relative body weight, body mass indices, or other measures of body fatness was not available for the present study, statistical adjustment of weight for height (and height for weight) through partial correlations was also performed.

International cancer incidence data available from the International Association of Cancer Registries (IACR) and the International Agency for Research on Cancer (IARC) were used in these analyses (17). This volume of the monograph series represents cancer registry data for 1971–1977, with the years 1973–1977 being reported and used for most registries. All rates were age standardized to the world population. Incidence data that are more recent than the anthropometric data were used so that an adequate correspondence of birth cohorts be obtained between the cancer and anthropometry data. This resulted in a median "lag-time" interval of approximately 10 years. Only the following major anatomic sites were included in the present study: stomach (International Classification for Diseases, 8th Revision, rubric 151); colon (153); rectum (154); pancreas (157); trachea, bronchus, and lung (162) (referred to as "lung"); breast (174) (females only); cervix (180); corpus uteri (182);

ovary (183); prostate (185); bladder (188); brain and nervous system (191,192); and all sites combined (except nonmelanoma skin) (140–209, except 173).

All countries or population groups within countries for which there were available both anthropometric and cancer incidence data were included in the present analyses. For countries with cancer incidence data available from more than one geographic area (e.g., Japan and United States), cancer data for the area corresponding to the anthropometry population sample were selected. In all, information concerning 24 male and 23 female populations was used and appears in Tables 1 and 2. Simple, nonparametric (i.e., Spearman rank) and partial correlation coefficients were calculated using standard available statistical software (18).

Results

Height and weight were significantly correlated in both men ($r = 0.54$; $p = 0.008$) and women ($r = 0.74$; $p \leq 0.0001$). The simple and partial correlations between several cancer sites and height and weight appear in Table 3. In general, both anthropometric dimensions were positively related to cancer, with somewhat higher correlation coefficients for females compared with males for both variables. With few exceptions, stronger correlations were demonstrated for height than for weight. Also, the partial correlations for height adjusted for weight were generally comparable to the simple correlations with height, in contrast to the correlations for weight, which were substantially reduced after controlling for height. In decreasing order of statistical significance, simple correlations of height to cancer were seen for cancers of the central nervous system (CNS), prostate, bladder, pancreas, lung, and colon in men and rectum, pancreas, ovary, CNS, breast, uterine corpus, and bladder in women. The pattern for weight was rectum, pancreas, CNS, lung, and colon in men and rectum, CNS, uterine corpus, ovary, breast, and pancreas in women. Cancer of the stomach and cervix showed little relation to either anthropometric dimension. Scatter plots for some of the above correlations of height and cancer rates are shown in Figures 1 and 2.

Discussion

Few if any disease–risk factor associations depend solely on correlational analyses for their support. Ecological studies can, however, provide corroborative and informative data useful in identifying relationships warranting further investigation. Also, because such studies use data from diverse populations and generally include a greater range of exposure, they permit evaluation of disease occurrence at the extremes of exposure and may offer additional insights into the disease–risk factor relationship. Dietary components have received much attention in this regard (11,19). Anthropometric dimensions represent another example of such heterogeneity in disease risk factors across populations, in this instance contributed to by both genetic and environmental (particularly nutritional) factors.

Our findings provide evidence in support of a positive cancer–body size relationship, particularly for height. Cancer of the pancreas, bladder, and CNS showed strong correlations with height in both sexes. Also significantly associated with height and contributing to the positive all-sites correlations were prostate, lung, and colon cancer in men and rectum, ovary, breast, and corpus uteri cancer in women. These data, which remained relatively stable after adjustment for weight, corroborate the reported associations between height and cancer of the breast (3,4,6–9,15), lung (10), colon (6), endometrium (20), and ovary (21) and suggest additional cancers, not previously identified, which may be similarly related.

Earlier studies have shown positive associations to body weight for cancer of the breast (3,8,9,14), endometrium (20,22,23), and ovary (21,24). In the present investigation, rectal cancer alone was significantly related to weight in both men and women and CNS,

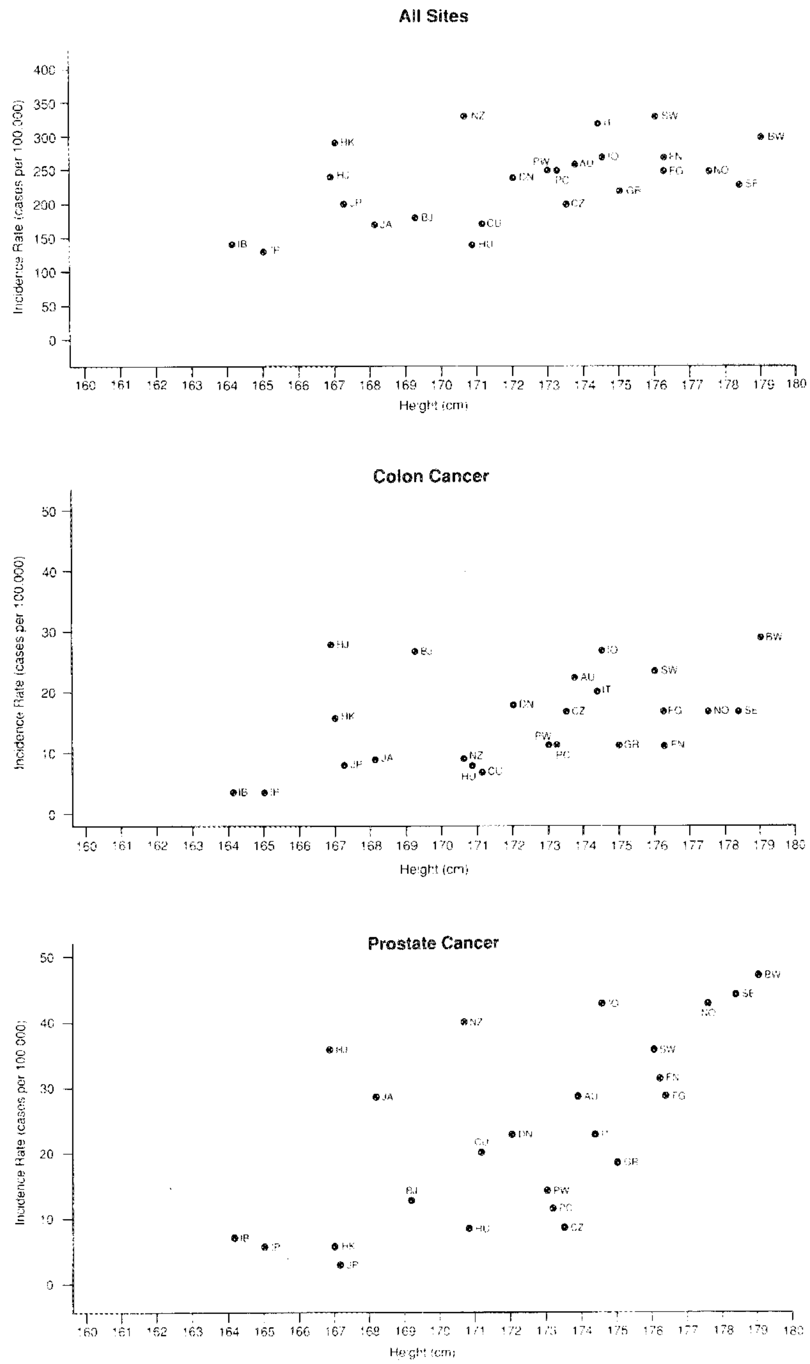

Figure 1. All-sites, colon, and prostate cancer incidence rates (1973–1977) by height in 24 male populations internationally.

by height in 24 male populations

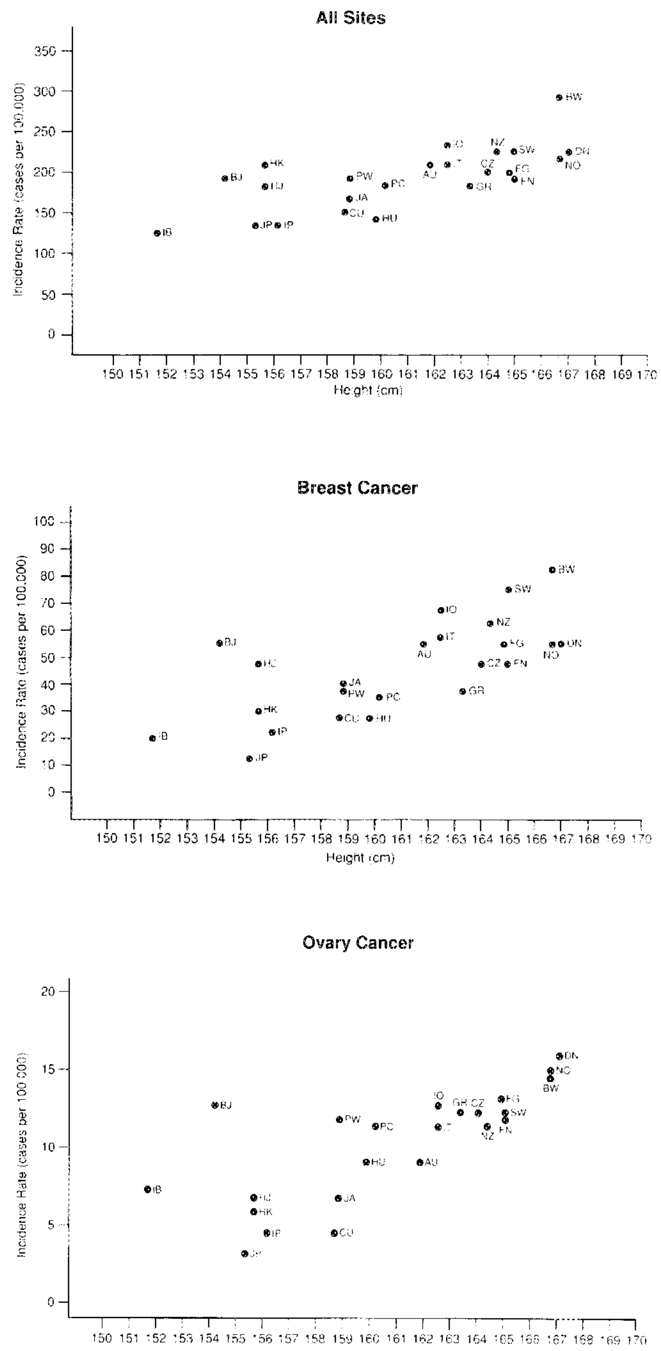

Figure 2. All-sites, breast, and ovary cancer incidence rates (1973–1977) by height in 23 female populations internationally.

Table 1. Age-Standardized Cancer Incidence Rates[a] and Anthropometry Data by Country for Males

	Cancer Rates									Anthropometry	
Cancer[b]	All sites	Stomach	Colon	Rectum	Pancreas	Lung	Prostate	Bladder	Central nervous system	Height, cm	Weight, kg
Cuba (CU)	169.8	12.4	7.1	4.4	4.9	44.4	19.9	9.1	2.5	168.0	57.1
Jamaica (JA)	173.5	17.7	8.7	3.7	2.3	19.8	28.6	8.5	2.4	174.5	61.0
SF-Bay, White	304.0	10.8	29.0	15.6	9.3	64.3	47.4	20.0	6.8	179.0	70.2
SF-Bay, Japanese (BJ)	180.3	28.1	26.7	15.3	3.9	28.7	12.7	6.5	3.0	169.2	66.4
Iowa (IO)	273.6	7.5	26.4	14.9	8.8	58.5	43.4	19.1	6.5	174.5	63.0
Hong Kong (HK)	289.5	22.5	15.0	11.6	3.7	55.5	5.1	17.1	2.7	169.0	54.3
India, Bombay (IB)	140.5	9.7	3.5	4.5	2.0	14.2	6.8	3.5	1.6	162.5	46.5
India, Poona (IP)	126.3	8.8	3.1	4.7	1.7	9.2	6.2	2.4	1.0	165.0	49.0
Japan (JP)	203.8	78.0	7.7	7.9	5.8	29.4	3.4	5.1	2.8	167.2	58.9
Czechoslovakia (CZ)	204.7	31.6	16.7	16.9	6.1	44.1	9.1	8.5	5.7	176.4	68.0
Denmark (DN)	239.4	20.5	17.5	17.2	10.0	48.9	23.0	20.5	6.7	172.0	74.7
Finland (FN)	271.5	29.7	10.7	10.2	11.2	80.9	32.1	11.2	7.3	177.3	65.8
FR Germany (FG)	251.4	26.7	16.5	12.9	7.8	64.4	28.5	13.7	4.1	176.3	66.1
German DR (GR)	217.1	30.3	10.7	13.3	6.7	59.0	18.1	10.1	5.4	175.0	65.5
Hungary (HU)	137.2	21.2	7.4	9.8	2.3	32.6	8.9	3.1	1.5	175.9	66.8
Italy (IT)	318.4	38.5	19.9	15.7	6.7	70.4	22.8	24.6	5.3	173.8	66.5
Norway NO)	246.1	21.0	16.9	13.2	10.0	34.3	42.4	16.7	8.0	179.3	67.7
Poland, Cracow (PC)	246.7	35.1	10.7	10.7	10.1	74.6	11.0	12.2	7.4	173.2	69.0
Poland, Warsaw (PW)	250.7	31.4	11.6	9.4	9.6	68.4	14.6	9.7	7.9	174.4	66.1
Sweden (SE)	227.9	18.3	16.3	10.9	9.1	23.8	44.4	13.7	9.2	178.4	65.4
Switzerland (SW)	328.6	20.9	22.9	16.2	8.8	69.4	36.3	30.2	7.9	176.0	61.8
Australia (AU)	258.7	14.2	22.6	13.5	8.3	54.8	28.2	15.7	6.4	173.8	65.5
New Zealand Maoris (NZ)	326.4	41.7	9.0	9.8	14.8	105.7	39.8	5.0	7.6	170.6	
Hawaii-Japanese (HJ)	240.7	34.0	27.5	21.4	8.6	38.3	35.9	9.9	2.0	166.9	59.0

a: Rates are per year per 100,000 persons.
b: Abbreviations include SF-Bay (San Francisco-Bay area, US); FR Germany (Federal Republic of Germany); German DR (German Democratic Republic). Country codes in parentheses also appear in Figures 1 and 2.

Poland, Cracow (PC)	246.7	35.1	10.7	10.7	10.1	74.6	11.0	12.2	7.4	173.2	69.0
Poland, Warsaw (PW)	250.7	31.4	11.6	9.4	9.6	68.4	14.6	9.7	7.9	174.4	66.1
Sweden (SE)	227.9	18.3	16.3	10.9	9.1	23.8	44.4	13.7	9.2	178.4	65.4
Switzerland (SW)	328.6	20.9	22.9	16.2	8.8	69.4	36.3	30.2	7.9	176.0	61.8
Australia (AU)	258.7	14.2	22.6	13.5	8.3	54.8	28.2	15.7	6.4	173.8	65.5
New Zealand Maoris (NZ)	326.4	41.7	9.0	9.8	14.8	105.7	39.8	5.0	7.6	170.6	
Hawaii-Japanese (HJ)	240.7	34.0	27.5	21.4	8.6	38.3	35.9	9.9	2.0	166.9	59.0

a: Rates are per year per 100,000 persons.
b: Abbreviations include SF-Bay (San Francisco-Bay area, US); FR Germany (Federal Republic of Germany); German DR (German Democratic Republic). Country codes in parentheses also appear in Figures 1 and 2.

Table 2. Age-Standardized Cancer Incidence Rates[a] and Anthropometry Data by Country for Females

	Cancer Rates												Anthropometry	
Country[b]	All sites	Stomach	Colon	Rectum	Pancreas	Lung	Breast	Cervix	Corpus	Ovary	Bladder	Central nervous system	Height, cm	Weight, kg
Cuba (CU)	147.0	7.3	8.7	4.2	3.1	16.1	28.0	19.5	10.9	4.6	2.2	2.1	156.5	51.5
Jamaica (JA)	165.5	9.3	7.5	3.8	3.2	4.0	39.0	29.8	7.8	7.0	3.9	1.1	160.0	51.5
SF-Bay, White	290.4	4.9	24.1	9.5	6.4	24.7	83.7	10.7	36.7	14.4	5.5	5.4	166.6	59.8
SF-Bay, Japanese (BJ)	190.7	24.3	27.4	4.5	4.8	7.6	55.1	4.7	14.7	12.7	3.2	2.5	154.2	52.1
Iowa (IO)	231.9	3.1	25.9	9.3	5.1	12.1	68.4	11.9	21.0	12.6	4.7	4.3	162.5	54.4
Hong Kong (HK)	207.6	10.3	11.6	8.7	2.3	23.4	31.1	30.4	5.7	5.8	5.9	2.3	156.7	45.3
India, Bombay (IB)	128.5	5.9	3.5	3.1	0.9	4.0	21.2	23.3	1.4	7.2	0.9	1.3	151.7	42.5
India, Poona (IP)	135.6	7.7	2.8	2.9	1.1	2.7	23.3	30.7	2.2	4.6	1.2	0.9	156.2	42.5
Japan (JP)	137.2	38.5	6.3	4.7	3.4	8.5	12.7	17.2	1.4	3.4	1.5	2.4	155.3	48.9
Czechoslovakia (CZ)	196.4	15.7	10.5	9.8	5.0	6.9	47.2	21.7	13.7	12.1	8.5	3.1	164.0	59.4
Denmark (DN)	227.6	10.9	18.7	10.9	6.3	10.1	54.4	27.1	12.6	15.9	5.4	5.0	167.0	
Finland (FN)	188.4	15.5	10.4	7.0	6.7	7.1	46.7	9.3	11.9	11.8	2.7	7.3	165.0	56.8
FR Germany (FG)	201.0	12.6	14.9	9.2	4.5	10.0	55.7	18.4	10.3	13.3	3.1	2.7	164.9	57.4
German DR (GR)	186.7	14.3	10.8	9.8	3.9	5.3	37.4	30.1	14.3	12.2	1.8	4.8	163.0	57.4
Hungary (HU)	140.1	11.5	11.3	8.6	2.9	5.8	27.6	18.5	9.4	9.0	0.4	0.6	160.8	55.8
Italy (IT)	208.0	19.1	16.9	9.1	3.9	5.8	57.6	11.7	14.2	11.3	3.1	4.8	160.2	56.5
Norway NO)	216.7	11.1	16.1	9.6	6.2	6.9	55.0	21.6	10.5	14.9	4.7	7.6	166.6	58.7
Poland, Cracow (PC)	184.9	15.6	7.6	6.0	3.4	11.1	35.2	20.4	9.8	11.4	1.9	7.3	160.2	59.0
Poland, Warsaw (PW)	188.8	12.9	9.8	6.2	5.4	11.7	36.5	19.1	9.7	11.9	2.4	6.6	161.0	55.3
Switzerland (SW)	225.2	9.4	16.4	9.0	5.0	8.5	76.1	11.8	16.2	12.2	5.2	3.4	165.0	58.0
Australia (AU)	205.7	7.1	18.6	8.7	4.9	9.5	55.0	13.3	8.0	9.2	4.3	4.5	161.8	55.3
New Zealand (NZ)	228.5	7.0	26.9	11.2	5.0	11.5	62.6	10.8	11.2	11.3	3.4	4.8	164.3	
Hawaii-Japanese (HJ)	181.9	15.1	18.8	8.8	4.5	11.5	47.1	6.4	19.4	7.0	3.4	2.1	155.7	49.9

a: Rates are per year per 100,000 persons.
b: Abbreviations include SF-Bay (San Francisco-Bay area, US); FR Germany (Federal Republic of Germany); German DR (German Democratic Republic).

Table 3. Correlations Between Body Size and Cancer Incidence Across 24 Male and 23 Female Populations[a,b]

	Males				Females			
	Height		Weight		Height		Weight	
All sites	0.50*	(0.64)*	0.12	(−0.31)	0.70‡	(0.54)†	0.44†	(−0.09)
Stomach	−0.07	(−0.25)	0.27	(0.25)	−0.13	(−0.35)	0.18	(0.27)
Colon	0.46†	(0.33)	0.31	(0.02)	0.39	(0.13)	0.22	(0.10)
Rectum	0.38	(0.16)	0.46†	(0.27)	0.76‡	(0.55)*	0.60*	(−0.06)
Pancreas	0.59*	(0.66)‡	0.37	(−0.09)	0.75‡	(0.43)	0.42†	(0.19)
Lung	0.47†	(0.49)†	0.32	(0.00)	0.12	(0.07)	0.09	(0.00)
Breast					0.65‡	(0.50)†	0.48†	(−0.03)
Uterine cervix					−0.14	(0.09)	−0.14	(−0.23)
Uterine corpus					0.50†	(0.23)	0.53*	(0.18)
Ovary					0.73‡	(0.45)†	0.51†	(0.19)
Prostate	0.66‡	(0.71)‡	0.19	(−0.36)				
Bladder	0.65‡	(0.58)*	0.27	(−0.21)	0.48†	(0.38)	0.23	(−0.14)
Central nervous system	0.72‡	(0.79)‡	0.36	(−0.18)	0.68‡	(0.31)	0.59*	(0.17)

a: Significance was as follows: *, $0.001 < p \leq 0.01$; †, $0.01 < p \leq 0.05$; ‡, $p \leq 0.001$.
b: Partial correlations are given in parentheses.

endometrium, ovary, breast, and pancreas cancers were so only in women. The cancer-weight correlations were, however, greatly diminished after adjustment for height. This suggests a lesser role for relative weight than for weight itself in the international variation in cancer. These data, therefore, highlight the importance of absolute body size, as measured by height (and to a lesser degree, absolute weight).

The inherent limitations of ecological analyses are well known and have been previously discussed in the context of diet-cancer relationships (11). They include such issues as validity and representativeness of risk factor and disease levels, appropriateness of the available measurement periods, and possible confounding. For example, the present analysis was not designed to rule out possible associations with other environmental factors (e.g., smoking or diet), in part because adequate data for each of these populations are not readily available for all such factors and because it is unclear whether ecological studies can actually accomplish this (11). Nonetheless, it is doubtful whether all the sites showing significant correlations in the present study could be explained by one or two other environmental factors. Despite such potential shortcomings, the present investigation suggests a generally positive association cross nationally between cancer incidence and height and weight, consistent with several previous studies conducted within individual populations. The analysis also identifies a few cancer sites that have not been previously associated with body size.

Acknowledgments and Notes

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	Females		
ght		Weight	
(0.54)†	0.44†	(−0.09)	
(−0.35)	0.18	(0.27)	
(0.13)	0.22	(0.10)	
(0.55)*	0.60*	(−0.06)	
(0.43)	0.42†	(0.19)	
(0.07)	0.09	(0.00)	
(0.50)†	0.48†	(−0.03)	
(0.09)	−0.14	(−0.23)	
(0.23)	0.53*	(0.18)	
(0.45)†	0.51†	(0.19)	
(0.38)	0.23	(−0.14)	
(0.31)	0.59*	(0.17)	

5; ‡, $p \leq 0.001$.

only in women. The cancer- adjustment for height. This in the international variation solute body size, as measured

wn and have been previously include such issues as validity ropriateness of the available , the present analysis was not ntal factors (e.g., smoking or ions are not readily available ological studies can actually the sites showing significant or two other environmental stigation suggests a generally nce and height and weight, individual populations. The eviously associated with body

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