Relations of body fat distribution and height with cataract in men[1–3]

Debra A Schaumberg, Robert J Glynn, William G Christen, Susan E Hankinson, and Charles H Hennekens

See corresponding editorial on page 1417.

ABSTRACT

Background: Cataract is the leading cause of blindness worldwide. Body mass index (BMI; in kg/m^2) is a risk factor for cataract, but other anthropometric measurements may also be important.
Objective: We tested relations of alternative measures of body size, including height and waist-to-hip ratio (WHR), as well as BMI, with cataract.
Design: This was a prospective follow-up study. We analyzed data from 20 271 participants in the Physicians' Health Study who did not have cataract at baseline and for whom there was complete information on weight, height, and other risk factors. For analyses concerning WHR, we excluded 3121 additional men for whom we did not have these measurements, assessed at the ninth year of follow-up. The main outcome measures were incident cataract and cataract surgery.
Results: Among the 17 150 men for whom there were complete data, we confirmed an incident cataract in 1727 during an average of 14 y of follow-up. In proportional hazards regression models that adjusted for many known or suspected risk factors, higher BMI [rate ratio (RR) = 1.25 for ≥27.8 compared with <22, *P* for trend = 0.03], height (RR = 1.23 for ≥184 cm compared with ≤170 cm, *P* for trend = 0.02), and WHR (RR = 1.31 for top compared with bottom quintile, *P* for trend = 0.003) were each independently associated with incident cataract.
Conclusions: In addition to BMI, both height and abdominal adiposity are independent risk factors for cataract. These relations are biologically plausible and, if causal, suggest that prevention of obesity and beneficial lifestyle changes resulting in weight loss and reduction of central obesity would lessen the incidence and costs of cataract. *Am J Clin Nutr* 2000;72:1495–502.

KEY WORDS Body fat distribution, height, cataract, men, Physicians' Health Study

INTRODUCTION

Cataract accounts for nearly half of all blindness worldwide (1). At the population level, the costs and consequences of cataract could be reduced greatly if the development of cataract could be delayed. Restriction of total energy consumption, resulting in lower body weight, delays the onset of cataract (2, 3) and prolongs the life span of rodents (3, 4). In keeping with these data, most epidemiologic studies showed an increased risk of cataract with higher body weight (5–8), but 2 studies found an inverse relation (9, 10).

Although most studies concentrated on body mass index (BMI; in kg/m^2), which appears to be a valid measure of body composition (11, 12), other anthropometric measures may be relevant to health outcomes (13). For example, height provides information on body size, whereas BMI dose not (13). In addition, the waist-to-hip ratio (WHR) is more indicative than is BMI of intraabdominal (visceral) fat, which has important metabolic consequences (14–16).

In an analysis based on the first 5 y of follow-up in the Physicians' Health Study (PHS), we showed that BMI was an independent risk factor for cataract (5). The objective of the present study was to test whether alternative measures of body size and composition also predict risk of cataract and to reexamine the relation of BMI with cataract over a longer follow-up period.

SUBJECTS AND METHODS

The PHS, a randomized trial of 22 071 apparently healthy male US physicians who were aged 40–84 y in 1982, tested the benefits and risks of alternate-day low-dose aspirin and β-carotene on cardiovascular disease and cancer (17–19). Men with a history of cancer, myocardial infarction, stroke, transient cerebral ischemia, renal or liver disease, peptic ulcer, or gout were excluded. Informed consent was obtained from all participants, and the research protocol was approved by the institutional review board at Brigham and Women's Hospital, Boston.

The participants completed mailed questionnaires every 6 mo during the first year and then annually. Self-reported weight and height were assessed at baseline and weight was updated annually starting at 8 y. We calculated BMI at each weight assessment and formed categories of BMI (<22, 22–24.9, 25–27.7, and ≥27.8) and height (≤170, 171–178, 179–183, and ≥174 cm) to facilitate comparisons with previous articles (5, 7). In addition, since the National Heart, Lung, and Blood Institute and other organizations, including the World Health Organization, recently

[1] From the Division of Preventive Medicine and the Channing Laboratory of the Brigham and Women's Hospital, Harvard Medical School, and the Departments of Epidemiology and Biostatistics, Harvard School of Public Health, Boston.

[2] Supported by grants EY000365, EY06633, CA34944, CA40360, HL26490, and HL34595 from the National Institutes of Health.

[3] Address reprint requests to DA Schaumberg, Division of Preventive Medicine, Brigham and Women's Hospital, Harvard Medical School, 900 Commonwealth Avenue East, Boston, MA 02215. E-mail: dschaumberg@rics.bwh.harvard.edu.

Received December 29, 1999.
Accepted for publication June 8, 2000.

TABLE 1
Spearman correlation coefficients among anthropometric measures in the Physicians' Health Study[1]

Variable[2]	Baseline		9 y				
	Weight (kg)	BMI (kg/m²)	Weight (kg)	BMI (kg/m²)	Waist (cm)	Hip (cm)	WHR
				±			
Height, 1.78 ± 0.76 m	0.56	−0.04	0.52	−0.03	0.25	0.33	0.02
Baseline weight, 79.08 ± 10.66 kg		0.76	0.88	0.64	0.69	0.69	0.27
Baseline BMI, 24.93 ± 3.03 kg/m²			0.66	0.84	0.63	0.58	0.32
9-y weight, 80.84 ± 11.91 kg				0.80	0.77	0.78	0.30
9-y BMI, 25.49 ± 3.45 kg/m²					0.72	0.68	0.34
Waist, 37.87 ± 3.76 cm						0.75	0.66
Hip, 40.13 ± 3.21 cm							0.06
WHR, 0.94 ± 0.07							

[1] All correlation coefficients were significant at $P < 0.05$. WHR, waist-to-hip ratio.
[2] $\bar{x}$ ± SD.

adopted BMI cutoffs of 25–29.9 for overweight and of ≥30 for obesity, we also fitted a model using these categories (20).

Along with the 9-y questionnaire, the participants were mailed a tape measure and instructions for measuring their waist and hip circumferences to the nearest quarter inch (≈0.6 cm). Waist circumference was measured at the umbilicus, and hip was measured around the largest circumference between the waist and thighs while the subjects were standing and not wearing bulky clothing. We formed 5 groups based on quintiles of the distribution of WHR in the study population.

Physician self-reports of anthropometric measurements appear reliable (21, 22). In a previous validation study, correlations of self-reported versus technician measurements were 0.97 for weight, 0.95 for waist, 0.88 for hip, and 0.69 for WHR (22).

Annually, we asked each participant whether, during the previous year, he had had a cataract diagnosed in his right or left eye. We confirmed an incident cataract if the self-report was substantiated by review of medical records (23) as being age related, associated with a reduction in best-corrected visual acuity of 20/30 or worse as a result of the cataract, and diagnosed after baseline (5, 19, 23, 24). Other researchers found few differences between risk factors for incident cataract and cataract progression (25). We analyzed individuals because an independent examiner did not assess cataract in each eye. We considered a participant to have an incident cataract at the time cataract was confirmed in either eye.

For the present study, 1800 men were ineligible, leaving 20 271 for the analysis. Reasons for exclusion were prevalent cataract at baseline (n = 1103) and missing information (n = 697). In analyses of WHR we excluded 3121 additional men with missing (n = 3103) or implausible (n = 18) WHRs or BMIs at 96 mo. Waist or hip circumferences >60 inches (152.4 cm) or <15 inches (38.1 cm) were considered implausible.

We followed subjects from baseline until diagnosis of cataract, death, or December 1997, whichever came first. During 277 137 person-years, 2007 study participants developed a confirmed incident cataract; of these, 1764 had a nuclear component, 750 had a cortical component, and 828 had a posterior subcapsular component (>1 subtype could be present simultaneously). Incident cataract surgery was confirmed in 1157 men.

We calculated Spearman correlations among the anthropometric variables and the prevalence of baseline characteristics adjusted for age in 5-y categories. To obtain rate ratios (RRs) and 95% CIs of cataract for each exposure, we used proportional hazards regression models (26) that adjusted for age and randomization assignments (aspirin compared with placebo and β-carotene compared with placebo). We extended these models to control for cigarette smoking status (never, past, current smoker of <20 cigarettes/d, or current smoker of ≥20 cigarettes/d), daily alcohol intake (no or yes), multivitamin use (never, past, or current), and weekly vigorous exercise (no or yes). We also fitted models adjusting for pack-years of smoking, assessed on the 5-y questionnaire (27), as well as alcohol consumption (≥2 drinks/d, 1 drink/d, 5–6 drinks/wk, 2–4 drinks/wk, 1 drink/wk, 1–3 drinks/mo, or rare or no consumption of alcohol), vitamin E use (never, past, or current), vitamin C use (never, past, or current), and mean daily servings of vegetables (sum of servings of broccoli, Brussels sprouts, carrots, spinach, dark-green lettuce, yellow squash, yams or sweet potatoes, and tomato juice or tomatoes), fruit (sum of servings of orange juice, cantaloupe, peaches, apricots, and nectarines), and cold breakfast cereal. High blood pressure, gout, and diabetes mellitus are direct effects of obesity, so we deliberately did not control for these factors in our primary analyses because we were interested in assessing the total effect of body weight. To assess possible effects of adiposity independent of these pathways, we also performed separate analyses adjusting for these factors, which were treated as time-varying covariates.

We initially tested relations of BMI and height with cataract. In addition to baseline values, we used time-varying exposure models to test the effect of the nearest past BMI measurement. We investigated whether relations of BMI and height with cataract were similar in the 17 150 men for whom we had a WHR measurement. If they were, we extended the models with BMI and height to include WHR. We repeated the analyses in the 16 226 participants who had complete information and remained free of cataract at the time of the WHR measurement. In this subset, 806 participants had an incident cataract confirmed during an average of 5.6 y of follow-up. We also tested the assumption of proportional hazards over time and found no violation of this assumption for any exposure ($P \geq 0.2$ for each) (26).

RESULTS

Means and SDs for the anthropometric variables are provided in **Table 1**. Because of the large sample size, all correlations between the anthropometric variables were significantly different from zero ($P < 0.05$ for each), but the magnitude of the correlations varied considerably. For example, there were strong correlations between baseline weight and baseline BMI (r = 0.76)

TABLE 2
Age-adjusted relations of anthropometric measures with other risk factors for cataract in the Physicians' Health Study

Variable	Age	Subjects with characteristic at baseline					
		Systolic blood pressure ≥140 mm Hg	Diabetes mellitus	Current smoker of ≥20 cigarettes/d	Vigorous exercise weekly	Daily alcohol intake	Current multivitamin use
	y	%					
Height (cm)							
≤170 (*n* = 1935) [9.5][1]	53.05 ± 9.92[2]	5.7	2.5	6.0	64.6	18.6	18.9
171–178 (*n* = 8828) [43.5]	53.22 ± 9.20	6.4	2.1	7.0	71.4	23.9	19.2
179–183 (*n* = 5957) [29.4]	52.07 ± 8.74	6.3	2.2	7.7	74.5	24.7	19.8
≥184 (*n* = 3551) [17.5]	51.11 ± 8.21	6.4	2.0	6.4	75.3	27.7	18.9
P for trend		0.7	0.3	0.7	<0.001	<0.001	0.6
Weight (kg)							
≤68 (*n* = 2318) [11.4]	52.43 ± 10.03	4.1	1.9	6.5	70.6	23.0	21.5
69–79 (*n* = 9652) [43.7]	52.65 ± 9.20	5.3	2.0	6.4	74.7	24.8	19.8
80–90 (*n* = 6121) [27.7]	52.47 ± 8.59	6.9	2.1	7.5	71.2	25.1	18.6
≥91 (*n* = 2180) [10.8]	51.96 ± 8.06	11.2	3.7	8.9	67.7	21.3	17.5
P for trend		<0.001	<0.001	<0.001	<0.001	0.2	<0.001
BMI (kg/m^2)							
<22 (*n* = 2456) [12.1]	51.60 ± 9.48	3.8	1.9	6.8	74.7	27.4	22.0
22–24.9 (*n* = 9006) [44.4]	52.36 ± 9.14	4.9	1.8	6.3	75.6	25.2	20.1
25–27.7 (*n* = 6049) [29.8]	53.02 ± 8.81	7.3	2.1	7.5	70.8	24.0	18.5
≥27.8 (*n* = 2760) [13.6]	52.61 ± 8.49	10.8	3.8	9.0	63.5	19.7	17.2
P for trend		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Waist-to-hip ratio							
<0.897 (*n* = 3365) [16.6]	50.01 ± 8.06	4.1	1.9	4.4	78.4	22.1	20.0
0.897–0.924 (*n* = 3517) [17.3]	51.28 ± 8.21	4.9	1.1	5.0	76.3	23.3	18.4
0.925–0.950 (*n* = 3395) [16.7]	52.34 ± 8.50	5.8	1.4	6.4	74.9	25.5	18.0
0.951–0.985 (*n* = 3430) [16.9]	53.24 ± 8.86	7.0	2.0	7.5	69.3	24.7	18.8
≥0.986 (*n* = 3443) [17.0]	53.81 ± 8.95	7.2	2.5	9.8	67.6	24.0	20.0
Unavailable (*n* = 3121) [15.4]	54.45 ± 10.64	7.8	3.7	10.1	67.6	25.0	20.1
P for trend		0.002	<0.001	<0.001	<0.001	0.03	0.8

[1] Percentage of subjects in brackets.
[2] $\bar{x}$ ± SD.

and between baseline BMI and BMI at 9 y. As expected, the correlation between BMI and WHR was less strong, and weak correlations were observed for BMI and height and for WHR and height. Correlations tended to be slightly higher for variables measured at the same time than for variables measured at more distant intervals.

Taller men were more likely to exercise and drink alcohol than were shorter men (**Table 2**). Heavier men were more likely to have diabetes and high blood pressure and to smoke cigarettes and less likely to use multivitamins or exercise than were lighter men. Higher BMIs were associated directly with high blood pressure, diabetes, and current smoking and were inversely associated with vigorous exercise, daily alcohol consumption, and use of multivitamin supplements. Higher WHRs were also related to high blood pressure and cigarette smoking status; however, in contrast with BMI, WHRs had a J-shaped relation with diabetes and were positively associated with alcohol consumption. Participants for whom we did not have WHRs were older; had higher BMIs and blood pressure; had higher rates of cigarette smoking, alcohol consumption, and multivitamin use; and had lower rates of exercise than did those with WHRs. However, after adjustment for these factors, the risk of cataract was not significantly different between men for whom we did and men for whom we did not have WHRs (RR: 0.96; 95% CI: 0.84, 1.09). The average numbers of servings of vegetables, fruit, and cereal were generally higher in men with lower BMI and WHR and in taller men.

When we adjusted for age and randomization assignments, we observed significant relations of baseline BMI and height with cataract. Estimated RRs for time-varying BMIs were somewhat stronger (**Table 3**). Both BMI and height continued to predict cataract in models that controlled simultaneously for these variables and other risk factors. Relations of BMI and height with cataract persisted in models that were also adjusted for diabetes, gout, and systolic blood pressure.

There was no substantive difference in the estimates for BMI and height in the subgroup for whom we had WHR measurements (**Table 4**). Men with higher WHRs were more likely to develop cataract than were men with lower WHRs (RR: 1.31; 95% CI: 1.10, 1.55 for top compared with bottom quintile, *P* for trend = 0.003). The effect of WHR was similar in models with baseline BMI (data not shown) or time-varying BMIs, suggesting that WHR was not merely capturing information about later BMIs. Estimates of WHR were also not different in models that adjusted for diabetes mellitus, gout, and systolic blood pressure (RR: 1.27; CI: 1.07, 1.51 for top compared with bottom quintile). None of the relations of BMI, height, or WHR with incident cataract was substantially attenuated after more rigorous adjustment for potential confounders. In a model that adjusted for age, age squared, randomized aspirin and β-carotene assignments, vigorous exercise at least weekly, pack-years of smoking, vitamins E and C and multivitamin use, 7 levels of alcohol consumption, and average daily intake of fruit, vegetables, and cold

TABLE 3
Relations of weight, height, and BMI with risk of incident cataract over an average of 13.7 y of follow-up in the Physicians' Health Study[1]

Variable	Person-years	Incidence rate ratio (95% CI)		
		Adjusted for age	Multivariate model 1[2]	Multivariate model 2[3]
Baseline BMI (kg/m^2)				
<22 (*n* = 209 cases)	33871	1.00	1.00	1.00
22–24.9 (*n* = 867 cases)	123547	1.07 (0.92, 1.24)	1.07 (0.92, 1.25)	1.07 (0.92, 1.25)
25–27.7 (*n* = 633 cases)	82357	1.11 (0.95, 1.30)	1.11 (0.95, 1.29)	1.07 (0.91, 1.26)
≥27.8 (*n* = 298 cases)	37361	1.25 (1.05, 1.50)	1.25 (1.05, 1.50)	1.20 (1.00, 1.45)
P for trend		0.009	0.01	0.06
Nearest past BMI (kg/m^2)				
<22 (*n* = 237 cases)	32844	1.00	1.00	1.00
22–24.9 (*n* = 816 cases)	113272	1.13 (0.98, 1.31)	1.14 (0.98, 1.32)	1.12 (0.96, 1.30)
25–27.7 (*n* = 623 cases)	85233	1.20 (1.03, 1.40)	1.20 (1.03, 1.39)	1.17 (1.00, 1.37)
≥27.8 (*n* = 331 cases)	45788	1.34 (1.13, 1.59)	1.33 (1.12, 1.58)	1.28 (1.08, 1.53)
P for trend		0.0004	0.0006	0.005
Height (cm)				
≤170 (*n* = 203 cases)	26091	1.00	1.00	1.00
171–178 (*n* = 928 cases)	119937	1.02 (0.88, 1.19)	1.05 (0.90, 1.22)	1.07 (0.91, 1.25)
179–183 (*n* = 548 cases)	81913	1.04 (0.88, 1.22)	1.06 (0.90, 1.25)	1.09 (0.92, 1.29)
≥184 (*n* = 328 cases)	49196	1.19 (1.00, 1.42)	1.22 (1.02, 1.46)	1.25 (1.04, 1.50)
P for trend		0.03	0.02	0.02

[1] All estimates are based on the 20271 subjects in the present study (including subjects who did not have information on waist-to-hip ratio). All estimates were obtained from separate proportional hazards regression models for each variable in the table, with adjustment for age (y), age squared, and randomized aspirin (aspirin compared with placebo) and β-carotene (β-carotene compared with placebo) assignments.

[2] Also adjusted for cigarette smoking status (never, past, current smoker of <20 cigarettes/d), or current smoker of ≥20 cigarettes/d), daily alcohol consumption (no or yes), vigorous exercise at least weekly (no or yes), and multivitamin use (none, past, or current). In addition, for both baseline and nearest past BMI, multivariate model 1 also adjusted for height; for height, multivariate model 1 also adjusted for nearest past BMI.

[3] Adjusted for factors listed for multivariate model 1 as well as for potential intermediate variables: diabetes mellitus, gout, and systolic blood pressure; 89 participants were excluded from these analyses because of missing information.

cereal, the RRs (with 95% CIs) were 1.30 (1.05, 1.60) for BMI ≥ 27.8 compared with <22, 1.30 (1.05, 1.63) for height ≥184 compared with ≤170 cm, and 1.30 (1.08, 1.57) for the top compared with bottom quintile of WHR.

When we used recently adopted cutoff points for overweight and obesity (20), the relation of BMI with cataract appeared stronger. Compared with men with BMIs < 22, the RR (with 95% CIs) of overweight men was 1.20 (1.03, 1.38) and of obese men was 1.40 (1.13, 1.74), and the estimates for height and WHR did not change substantially. In analyses restricted to 16226 men who were free of cataract at 9 y, the relation of WHR with cataract was of a similar magnitude (**Table 5**).

As shown in **Table 6**, there were significant relations of BMI with both nuclear (*P* for trend = 0.04) and posterior subcapsular (*P* for trend = 0.02) cataract. Taller stature was related to increased risk of nuclear cataract (*P* for trend = 0.02). WHR was related to both nuclear (*P* for trend = 0.007) and posterior subcapsular subtypes (*P* for trend = 0.01).

DISCUSSION

These data show that higher adult height and WHR are associated with a higher incidence of cataract, and these variables appear to capture additional information about risk that is not encompassed by BMI. Control for several potential confounders, as well as potential biological mediators such as diabetes mellitus, gout, and systolic blood pressure, had only a small effect on these relations.

Men with diseases at baseline that can affect body weight were excluded, reducing the potential for confounding by comorbid conditions (17). Although men who developed diseases during follow-up were not excluded, there are few data to suggest any strong relations of chronic diseases with age-related cataract, other than diabetes and perhaps high blood pressure and gout, which are more likely to be intermediate variables than confounders. Control for these conditions did not provide an explanation of the relations of the anthropometric measures with cataract. Residual confounding by known risk factors for cataract is possible in every epidemiologic study. In the present study, although we controlled for several dietary items, we were not able to control for some specific nutrients, such as lutein and zeaxanthin, that were related to cataract in some previous studies (28–30). Because men with higher BMIs and WHRs on average consumed fewer daily servings of fruit, vegetables, and cereal, it is possible that the increased risk of cataract we observed in these men may have been due to diets that were relatively deficient in important micronutrients.

Because we relied on the physicians to self-report their diagnoses of cataract, a remaining concern is the possibility that men with higher WHRs had more frequent health visits than did men with lower WHRs and therefore earlier detection of their cataracts. Although we did not have information on the frequency of eye examinations in the present study, data from a parallel cohort of women show that heavier individuals tend to have less frequent eye examinations than do lighter individuals (DA Schaumberg, unpublished observations, 1999). If this were also true of men, we may have underestimated some associations. To minimize this potential bias, we used a visual-acuity criterion for our definition of cataract and, accordingly, some lens opacities were not included as cataract. Underdetection of lens opacities does not bias the results of a follow-up study, however, as long as the specificity of the endpoint is high. Still, although the numbers of cortical and

TABLE 4
Relations of BMI, height, and waist-to-hip ratio (WHR) with risk of incident cataract and cataract surgery over an average of 12 y of follow-up in the Physicians' Health Study

	Incidence rate ratio (95% CI)			
	Models without WHR[1]		Models with WHR[1,2]	
Variable	Incident cataract (n = 1727 cases, 241 434 person-years)	Cataract surgery (n = 1020 cases, 245 437 person-years)	Incidence cataract (n = 1727 cases, 241 434 person-years)	Cataract surgery (n = 1020 cases, 245 437 person-years)
Nearest past BMI (kg/m²)[3]				
<22	1.00	1.00	1.00	1.00
22–24.9	1.16 (0.99, 1.36)	1.16 (0.94, 1.43)	1.13 (0.96, 1.32)	1.14 (0.92, 1.41)
25–27.7	1.21 (1.03, 1.43)	1.32 (1.06, 1.64)	1.15 (0.97, 1.36)	1.27 (1.02, 1.59)
≥27.8	1.35 (1.12, 1.62)	1.45 (1.13, 1.84)	1.25 (1.03, 1.51)	1.36 (1.06, 1.75)
P for trend	0.001	0.0006	0.03	0.006
Height (cm)				
≤170	1.00	1.00	1.00	1.00
171–178	1.04 (0.88, 1.23)	1.18 (0.93, 1.49)	1.04 (0.87, 1.23)	1.17 (0.93, 1.48)
179–183	1.06 (0.89, 1.27)	1.20 (0.94, 1.53)	1.05 (0.87, 1.25)	1.18 (0.93, 1.51)
≥184	1.25 (1.03, 1.52)	1.53 (1.18, 1.98)	1.23 (1.01, 1.49)	1.50 (1.16, 1.95)
P for trend	0.01	0.001	0.02	0.002
WHR				
<0.897	—	—	1.00	1.00
0.897–0.924	—	—	1.15 (0.97, 1.37)	1.04 (0.83, 1.30)
0.925–0.950	—	—	1.14 (0.96, 1.36)	0.99 (0.79, 1.24)
0.951–0.985	—	—	1.20 (1.02, 1.43)	1.14 (0.92, 1.42)
≥0.986	—	—	1.31 (1.10, 1.55)	1.17 (0.94, 1.45)
P for trend			0.003	0.08

[1] Estimates are based on the 17 150 participants for whom we had information on WHR and were obtained from proportional hazards regression models adjusted for age (y), age squared, randomized aspirin (aspirin compared with placebo) and β-carotene (β-carotene compared with placebo) assignments, cigarette smoking status (never, past, current smoker of <20 cigarettes/d, or current smoker of ≥20 cigarettes/d), daily alcohol consumption (no or yes), vigorous exercise at least weekly (no or yes), and multivitamin use (none, past, or current). Height and nearest past BMI were included in the models simultaneously.

[2] Further adjusted for WHR.

[3] Measured at baseline and then yearly beginning at the eighth year of follow-up.

posterior subcapsular opacities were similar, underdetection of cortical opacities (which often begin peripherally, where they have little or no effect on visual acuity) would have limited our power to detect more modest associations with this type of opacity.

BMI is strongly correlated with fat mass (12), making it a useful measure of overall obesity. In our data, after adjustment for potentially confounding variables, obese men had an elevated risk of cataract. Data from 3 previous prospective studies are consistent with this observation (5–7). In another prospective study, although BMI was not related to cataract surgery (31), it was associated with increased risk of posterior subcapsular cataract in subjects without diabetes (25).

TABLE 5
Relations of waist-to-hip ratio (WHR) with risk of cataract during years 9 through 12 of follow-up in 16 226 eligible participants in the Physicians' Health Study[1]

		Incidence rate ratio (95% CI)		
WHR	Person-years	Model 1: adjusted for age and treatment assignments[2]	Model 2: adjusted for multiple potential confounders[3]	Model 3: adjusted for multiple potential confounders, BMI, and height[4]
<0.897 (n = 104 cases)	18 531	1.00	1.00	1.00
0.897–0.924 (n = 134 cases)	17 788	1.17 (0.91, 1.52)	1.17 (0.91, 1.51)	1.16 (0.90, 1.50)
0.925–0.950 (n = 154 cases)	18 176	1.17 (0.91, 1.50)	1.16 (0.90, 1.49)	1.13 (0.89, 1.45)
0.951–0.985 (n = 200 cases)	18 118	1.38 (1.09, 1.75)	1.35 (1.06, 1.71)	1.30 (1.01, 1.66)
≥0.986 (n = 214 cases)	17 781	1.42 (1.12, 1.80)	1.38 (1.09, 1.75)	1.31 (1.02, 1.67)
P for trend		0.001	0.003	0.02

[1] Excludes men for whom we had no information on WHR or BMI at 8 y and those who had developed cataract before the WHR measurement.

[2] Variables adjusted for included age (y), age squared, and randomized aspirin (aspirin compared with placebo) and β-carotene (β-carotene compared with placebo) assignments.

[3] Adjusted for the variables in model 1 plus cigarette smoking status (never, past, current smoker of <20 cigarettes/d, or current smoker of ≥20 cigarettes/d), daily alcohol consumption (no or yes), vigorous exercise at least weekly (no or yes), and multivitamin use (none, past, or current).

[4] Adjusted for the variables in model 2 plus the nearest past BMI (in kg/m²) and height (in cm).

TABLE 6
Relations of anthropometric measures with risk of specific cataract subtypes after an average of 13.7 y of follow-up in the Physicians' Health Study

	Incidence rate ratio (95% CI)[1]		
Variable	Nuclear (n = 1512 cases)	Cortical (n = 652 cases)	Posterior subcapsular (n = 721 cases)
BMI (kg/m^2)[2]			
<22	1.00	1.00	1.00
22–24.9	1.12 (0.94, 1.32)	1.18 (0.92, 1.52)	1.15 (0.89, 1.49)
25–27.7	1.12 (0.94, 1.34)	1.08 (0.83, 1.42)	1.27 (0.97, 1.67)
≥27.8	1.26 (1.03, 1.55)	1.18 (0.86, 1.60)	1.38 (1.02, 1.86)
P for trend	0.04	0.59	0.02
Height (cm)			
≤170	1.00	1.00	1.00
171–178	1.09 (0.91, 1.31)	0.90 (0.69, 1.17)	0.95 (0.74, 1.23)
179–183	1.13 (0.93, 1.38)	0.95 (0.72, 1.26)	0.89 (0.68, 1.18)
≥184	1.28 (1.03, 1.58)	1.13 (0.83, 1.54)	1.09 (0.81, 1.47)
P for trend	0.02	0.20	0.58
Waist-to-hip ratio			
<0.897	1.00	1.00	1.00
0.897–0.924	1.18 (0.98, 1.43)	1.14 (0.86, 1.51)	1.34 (1.01, 1.78)
0.925–0.950	1.08 (0.90, 1.43)	1.10 (0.83, 1.45)	1.31 (0.99, 1.73)
0.951–0.985	1.17 (0.97, 1.40)	1.05 (0.79, 1.38)	1.55 (1.18, 2.03)
≥0.986	1.32 (1.10, 1.58)	1.24 (0.95, 1.63)	1.44 (1.09, 1.89)
P for trend	0.007	0.25	0.01

[1] Obtained from separate proportional hazards regression models for each subtype with adjustment for the other anthropometric variables listed as well as for age (y), age squared, randomized aspirin (aspirin compared with placebo) and β-carotene (β-carotene compared with placebo) assignments, cigarette smoking status (never, past, current smoker of <20 cigarettes/d, or current smoker of ≥20 cigarettes/d), daily alcohol consumption (no or yes), vigorous exercise at least weekly (no or yes), and multivitamin use (none, past, or current).

[2] Measured at baseline and then annually starting at 8 y.

We observed a direct relation of adult height and risk of cataract, particularly nuclear cataract. In agreement with our findings, one cross-sectional study also showed an increased risk of nuclear cataract in taller men (32). Although 2 other cross-sectional studies showed inverse relations of height with cataract (33, 34), confounding by socioeconomic status was a concern. Confounding by socioeconomic factors is unlikely to explain our finding because all the subjects were US physicians, a relatively homogeneous socioeconomic group. Adult height is directly associated with other age-related diseases, particularly cancer (35). Both nuclear and cortical cataracts have been shown to aggregate in families, suggesting the possibility of genetic susceptibility (36). A direct association between height and cataract might be explained by a genetic predisposition to both taller height attainment and cataract. It is also possible that other exposures both in utero and during early development may influence adult height and the subsequent risk of cataract.

WHR is a valid measure of abdominal fat, albeit an imperfect proxy for visceral fat (11). Men with higher WHRs had a consistently higher risk of cataract in the present study. The only other study that we are aware of (37) showed a significant association between higher WHRs and increased risk of cataract, but the authors had not adjusted for BMI, so the results reflect overall as well as abdominal adiposity. Nevertheless, these authors' results are consistent with those of the present study, suggesting that higher WHRs may be a risk factor for cataract.

There are plausible biological pathways through which abdominal adiposity might cause earlier development of cataract. Obesity is a risk factor for increased serum uric acid concentrations and gout, factors related to increased risk of cataract (9, 38, 39). Overweight individuals also have higher amounts of systemic inflammation (40, 41), which may also be a risk factor for cataract (40). Last, abdominal adiposity is a strong risk factor for glucose intolerance and insulin resistance, conditions closely related to development of type 2 diabetes and high blood pressure. Diabetes causes earlier cataract formation, possibly through several pathways (42–46), and at least some laboratory (47, 48) and epidemiologic (8, 10, 49–54) studies suggested a relation of blood pressure with cataract. However, the present study showed higher risks of cataract in obese men and men with abdominal adiposity, even after diabetes and systolic blood pressure were controlled for, suggesting that the relations, if causal, may not be mediated through these pathways. On the other hand, there is evidence from other studies that both glucose intolerance (55) and insulin resistance (56, 57) are related to increased risk of cataract, even in the absence of diabetes. We did not have information on these factors in our study population, however, so we were not able to assess their possible role in mediating the relations of BMI and WHR with cataract.

This prospective study showed that greater adult heights and a pattern of abdominal adiposity were independent risk factors for cataract in men. If indicative of causal relations, these data imply that beneficial lifestyle changes to reduce body weight and central adiposity, which clearly have other health benefits as well, would also help to lessen the incidence and associated costs of cataract, the leading cause of blindness throughout the world.

REFERENCES

1. Thylefors B, Negrel AD, Pararajasegaram R, Dadzie KY. Global data on blindness. Bull World Health Organ 1995;73:115–21.
2. Taylor A, Zuliani AM, Hopkins RE, et al. Moderate caloric restriction delays cataract formation in the Emory mouse. FASEB J 1989;3:1741–6.

3. Taylor A, Lipman RD, Jahngen-Hodge J, et al. Dietary calorie restriction in the Emory mouse: effects on lifespan, eye lens cataract prevalence and progression, levels of ascorbate, glutathione, glucose, and glycohemoglobin, tail collagen breaktime, DNA and RNA oxidation, skin integrity, fecundity, and cancer. Mech Ageing Dev 1995;79:33–57.
4. Masoro EJ. Nutrition and aging—a current assessment. J Nutr 1985;115:842–8.
5. Glynn RJ, Christen WG, Manson JE, Bernheimer J, Hennekens CH. Body mass index. An independent predictor of cataract. Arch Ophthalmol 1995;113:1131–7.
6. Hankinson SE, Seddon JM, Colditz GA, et al. A prospective study of aspirin use and cataract extraction in women. Arch Ophthalmol 1993;111:503–8.
7. Hiller R, Podgor MJ, Sperduto RD, et al. A longitudinal study of body mass index and lens opacities. The Framingham studies. Ophthalmology 1998;105:1244–50.
8. Tavani A, Negri E, La Vecchia C. Selected diseases and risk of cataract in women. A case-control study from northern Italy. Ann Epidemiol 1995;5:234–8.
9. Leske MC, Chylack LT Jr, Wu SY. The Lens Opacities Case-Control Study. Risk factors for cataract. Arch Ophthalmol 1991;109:244–51.
10. Mohan M, Sperduto RD, Angra SK, et al. India-US case-control study of age-related cataracts. India-US Case-Control Study Group. Arch Ophthalmol 1989;107:670–6. (Published erratum appears in Arch Ophthalmol 1989 107:1288).
11. Willett WC. Nutritional epidemiology. New York: Oxford University Press, 1998.
12. Spiegelman D, Israel RG, Bouchard C, Willett WC. Absolute fat mass, percent body fat, and body-fat distribution: which is the real determinant of blood pressure and serum glucose? Am J Clin Nutr 1992;55:1033–44.
13. Michels KB, Greenland S, Rosner BA. Does body mass index adequately capture the relation of body composition and body size to health outcomes? Am J Epidemiol 1998;147:167–72.
14. Kissebah AH, Vydelingum N, Murray R, et al. Relation of body fat distribution to metabolic complications of obesity. J Clin Endocrinol Metab 1982;54:254–60.
15. Bjorntorp P. Metabolic implications of body fat distribution. Diabetes Care 1991;14:1132–43.
16. Despres JP, Moorjani S, Lupien PJ, Tremblay A, Nadeau A, Bouchard C. Regional distribution of body fat, plasma lipoproteins, and cardiovascular disease. Arteriosclerosis 1990;10:497–511.
17. Steering Committee of the Physicians' Health Study Research Group. Final report on the aspirin component of the ongoing Physicians' Health Study. N Engl J Med 1989;321:129–35.
18. Hennekens CH, Buring JE, Manson JE, et al. Lack of effect of long-term supplementation with beta carotene on the incidence of malignant neoplasms and cardiovascular disease. N Engl J Med 1996; 334:1145–9.
19. Seddon JM, Christen WG, Manson JE, Buring JE, Sperduto RD, Hennekens CH. Low-dose aspirin and risks of cataract in a randomized trial of US physicians. Arch Ophthalmol 1991;109:252–5.
20. National Institutes of Health. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults—the evidence report. Obes Res 1998;6(suppl):51S–209S. (Published erratum appears in Obes Res 1998;6:464.)
21. Klag MJ, He J, Mead LA, Ford DE, Pearson TA, Levine DM. Validity of physicians' self-reports of cardiovascular disease risk factors. Ann Epidemiol 1993;3:442–7.
22. Rimm EB, Stampfer MJ, Colditz GA, Chute CG, Litin LB, Willett WC. Validity of self-reported waist and hip circumferences in men and women. Epidemiology 1990;1:466–73.
23. Christen WG, Glynn RJ, Seddon JM, Manson JE, Buring JE, Hennekens CH. Confirmation of self-reported cataract in the Physicians' Health Study. Ophthalmic Epidemiol 1994;1:85–91.
24. Manson JE, Christen WG, Seddon JM, Glynn RJ, Hennekens CH. A prospective study of alcohol consumption and risk of cataract. Am J Prev Med 1994;10:156–61.
25. Klein BE, Klein R, Lee KE. Diabetes, cardiovascular disease, selected cardiovascular disease risk factors, and the 5-year incidence of age-related cataract and progression of lens opacities: the Beaver Dam Eye Study. Am J Ophthalmol 1998;126:782–90.
26. Cox DR. Regression models and life-tables (with discussion). J R Stat Soc (B) 1972;34:187–200.
27. Christen WG, Glynn RJ, Manson JE, Ajani UA, Buring JE. A prospective study of cigarette smoking and risk of age-related macular degeneration in men. JAMA 1996;276:1147–51.
28. Lyle BJ, Mares-Perlman JA, Klein BE, Klein R, Greger JL. Antioxidant intake and risk of incident age-related nuclear cataracts in the Beaver Dam Eye Study. Am J Epidemiol 1999;149:801–9.
29. Brown L, Rimm EB, Seddon JM, et al. A prospective study of carotenoid intake and risk of cataract extraction in US men. Am J Clin Nutr 1999;70:517–24.
30. Chasan-Taber L, Willett WC, Seddon JM, et al. A prospective study of carotenoid and vitamin A intakes and risk of cataract extraction in US women. Am J Clin Nutr 1999;70:509–16.
31. Klein BE, Klein R, Moss SE. Incident cataract surgery: the Beaver Dam eye study. Ophthalmology 1997;104:573–80.
32. Caulfield LE, West SK, Barron Y, Cid-Ruzafa J. Anthropometric status and cataract: the Salisbury Eye Evaluation project. Am J Clin Nutr 1999;69:237–42.
33. Evans JR, Rauf A, Aihie Sayer A, Wormald RP, Cooper C. Age-related nuclear lens opacities are associated with reduced growth before 1 year of age. Invest Ophthalmol Vis Sci 1998;39:1740–4.
34. Chatterjee A, Milton RC, Thyle S. Prevalence and aetiology of cataract in Punjab. Br J Ophthalmol 1982;66:35–42.
35. Hebert PR, Ajani U, Cook NR, Lee IM, Chan KS, Hennekens CH. Adult height and incidence of cancer in male physicians (United States). Cancer Causes Control 1997;8:591–7.
36. Heiba IM, Elston RC, Klein BE, Klein R. Genetic etiology of nuclear cataract: evidence for a major gene. Am J Med Genet 1993; 47:1208–14.
37. Leske MC, Wu SY, Hennis A, Connell AM, Hyman L, Schachat A. Diabetes, hypertension, and central obesity as cataract risk factors in a black population. The Barbados Eye Study. Ophthalmology 1999; 106:35–41.
38. The Italian-American Cataract Study Group. Risk factors for age-related cortical, nuclear, and posterior subcapsular cataracts. Am J Epidemiol 1991;133:541–53.
39. Leske MC, Wu SY, Hyman L, et al. Biochemical factors in the lens opacities. Case-control study. The Lens Opacities Case-Control Study Group. Arch Ophthalmol 1995;113:1113–9.
40. Schaumberg DA, Ridker PM, Glynn RJ, Christen WG, Dana MR, Hennekens CH. High levels of plasma C-reactive protein and future risk of age-related cataract. Ann Epidemiol 1999;9:166–71.
41. Mendall MA, Patel P, Ballam L, Strachan D, Northfield TC. C reactive protein and its relation to cardiovascular risk factors: a population based cross sectional study. BMJ 1996;312:1061–5.
42. Altomare E, Vendemiale G, Grattagliano I, Angelini P, Micelli-Ferrari T, Cardia L. Human diabetic cataract: role of lipid peroxidation. Diabet Metab 1995;21:173–9.
43. Nakayama H, Mitsuhashi T, Kuwajima S, et al. Immunochemical detection of advanced glycation end products in lens crystallins from streptozocin-induced diabetic rat. Diabetes 1993;42:345–50.
44. Lerner BC, Varma SD, Richards RD. Polyol pathway metabolites in human cataracts. Correlation of circulating glycosylated hemoglobin content and fasting blood glucose levels. Arch Ophthalmol 1984;102:917–20.
45. Ashizawa N, Yoshida M, Sugiyama Y, et al. Effects of a novel potent aldose reductase inhibitor, GP-1447, on aldose reductase activity in vitro and on diabetic neuropathy and cataract formation in rats. Jpn J Pharmacol 1997;73:133–44.
46. Cekic O, Bardak Y. Lenticular calcium, magnesium, and iron levels in diabetic rats and verapamil effect. Ophthalmic Res 1998;30: 107–12.

47. Rodriguez-Sargent C, Cangiano JL, Berrios Caban G, Marrero E, Martinez-Maldonado M. Cataracts and hypertension in salt-sensitive rats. A possible ion transport defect. Hypertension 1987;9:304–8.
48. Rodriguez-Sargent C, Berrios G, Irrizarry JE, Estape ES, Cangiano JL, Martinez-Maldonado M. Prevention and reversal of cataracts in genetically hypertensive rats through sodium restriction. Invest Ophthalmol Vis Sci 1989;30:2356–60.
49. Kahn HA, Leibowitz HM, Ganley JP, et al. The Framingham Eye Study. II. Association of ophthalmic pathology with single variables previously measured in the Framingham Heart Study. Am J Epidemiol 1977;106:33–41.
50. Hiller R, Sperduto RD, Ederer F. Epidemiologic associations with nuclear, cortical, and posterior subcapsular cataracts. Am J Epidemiol 1986;124:916–25.
51. Klein BE, Klein R, Jensen SC, Linton KL. Hypertension and lens opacities from the Beaver Dam Eye Study. Am J Ophthalmol 1995;119:640–6.
52. Klein BE, Klein R. Cataracts and macular degeneration in older Americans. Arch Ophthalmol 1982;100:571–3.
53. Chen TT, Hockwin O, Dobbs R, Knowles W, Eckerskorn U. Cataract and health status: a case-control study. Ophthalmic Res 1988;20:1–9.
54. Szmyd L Jr, Schwartz B. Association of systemic hypertension and diabetes mellitus with cataract extraction. A case-control study. Ophthalmology 1989;96:1248–52.
55. Karasik A, Modan M, Halkin H, Treister G, Fuchs Z, Lusky A. Senile cataract and glucose intolerance: the Israel Study of Glucose Intolerance Obesity and Hypertension (The Israel GOH Study). Diabetes Care 1984;7:52–6.
56. Gutman A, Andreus A, Adler JH. Hyperinsulinemia, insulin resistance and cataract formation in sand rats. Isr J Med Sci 1975;11:714–22.
57. Clayton RM, Cuthbert J, Duffy J, et al. Some risk factors associated with cataract in S.E. Scotland: a pilot study. Trans Ophthalmol Soc U K 1982;102:331–6.