Anthropometric status and cataract: the Salisbury Eye Evaluation project[1–3]

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ABSTRACT

Background: Weight or body mass index (BMI; in kg/m^2) is frequently identified as a risk factor for cataract, but the nature of the association is unclear.

Objective: We aimed to characterize the relation between BMI and stature and risk of different types of cataract.

Design: We analyzed data from participants in the Salisbury Eye Evaluation (SEE), a cross-sectional survey of visual status and demographic, nutritional, and environmental factors conducted between 1993 and 1995 in a representative sample of community-dwelling older persons in Salisbury, MD. Multiple logistic regression techniques were used to compare risk factors between individuals with nuclear, cortical, or posterior subcapsular (PSC) opacities and individuals with no cataract.

Results: Risk of nuclear opacification was greater in participants with lower BMIs [adjusted odds ratio of 1.13 (95% CI: 1.02, 1.27) with a BMI of 22.5 compared with 28.0] and of taller stature [1.12 (95% CI: 1.01, 1.25) with a stature of 170.5 cm compared with 164]. In contrast, risk of cortical opacification was greater in participants with higher BMIs and of taller stature, but the relation for stature diminished in magnitude and was not significant after adjustment for other risk factors. BMI was not related to risk of PSC opacities, but there was some evidence that taller stature is a risk factor for PSC opacification ($P = 0.06$) after adjustment for other risk factors.

Conclusions: Both BMI and stature are independent risk factors for cataracts in the SEE population, with the nature of the risk dependent on cataract type. *Am J Clin Nutr* 1999;69:237–42.

KEY WORDS Body mass index, BMI, stature, weight, elderly, cataract, Salisbury Eye Evaluation, posterior subcapsular opacity

INTRODUCTION

Cataract is the leading cause of blindness worldwide (1). As many as 50% of Americans >65 y of age have some type of cataract, and their removal is the principal reason for surgery in older Americans (2). Thus, the identification of modifiable risk factors for cataract formation is a national public health priority (3).

Previous research has identified many risk factors for age-related cataract, including injury, environment, disease, and nutrition-related factors (4, 5). In various studies, cataract risk has been shown to increase with older age, race, diabetes, hypertension, smoking, alcohol use, and low socioeconomic status or educational attainment. Variation in body mass index (BMI; in kg/m^2) has also been shown to influence cataract risk, although there is no consensus on the direction or nature of the association. Both higher (6) and lower (7–10) BMIs have been associated with increased risk of cataract. It is difficult to conclude much about the role of BMI in cataract formation for several reasons. First, lower BMIs are associated with smoking, alcohol consumption, and lower socioeconomic status, whereas higher BMIs are associated with African American race, diabetes, hypertension, and other morbidities, all of which also influence risk of cataract. Second, the etiologies of cataract differ by cataract type, and not all studies have examined whether the relation of BMI with cataract depends on the cataract type. Finally, BMI is a measure of body size, and although independent of height or stature, it makes sense to consider other indicators of body size, such as height or stature, as potential risk factors for cataract. The purpose of the present study was to assess whether BMI and stature are risk factors for cataract and specific cataract type in older men and women enrolled in The Salisbury Eye Evaluation (SEE), in whom other risk factors for cataract were also measured.

SUBJECTS AND METHODS

The SEE project is a population-based, longitudinal study of the effect of visual impairment and age-related eye diseases on the functional status of older, community-dwelling adults (11).

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The study was conducted in Salisbury, MD, a community of 41 430 located on Maryland's Eastern Shore. For the study, a random sample of 2520 residents aged 65–84 y was recruited for a home interview and an examination at the SEE clinic. Details on the study population and overall SEE methodology are reported elsewhere (11). The study protocol was approved by the Institutional Review Committee of The Johns Hopkins University School of Medicine.

The sample was selected from the US Health Care Financing Administration Medicare Database, which includes 98% of persons aged ≥65 y. At the time of recruitment, there were 7004 Salisbury residents 65–84 y of age; of these, 18.4% were African American and 81.6% were white. For the study, all the African American and a random, age-stratified sample of white participants were selected (56% of those aged 65–74 y and 62% of those aged 75–84 y). Institutionalized or housebound individuals (n = 155) and those who scored ≤17 on the Mini-mental state exam (12; n = 103) were excluded from the study. Of the 3906 eligible persons, 1020 (26%) refused to participate or could not be located (11).

To determine visual function, a 4-h examination was performed at the SEE clinic. As described by West et al (13), each subject's pupils were dilated and lens photographs were taken. Two nuclear photographs were taken with a photo slit lamp (SL-5D; Topcon, Tokyo) with the slit beam set at a height of 9 mm and a width of 0.1 mm and angled at 40°. Cortical photographs were taken with a retroillumination camera (Neitz, Inc, Tokyo) focused just posterior to the pupillary margin. A distance-recording device was set to zero at that point. Photographs were then taken of the posterior subcapsular (PSC) region of the lens, and the focusing distance to the back of the lens was measured. All photographs were processed by using standard processing techniques (Wilmer Photographic Services, Wilmer Eye Institute, Johns Hopkins Hospital, Baltimore) and photographs of each eye were evaluated separately.

Photographs were graded for type and severity of opacity by using the Wilmer grading scheme (14). Nuclear opacification was graded using a photographic standard as described by Bailey et al (15) and cortical opacification was estimated using the method developed by West et al (16). PSC opacities were graded as present or absent and if present, by the maximum height and width. All photographs were graded independently by 2 trained graders; in the event of disagreement a third grading was performed. A standard panel of 53 photographs was circulated among the photographs during the grading process and both intra- and interobserver variations were calculated. The weighted κ statistics for interobserver variation in the grading of the nuclear and cortical photographs were >0.90, indicating excellent agreement.

Standard definitions were used to determine cataract status. Nuclear opacity was defined as follows: for density, on a scale of 0.0–4.0, the presence of grade ≥2.0 in the photographs of at least one eye; for cortical opacity, measured as percentage area (in sixteenths) affected, the presence of grade ≥4/16 in the photographs of at least one eye. A PSC opacity was considered present if all 3 graders agreed. Subjects were considered to have opacity if at least one eye had any of the 3 types of cataract (nuclear, cortical, and PSC). If a participant had unilateral surgery or ungradeable photographs in one eye, the other eye was used to determine opacity grade. Two hundred forty-five participants had bilateral cataract surgery before enrollment and were excluded from the analyses.

During the clinic examination, each participant's weight and stature were measured by trained observers. For analyses, BMI and stature were treated as continuous as well as categoric variables divided into categories based on the deciles of their respective distributions. Information on other risk factors was obtained from the participants during the home interview. The variables examined during analyses included participants' age (in y), sex, race (white or African American), smoking habit, energy intake, alcohol consumption, exposure to ultraviolet-blue (UV-B), and presence or absence of diabetes, hypertension, and other significant morbidities. Energy intake was estimated by using the dietary intake portion (long version) of the Health Habits and History Questionnaire of the National Cancer Institute (17, 18). Exposure to UV-B was assessed over each individual's lifetime and divided by their exact age to give their average annual UV-B exposure (19, 20). Self reports of diabetes and hypertension were verified by assessing the subjects' medical records, glycosylated hemoglobin or blood pressure values during the clinical exam, or use of specific medications. New cases of diabetes were identified as those having glycosylated hemoglobin values 2 SDs above their age- and sex-specific means, and new cases of hypertension were identified by a blood pressure >160/90 mm Hg.

Of 2886 SEE participants, 2520 completed the clinical exam involving the vision tests. Of these, 374 were excluded because of bilateral surgery (n = 245), nondilatation, or ungradeable photos. Of 2146 participants with gradeable eye data, 1976 provided complete data on known risk factors for cataract except for UV-B exposure, which was available for only 1943 subjects.

The characteristics of the SEE participants were described across age and sex groups. The distributions of specific risk factors for cataract across BMI and stature were examined by using analysis of variance and chi-square tests as appropriate. The crude and adjusted effects on each cataract type of variation in BMI, stature, and other risk factors were estimated by using logistic regression, and were described as odds ratios (ORs) with 95% CIs. In these models, we sought to identify risk factors for each cataract type compared with no cataract at all; therefore, the exposure status of 826 cases of nuclear, 250 cases of cortical, and 95 cases of PSC were compared (in 3 separate models) to the exposure status of 949 individuals with no cataract. Subjects with multiple types of cataract (n = 44) were counted as cases for each type of cataract as appropriate. To illustrate the range of differences in cataract risk associated with BMI, ORs were calculated for every 5.5 kg/m^2 from the mean BMI (28) across ±2 SDs of BMI in the population (±11). For stature, ORs were calculated for every 6.5 cm from the mean stature (164 cm) across ±2 SD of stature (±13 cm).

RESULTS

The characteristics of the sample are presented in **Table 1**. Of the 1976 participants, 25% were African American and 56% were women. Whites were more likely to be educated beyond high school and to consume alcohol, whereas African Americans were more likely to smoke cigarettes and to have diabetes. The average BMI of white men and women and of African American men was ≈27, whereas African American women had an average BMI of 31.

The prevalences of nuclear, cortical, and PSC opacities in the sample are also presented in Table 1 by race and sex. Of the

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TABLE 1
Descriptive characteristics of participants in the Salisbury Eye Evaluation project[1]

	Men		Women	
Characteristic	White (n = 666)	African American (n = 203)	White (n = 808)	African American (n = 299)
Age (%)				
65–74 y	69.4	70.0	65.5	67.9
75–85 y	30.6	30.0	34.5	32.1
Education (%)				
< High school	15.8	47.8	15.4	38.1
High school	48.8	41.4	52.7	47.8
> High school	35.4	10.8	31.9	14.1
Height (cm)	173.1 ± 6.4[2]	170.4 ± 7.0	159.0 ± 6.2	157.9 ± 6.5
Weight (kg)	83.2 ± 13.9	80.1 ± 17.2	69.2 ± 14.2	77.1 ± 19.1
BMI (kg/m^2)	27.8 ± 4.3	27.5 ± 5.4	27.3 ± 5.4	31.0 ± 7.7
Smoking status (%)				
Never	23.0	24.6	51.9	49.5
Former	63.7	51.7	35.6	33.4
Current	13.3	23.7	12.5	17.1
Usual energy intake (kJ/d)	7238 ± 2188	6866 ± 2753	5653 ± 1803	5033 ± 2151
Drinks alcohol (%)	66.5	39.4	51.2	19.7
Cataract (%)				
Nuclear	42.9	23.7	48.6	33.1
Cortical	6.2	23.7	9.4	28.4
Posterior subcapsular	6.5	3.0	4.7	2.7
Average annual UV-B exposure[3]	0.02 ± 0.02	0.03 ± 0.02	0.01 ± 0.01	0.01 ± 0.01
Hypertension (%)	44.3	53.7	52.5	67.6
Diabetes (%)	14.9	24.6	12.3	27.8

[1] Available for 1943 subjects. UV-B, ultraviolet blue.
[2] $\bar{x}$ ± SD.
[3] As assessed over each individual's lifetime and divided by their exact age.

white subjects, 40–50% had nuclear opacities, 5–10% had cortical opacities with a grade ≥4/16, and 5–7% had PSC opacities. In contrast, only 24–33% of African Americans had nuclear opacities, but 24–28% had cortical opacities. African Americans were about one-half as likely as white subjects to have PSC opacities.

As expected, variation in BMI was associated with variation in other known risk factors for age-related cataracts (**Table 2**). Lower BMI was associated with older age, female sex, and current smoking and alcohol consumption. Individuals with a BMI <22 or >27.9 were more likely to be African American and to be less educated. The prevalences of both diabetes and hypertension were greater in those with higher BMIs. There was no difference in UV-B exposure across BMI categories.

The crude and adjusted ORs, calculated to describe the relation between BMI and cataract risk in the SEE population, are shown in **Table 3**. Risk of nuclear and PSC opacities was greater in those with lower BMIs; however, the association was significant ($P < 0.05$) for nuclear opacities only. In contrast, risk of cortical opacities tended to be greater in those with higher BMIs ($P < 0.05$).

To examine the effects of BMI adjusted for other covariates and confounding factors, known risk factors for each cataract type were then added to each logistic model and nonsignificant variables (except for stature) were removed. After adjustment for age, race, sex, stature, education, smoking, and hypertension, the risks were reduced but greater risk of nuclear opacification was still associated with lower BMIs ($P < 0.05$). As shown in Table 3, individuals with a BMI of 22.5 were 1.13 (95% CI: 1.02, 1.27) times more likely to have nuclear opacities than were individuals with a BMI of 28 (the population mean). Similarly, individuals with a BMI of 33.5 were 0.88 (95%CI: 0.79, 0.98) times less likely to have nuclear opacities than were those with the reference BMI. After adjustment for age, race, sex, alcohol consumption, and UV-B exposure, risk of cortical opacification remained greater in those with higher BMIs. Variation in BMI was still not associated with risk of PSC opacities in the multiple logistic regression model, which included age, race, stature, education, and diabetes.

The ORs relating variation in stature to risk of cataract estimated from the same regression models are shown in **Table 4**. Shorter SEE participants were at significantly greater risk for nuclear and cortical cataract; however, after adjustment, stature was associated with risk of nuclear opacities only—and in the opposite direction. In crude analyses, taller stature was associated with greater risk of PSC opacities, but the trend was not significant. After adjustment for BMI and other risk factors, the positive relation between stature and PSC opacities became stronger and was marginally significant ($P = 0.06$).

DISCUSSION

Our results indicate that both BMI and stature are independent risk factors for cataract in the SEE population, and that the nature of the risks varies depending on cataract type. Across the range of BMI and stature in this population, risk of nuclear opacities increased in a graded fashion as subjects became thinner and as stature increased. Risk of nuclear opacities associated with BMI was reduced after adjustment for other known risk factors, but the trend of greater risk of nuclear opacities with lower BMI remained significant. Whereas shorter individuals appeared to be at greater risk after the crude analyses, taller individuals

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TABLE 2
Association between BMI quartile and other risk factors for cataract in the Salisbury Eye Evaluation project

	BMI (kg/m^2)			
Characteristic	<22 (n = 209)	22–49 (n = 382)	25.0–27.9 (n = 477)	>27.9 (n = 908)
Age (%)[1]				
65–74 y	61.7	64.7	66.7	70.7
75–85 y	38.3	35.3	33.3	29.3
Sex (%)[1]				
Male	32.5	43.2	51.6	42.9
Female	67.5	56.8	48.4	57.1
Race (%)[1]				
African American	28.2	16.7	20.1	31.2
White	71.8	83.3	79.9	68.8
Education (%)[1]				
< High school	21.1	20.7	19.9	24.5
High school	47.9	45.6	52.0	50.2
> High school	31.1	33.8	28.1	25.3
Smoking status(%)[1]				
Never	31.6	36.7	37.7	42.3
Former	37.8	43.5	49.7	47.9
Current	30.6	19.9	12.6	9.8
Drinks alcohol (%)[1]	52.2	57.1	52.2	46.3
Average annual UV-B exposure[2,3]	0.02 ± 0.02	0.02 ± 0.02	0.02 ± 0.02	0.02 ± 0.02
Hypertension (%)[1]	37.8	43.7	49.7	60.0
Diabetes (%)[1]	9.6	10.0	13.6	22.9
Usual energy intake (kJ/d) [1]	6351 ± 2431	6360 ± 2197	6259 ± 2109	6033 ± 2305

[1] Different across BMI categories tested by chi-square or ANOVA, $P < 0.05$.
[2] Data available for 1943 subjects. UV-B, ultraviolet blue.
[3] $\overline{x}$ ± SD.

were at greater risk for nuclear opacities after adjustment for other known risk factors.

In contrast, risk of cortical opacities appeared to be greater in those with higher BMIs. The magnitude of the relation was similar to that observed for nuclear opacities, and it was not diminished after adjustment for other known risk factors in the multivariate analyses. Neither BMI nor stature is related to PSC opacities. The results are clear for BMI; however, sample size may have been a limiting factor for stature. No relation between stature and PSC opacity was observed during crude analyses, but after adjustment for other known risk factors (in particular female sex) the positive relation between stature and PSC opacity risk became strong in magnitude but was not significant.

Our results are consistent with most studies relating BMI and cataract risk in other populations (7–10). In these studies, lower BMI was interpreted as an indicator of undernutrition or nutritional deprivation. Consistent with this etiology of deprivation, risk of cataract is greater in those with lower socioeconomic status, with fewer years of education, with poorer quality of diet, in those who smoke, and in those with a history of diarrhea and dehydration (4, 5). Furthermore, the prevalence of cataract is highest in developing countries, where cataracts develop at earlier ages (4, 5). However, many of the previous studies describing an association between BMI and cataract have been criticized for failing to consider cataract type and to adequately adjust for other indicators of poverty, such as lower education, smoking, and dietary intake. Although not shown, variation in intakes of energy and micronutrients did not influence the relations between BMI, stature, and cataract described here. Thus, our results indicate that lower BMI is a risk factor for nuclear cataract independent of other risk factors that characterize the likelihood of undernutrition. Why would a higher BMI protect against nuclear cataract? We do not know, but note that our results may indicate some sort of tradeoff in risk between nuclear and cortical cataract associated with BMI. Taken together, our results suggest that tall, thin people are at increased risk for nuclear opacities, whereas short, heavy people are at increased risk for cortical opacities. This latter association, however, can be attributed to other known risk factors for cortical opacification. Whether having one type of cataract reduces the likelihood of developing another type of cataract is not known, but the etiologies differ by cataract type, and few individuals develop more than one type of cataract (in our study, only <5%).

Note, however, that our results are in direct contrast with those reported by Glynn et al (6), who found that among participants in the Physicians' Health Study the risk of developing nuclear and PSC cataract was higher in physicians with higher BMIs. The explanation for the divergent findings by Glynn et al (6) is not clear, but several factors may play a role. In our study, we calculated BMI with actual weights and heights taken by trained personnel during a clinical exam, whereas Glynn et al (6) used reported heights and weights of persons responding to a questionnaire. The definitions of cataracts were also different. Our study used photographic documentation of lens status, graded using a standard scheme. The Physicians' Health Study relied on self-reporting confirmed with medical records and required that the cataract be responsible for a decrease in visual acuity. Thus, individuals with early cataract were not included and were part of the noncataract group. They also examined the relation of BMI with prospective incidence of cataract, whereas the other studies (including our own) examined the association between BMI and prevalence of cataract at the time of the study. Finally, the natures of the populations were quite different; in contrast with our study, the Physicians' Health Study included

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TABLE 3
Crude and adjusted odds ratios (and 95% CIs) for risk of nuclear, cortical, and posterior subcapsular (PSC) cataracts associated with BMI in the Salisbury Eye Evaluation project

	Cataract type		
BMI (kg/m^2)	Nuclear	Cortical	PSC
Unadjusted risks			
17.0	1.47 (1.21, 1.79)[1]	0.69 (0.54, 0.89)[1]	1.18 (0.76, 1.83)
22.5	1.21 (1.10, 1.34)	0.83 (0.73, 0.95)	1.09 (0.87, 1.35)
28.0	1.00	1.00	1.00
33.5	0.83 (0.75, 0.91)	1.20 (1.06, 1.36)	0.92 (0.73, 1.13)
39.0	0.68 (0.56, 0.83)	1.44 (1.12, 1.85)	0.85 (0.55, 1.31)
Adjusted risks			
17.0	1.29 (1.03, 1.60)[1,2]	0.70 (0.53, 0.92)[1,3]	1.09 (0.68, 1.76)[4]
22.5	1.13 (1.02, 1.27)	0.84 (0.73, 0.96)	1.04 (0.82, 1.33)
28.0	1.00	1.00	1.00
33.5	0.88 (0.79, 0.98)	1.20 (1.04, 1.38)	0.96 (0.75, 1.22)
39.0	0.78 (0.62, 0.97)	1.26 (1.08, 1.89)	0.92 (0.57, 1.48)

[1] Test for linear trend, $P < 0.05$.
[2] Adjusted in a multiple logistic regression model for age, race, sex, stature, education, and smoking.
[3] Adjusted in a multiple logistic regression model for age, race, sex, stature, alcohol consumption, and average annual ultraviolet blue exposure.
[4] Adjusted in a multiple logistic regression model for age, race, sex, stature, education level, and diabetes.

men only, who were substantially younger, more educated, somewhat thinner, much less likely to suffer from diabetes and cataracts, and presumably white.

To our knowledge, this was the first study to identify adult stature as a risk factor for nuclear and perhaps PSC opacities. We did not hypothesize this association a priori; rather, we considered stature as a covariate in models examining BMI as a risk factor for cataract. We present the findings for stature because they remained significant after careful examination during analyses, including multivariate adjustment for other known risk factors for each cataract type. The interpretation of these findings is not clear, but final adult stature is known to be a function of genetic factors, the early nutritional environment, and growth during adolescence. Thus, stature, as a risk factor for cataract, likely includes aspects of one or all of these factors.

TABLE 4
Crude and adjusted odds ratios (and 95% CIs) for nuclear, cortical, and posterior subcapsular (PSC) cataracts associated with stature in the Salisbury Eye Evaluation project

	Cataract type		
Stature (cm)	Nuclear	Cortical	PSC
Unadjusted risks			
151	1.18 (1.03, 1.34)[1]	1.66 (1.36, 2.03)[1]	0.82 (0.61, 1.09)
157.5	1.08 (1.02, 1.16)	1.29 (1.07, 1.43)	0.90 (0.78, 1.05)
164	1.00	1.00	1.00
170.5	0.92 (0.86, 0.98)	0.78 (0.70, 0.86)	1.11 (0.96, 1.28)
177	0.85 (0.75, 0.97)	0.60 (0.49, 0.74)	1.22 (0.91, 1.64)
Adjusted risks			
151	0.79 (0.64, 0.99)[1,2]	1.07 (0.79, 1.47)[3]	0.64 (0.40, 1.02)[4,5]
157.5	0.89 (0.80, 0.99)	1.04 (0.89, 1.21)	0.80 (0.64, 1.01)
164	1.00	1.00	1.00
170.5	1.12 (1.01, 1.25)	0.96 (0.83, 1.13)	1.25 (0.99, 1.57)
177	1.26 (1.01, 1.57)	0.93 (0.68, 1.27)	1.56 (0.98, 2.47)

[1] Test for linear trend; $P < 0.05$.
[2] Adjusted in a multiple logistic regression model for age, race, sex, body mass index, education, and smoking.
[3] Adjusted in a multiple logistic regression model for age, race, sex, body mass index, alcohol consumption, and average annual ultraviolet blue exposure.
[4] Adjusted in a multiple logistic regression model for age, race, sex, body mass index, education, and diabetes.

In the SEE population, BMI and stature were each associated in a constant or graded fashion with variation in cataract risk. In epidemiologic terms, everyone is exposed to these anthropometric risk factors for cataract formation. Put simply, everyone has a BMI and a stature. This means that although variations in cataract risk across BMI and stature appear small, such risks can potentially translate into many cases of cataract at the population level attributable to BMI, stature, or both. This also means that shifts in the BMI distribution will also likely translate into changes in the proportion of cataract attributable to BMI in a population, if the relation is causal.

Consideration of BMI is also important because it is one of the few modifiable risk factors for cataract. Given its relation with risk of nuclear cataract in this and other studies, further research is needed to clarify the mechanism through which BMI and stature influence cataract risk and the likely change in cataract burden at the target population, given interventions to influence adult BMI. Further research is also needed on stature as a risk factor for cataract in this and other populations.

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