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Associations between Narrow Angle and Adult Anthropometry: The Liwan Eye Study

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Abstract

Purpose—To assess the associations between narrow angle and adult anthropometry.

Methods—Chinese adults aged 50 years and older were recruited from a population-based survey in the Liwan District of Guangzhou, China. Narrow angle was defined as the posterior trabecular meshwork not visible under static gonioscopy in at least three quadrants (i.e. a circumference of at least 270°). Logistic regression models were used to examine the associations between narrow angle and anthropomorphic measures (height, weight and body mass index, BMI).

Results—Among the 912 participants, lower weight, shorter height, and lower BMI were significantly associated with narrower angle width (tests for trend: mean angle width in degrees vs weight $p < 0.001$; vs height $p < 0.001$; vs BMI $p = 0.012$). In univariate analyses, shorter height, lower weight and lower BMI were all significantly associated with greater odds of narrow angle. The crude association between height and narrow angle was largely attributable to a stronger association with age and sex. Lower BMI and weight remained significantly associated with narrow angle after adjustment for height, age, sex, axial ocular biometric measures and education. In analyses stratified by sex, the association between BMI and narrow angle was only observed in women.

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DECLARATION OF INTEREST

The authors report no conflicts of interest.

Conclusion—Lower BMI and weight were associated with significantly greater odds of narrow angle after adjusting for age, education, axial ocular biometric measures and height. The odds of narrow angle increased 7% per 1 unit decrease in BMI. This association was most evident in women.

Keywords

Anterior chamber angle width; body mass index; height; narrow angle; weight

INTRODUCTION

Primary angle closure glaucoma (PACG), although less prevalent than primary open angle glaucoma, has been predicted to account for nearly half of binocular glaucoma blindness by 2020 due to its more severe visual morbidity.¹ It is recognized that populations of East Asian origin have a higher prevalence of PACG compared with those of European or African descent. Although up to 87% of all people with PACG around the world reside in Asia,² according to a recent estimation of PACG prevalence in Europe,³ there are 130,000 people with PACG in the UK, 1.60 million in Europe and nearly 581,000 in the USA.

Understanding the risk factors for PACG is important for the early recognition and effective prophylaxis of this potentially preventable disease. Shallower anterior chamber depth (ACD), shorter axial length (AL), greater lens thickness and smaller radius of corneal curvature are associated with narrow angles and higher risk of developing primary angle closure disease.^{4,5} Several studies have reported a possible association between central or limbal ACD and adult anthropometry. In a population-based cross-sectional survey, Wong and colleagues⁶ found a tendency for taller persons to have longer AL, deeper ACD, longer vitreous cavity distance, flatter corneas and thinner lenses, compared with shorter persons of similar weight, age, sex and socioeconomic status. In another population-based study from Beijing, a significant association was found between shallower limbal ACD and shorter body stature.⁷ Although ACD is widely recognized as an important anatomical risk factor for primary angle closure,⁵ gonioscopic assessment still remains the gold standard for the diagnosis of angle closure. Data regarding associations between anthropometric measures and angle configuration directly observed under gonioscopy may serve as a beneficial addition to the existing literature.

In the current analysis, based on data from a population-based prevalence survey of urban citizens in southern China, we describe the association between angle configuration measured by gonioscopy and adult anthropomorphic measures, namely height, weight and body mass index (BMI).

MATERIALS AND METHODS

Study Subjects

Study approval was obtained from the Ethical Review Board of Sun Yat-sen University, the ethics committee of Zhongshan Ophthalmic Center. The study was conducted in accordance with the tenets of the World Medical Association's Declaration of Helsinki. Participants in

this study were recruited from a population-based cross-sectional survey (the Liwan Eye Study), which was carried out between September 2003 and February 2004 in Guangzhou, the capital city of Guangdong Province in southern China. Detailed methodology of the Liwan Eye Study has been reported elsewhere.^{8,9} In brief, subjects aged 50 years and over were enrolled from the Liwan District of Guangzhou using cluster random sampling. In total, of the 1864 residents identified as eligible in the clustered sampling, 1405 participated in the cross-sectional survey and were examined. Among these 1405 participants, only phakic subjects with anthropomorphic measurement data available were considered in the current analysis. Socioeconomic information was collected by a trained interviewer using a standard questionnaire. A hand-held autorefractor (ARK-30; Nidek Corp, Gamagori, Japan) was used to measure noncycloplegic refraction. Axial ocular biometric parameters including central ACD and AL were measured using A-mode ultrasound (Echoscan US1800; Nidek Co, Gamagori, Japan).

Measurement of Anthropomorphic Parameters

Height was measured with the subject standing up straight without shoes and recorded in meters. Weight was measured with the patient dressed but after removing coats and shoes and was recorded in kilograms. BMI was derived from the ratio of the subject's weight divided by the square of the subject's height and recorded in kilograms per square meter. The scales (height scale: SECA 202, Saikang, Hangzhou, China; weight scale: RGZ-120, China Weighing Apparatus Factory, Jiangsu, China) used for measuring anthropomorphic parameters were calibrated on a daily basis.

Gonioscopy and Definition of Narrow Angle

Detailed methods regarding gonioscopy in the Liwan Eye Study have been described previously.⁹ In brief, static gonioscopy was performed using a Goldmann-type, one-mirror gonioscopic lens (Haag Streit, Bern, Switzerland) with low ambient illumination and a 1 mm narrow beam. Care was taken to avoid the beam falling on the pupil in order to prevent alteration of the angle configuration. If trabecular meshwork could not be seen because of marked iris convexity, an "over the hill" view was obtained by slightly tilting the lens towards the trabecular meshwork without causing inadvertent corneal indentation. Angle width was estimated in the superior and inferior quadrants as the angle in degrees between a tangent line to the surface of the trabecular meshwork and another tangent line to the peripheral third of the iris, and then recorded in five-point categories (0°, 10°, 20°, 30° and 40°). Mean angle width of each eye was calculated from the angle width of the superior and inferior quadrants. All gonioscopic examinations in this study were carried out by an experienced specialist-trained ophthalmologist (MH).

The status of narrow anterior chamber angle in this study referred to eyes in which the pigmented posterior trabecular meshwork was not visible in at least three quadrants (270°) under static gonioscopy.

Statistical Analysis

Only right eye data were included in the current analysis, while results were similar if analysis was undertaken using left eyes only. Student's *t* tests, Mann Whitney U tests and χ^2

tests were used for comparison of demographic, refractive, axial ocular biometric and socioeconomic parameters between included and excluded phakic subjects. The tests for trend across ordered groups were used to examine the correlation between angle width and different quartile levels of anthropomorphic measures. Univariable and multivariable logistic regression models were used to assess the association between occludable angle and anthropomorphic measures. All statistical analysis was performed using Stata 12 (StataCorp, College Station, TX, USA).

RESULTS

Of 1358 phakic subjects examined, 912 (67.2%) had anthropometry data available and were included in the current analysis. Included and excluded subjects were similar in terms of sex, education level and refractive status. Compared to those excluded, included subjects were younger (median age 65 years vs 68 years, $p < 0.05$) and had slightly shallower ACD (2.66 ± 0.33 mm vs 2.80 ± 0.31 mm, $p < 0.05$).

A higher proportion of individuals with lower body weight and shorter height had narrow angles (Table 1). The lowest quartiles of weight, height, and BMI were associated with smaller angle width ($p < 0.001$). In univariate analysis, shorter height, lower body weight and lower BMI were all significantly associated with greater odds of having narrow angles (Table 2).

In multiple logistic regression analyses, to avoid collinearity, BMI and weight were not included in the same regression model. As shown in Table 3, the association between lower BMI and narrow angle remained statistically significant, after adjusting for height, age, sex, education level, AL and ACD. This association was also shown to be significant in multiple linear regression models employing mean angle width as a continuous variable (regression coefficient $r = 0.030$, $p = 0.008$ for BMI; $r = 0.013$, $p = 0.001$ for weight). Similar results were seen in the multivariable regression model assessing the association between weight and narrow angle (data not shown). The association between height and narrow angle was no longer statistically significant after adjusting for age, AL and ACD in both men and women (Table 4).

In a sex-stratified multiple regression model examining the association between BMI and narrow angle, a significant association between BMI and narrow angle was only present in women (Table 5). However, the interaction between BMI and sex in multivariable models was not statistically significant (tests for interaction $p = 0.33$).

DISCUSSION

Individuals with lower body weight and shorter height had a higher likelihood of having narrow anterior chamber angles. In multiple logistic regression models adjusting for height, age, sex, central ACD and AL, lower BMI and weight were significantly associated with greater risk for narrow angle. When stratifying the multivariate analysis by sex, the association between lower BMI and narrow angle was statistically significant only in female subjects.

Our findings are in agreement with those of a previous study in Singapore¹⁰ which assessed the value of height for rapid assessment of risk for narrow angle. This study confirmed the findings by Wong and co-authors⁶ based on data from the same cross-sectional survey that shorter adult height was significantly associated with shallower ACD. However, after adjusting for age and sex, adult height was not significantly associated with narrower angles.¹⁰ Another community-based cross-sectional study of predominantly Chinese subjects reported no significant association between height and narrow angle.¹¹ In the current analysis, when only adjusting for sex or age, height remained significantly associated with narrow angles. The association between height and narrow angles disappeared when both age and sex were included in the regression model (as shown in Table 4, *p* values for height, sex and age when the three variables were included in the same model were 0.455, 0.080 and <0.001, respectively). This suggests a potential interaction between age and sex, though this did not reach statistical significance (*p* = 0.98). It has been suggested that shorter body stature is associated with smaller ocular dimensions (mainly represented by shorter AL) but not necessarily with narrow angle configuration.¹⁰ Although shorter individuals may have relatively shallower anterior chambers and greater central lens thickness, they may also have steeper corneas and more convex anterior lens surfaces, both of which may contribute to widening the drainage angle in the peripheral anterior chamber.

The association between BMI and ocular traits has been studied in other population-based cohorts. Lower BMI was associated with smaller neuroretinal rim area and larger cup-to-disc ratio¹² as well as thinner central retina and fovea.¹³ In the current study, lower BMI was significantly associated with higher risk for having narrow angles after adjusting for age, sex, ACD, AL and education level. One explanation for the findings in this study might be the possible relationship between low BMI, especially at earlier stages of life, and compromised development of the ocular structures. For example, children with lower BMI have been shown to have narrower retinal blood vessels.¹⁴ There has been consistent evidence from previous studies showing that genetic factors are very important contributors to variation in BMI.^{15–17} Thus the possibility of compromised development in the ocular anterior segment cannot be ruled out in individuals with lower BMI. It is also likely that BMI affects drainage angle configurations through dynamic behaviors of the iris (e.g. changes of iris thickness and volume under different illumination), since variations in BMI have recently been associated with different dynamic changes of the pupil.¹⁸ Among individuals with lower BMI, certain changes in the thickness or volume of the peripheral iris under different illumination could possibly make the anterior chamber angle appear to be comparatively narrower in dark illumination environments where gonioscopy is usually carried out. Further investigation is needed to unveil the characteristics of iris tissue and dynamic iris behaviors in individuals of different BMIs.

In the current study, stratified analysis detected an association between BMI and narrow angle only in females. Female sex is associated with narrower drainage angle and higher incidence of angle closure, especially among East Asians.^{19,20} Some believe that the relatively narrower angle configuration in women might result from a smaller overall ocular dimension and general body size.²¹ Considering the age and ethnic background of female

subjects in this study, lower BMI seemed to serve as another risk factor in this high-risk population for primary angle closure.

Limbal ACD measured by the van Herick grading system²² has been recognized as a useful tool for identifying individuals with narrow angles²³ and has also been shown to have good agreement with gonioscopy in assessing angle configuration.²⁴ However, in contrast to our findings, Xu and colleagues⁷ found no significant association between limbal ACD and BMI in univariable analysis. In multivariable models with age, sex, height and weight included as independent variables, they found that limbal ACD remained significantly associated with height but not with body weight. The differences between these findings and the results of our study suggest that the association between adult anthropometry and limbal ACD may not be representative of the association between anthropomorphic measures and actual angle configuration directly observed under gonioscopy. Alternatively, given the limited data to support both findings, it is also possible that no real association exists.

Several limitations should be considered when interpreting our results. Anthropometry data were only available for 912 of the 1358 phakic subjects examined in the population-based prevalence survey. While excluded participants were relatively older and had deeper ACD, it is not likely that the associations we described would be systematically different in these people. Another limitation is that gonioscopy is dependent on the examiner's skills, experience and subjective judgments. Nevertheless, all gonioscopic examinations were carried out by the same experienced examiner (MH), which would greatly limit bias.

In conclusion, our findings suggest that height was not independently associated with narrow angle in this cohort, once adjusted for age and sex. However, Chinese persons of lower BMI and lower body weight were more likely to have narrow anterior chamber angles, independent of age, sex, central ACD, AL, and education level. This association was detected only in women. Our findings suggest that lower BMI/body weight may provide important information to the decision making process for referring people for further assessment of angle configuration, especially when combined with other well recognized risk factors such as female sex, old age, certain ethnic groups and hyperopia.

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TABLE 1

Weight, height, body mass index and mean angle width in the Liwan Eye Study.

	Mean angle width ^a , n (%)			
	0–10°	15–25°	30°	Total, n (%)
Weight, kg				
27–49	55 (40.74)	57 (33.53)	124 (20.84)	236 (26.22)
50–57	39 (28.89)	43 (25.29)	141 (23.70)	223 (24.78)
57–63	26 (19.26)	41 (24.12)	167 (28.07)	234 (26.00)
64–94	15 (11.11)	29 (17.06)	163 (27.39)	207 (23.00)
Tests for trend across ordered groups: z = 6.38, p<0.001				
Height, m				
1.18–1.49	58 (42.96)	70 (41.18)	123 (20.67)	251 (27.89)
1.50–1.54	37 (27.41)	37 (21.76)	135 (22.69)	209 (23.22)
1.55–1.61	27 (20.00)	36 (21.18)	165 (27.73)	228 (25.33)
1.62–1.81	13 (9.63)	27 (15.88)	172 (28.91)	212 (23.56)
Tests for trend across ordered groups: z = 7.62, p<0.001				
Body mass index, kg/m ²				
14.79–21.33	47 (34.81)	42 (24.71)	136 (22.86)	225 (25.00)
21.34–23.50	38 (28.15)	40 (23.53)	148 (24.87)	226 (25.11)
23.51–25.77	24 (17.78)	44 (25.88)	158 (26.55)	226 (25.11)
25.78–35.82	26 (19.26)	44 (25.88)	153 (25.71)	223 (24.78)
Tests for trend across ordered groups: z = 2.50, p<0.01				
Total	135 (100.00)	170 (100.00)	595 (100.00)	900 (100.00)

^a Mean Shaffer grade of the superior and inferior quadrant; Shaffer grade was missing in 12 subjects.

TABLE 2

Association of narrow angles with anthropomorphic measures and other factors in the Liwan Eye Study (univariate analysis).

	Narrow angle ^a		
	Odds ratio	95% confidence interval	p Value
Age, per decade	2.12	(1.69–2.67)	<0.001
Sex			
Male	Reference		
Female	2.05	(1.29–3.24)	0.002
Weight, per 10 kg	0.53	(0.42–0.67)	<0.001
Height, per 10 cm	0.55	(0.43–0.71)	<0.001
Body mass index, kg/m ²	0.89	(0.83–0.95)	0.001
Axial length, mm	0.45	(0.34–0.58)	<0.001
Anterior chamber depth, mm	0.02	(0.01–0.05)	<0.001
Spherical equivalent, diopters	1.27	(1.10–1.46)	0.001
Education level			
No formal or primary	Reference		
Middle or college	0.39	(0.25–0.61)	<0.001
Occupation	1.09	(0.93–1.28)	0.29
Income	0.69	(0.47–1.02)	0.07

^aNarrow angle defined as pigmented trabecular meshwork not visible in at least three quadrants under static gonioscopy.

TABLE 3

Association between narrow angles and body mass index in the Liwan Eye Study (multivariable-adjusted logistic regression model).

	Narrow angle ^a		
	Odds ratio	95% confidence interval	p Value
Age per decade	2.01	(1.49–2.71)	<0.001
Sex			
Male	Reference		
Female	1.28	(0.63–2.62)	0.50
Body mass index, kg/m ²	0.93	(0.86–0.99)	0.026
Height, per 10 cm	0.99	(0.64–1.54)	0.97
Education level			
No formal or primary	Reference		
Middle or college	0.90	(0.51–1.58)	0.72
Axial length, mm	0.59	(0.42–0.81)	0.001
Anterior chamber depth, mm	0.05	(0.02–0.17)	<0.001

^a Narrow angle defined as pigmented trabecular meshwork not visible in at least three quadrants under static gonioscopy.

TABLE 4

Association between narrow angles and height in the Liwan Eye Study.

	Narrow angle ^a		
	Odds ratio	95% confidence interval	p Value
Crude data			
Height, per 10cm	0.55	(0.43–0.71)	<0.001
Adjusted for sex			
Height, per 10cm	0.57	(0.41–0.79)	0.001
Sex	1.08	(0.60–1.94)	0.808
Adjusted for age			
Height, per 10cm	0.69	(0.52–0.90)	0.006
Age	1.07	(1.04–1.09)	<0.001
Adjusted for age and sex			
Height, per 10cm	0.87	(0.59–1.26)	0.455
Sex	1.77	(0.93–3.36)	0.080
Age	1.07	(1.05–1.10)	<0.001
Adjusted for axial length and ACD			
Height, per 10cm	0.67	(0.50–0.89)	0.006
Axial length, mm	0.74	(0.56–0.99)	0.039
ACD, mm	0.03	(0.01–0.09)	<0.001
Adjusted for axial length, ACD, sex and age			
Height, per 10cm	1.00	(0.65–1.54)	0.999
Sex	1.37	(0.69–2.74)	0.371
Age	1.08	(1.05–1.11)	<0.001
Axial length, mm	0.60	(0.43–0.83)	0.002
ACD, mm	0.05	(0.02–0.14)	<0.001

^aNarrow angle defined as pigmented trabecular meshwork not visible in at least three quadrants under static gonioscopy.

ACD, anterior chamber depth

TABLE 5

Association between body mass index and narrow angles in the Liwan Eye Study (multivariable-adjusted logistic regression stratified by sex).

	Narrow angle ^a		
	Odds ratio	95% confidence interval	p Value
Males			
Age, per decade	2.71	(1.58–4.63)	<0.001
Body mass index, kg/m ²	0.97	(0.85–1.11)	0.629
Height, per 10 cm	0.92	(0.42–1.99)	0.83
Education level			
No formal or primary		Reference	
Middle or college	1.81	(0.66–4.95)	0.25
Axial length, mm	0.38	(0.20–0.73)	0.004
Anterior chamber depth, mm	0.14	(0.03–0.80)	0.027
Females			
Age, per decade	1.77	(1.23–2.56)	0.002
Body mass index, kg/m ²	0.90	(0.83–0.98)	0.014
Height, per 10 cm	1.04	(0.61–1.79)	0.88
Education level			
No formal or primary		Reference	
Middle or college	0.62	(0.30–1.29)	0.20
Axial length, mm	0.67	(0.46–0.98)	0.038
Anterior chamber depth, mm	0.04	(0.01–0.16)	<0.001

^aNarrow angle defined as pigmented trabecular meshwork not visible in at least three quadrants under static gonioscopy.