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The association between serum albumin–globulin ratio and overactive bladder in American adults: a cross-sectional study

Yuan-Zhuo Du[1,2], Jia-Hao Liu[1,2], Fu-Chun Zheng[1,2], Qiang Zhou[1,2*] and Ju Guo[1,2*]

Abstract

Objectives The albumin–globulin ratio (AGR) is considered an important indicator reflecting an individual's immune function and nutritional status, and it is closely associated with various health conditions. However, despite its widely studied correlations in numerous health fields, the link between AGR and Overactive Bladder (OAB) is still not completely comprehended.

Methods Data were sourced from the National Health and Nutrition Examination Survey (NHANES) database, selecting adult samples spanning from 2007 to 2018. Through comprehensive questionnaires and laboratory tests, we gathered data pertinent to OAB and the AGR. To explore the association between AGR levels and the likelihood of developing OAB, we utilized advanced statistical techniques, such as weighted multivariate logistic regression and restricted cubic spline (RCS) models. Furthermore, we carried out subgroup analyses to assess the uniformity of this association across various demographics.

Results After adjusting for relevant covariates, we discovered a marked negative correlation between AGR levels and the risk of OAB. As AGR increased, the incidence of OAB showed a declining trend (OR = 0.69; 95% CI 0.56–0.85). Furthermore, significant nonlinear dose–response relationship was observed between AGR levels and the risk of OAB ($P < 0.001$), and this association remained stable in stratified analyses.

Conclusions Our results indicate that elevated AGR levels could be linked to a reduced risk of OAB. This observation highlights the potential role of AGR in assessing and preventing the occurrence of OAB.

Keywords Overactive bladder, Albumin–globulin ratio, NHANES, Cross, Sectional study

Introduction

Overactive bladder (OAB), commonly diagnosed by symptoms, such as urgent urination, frequency, and incontinence, significantly impacts the mental health and overall life satisfaction of patients [1, 2]. It is estimated that millions of people globally are afflicted by OAB, with incidence rates rising due to aging populations and lifestyle changes [3–5]. Although the precise mechanisms underlying OAB remain unclear, factors such as neural regulation, bladder muscle dysfunction, and chronic inflammation have been closely linked to its onset and progression [6–9].

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The immune system could be crucial in the development of OAB. Abnormal activation of immune-related factors, including white blood cells, cytokines, and inflammatory mediators, has been observed to correlate with the development and progression of OAB [8]. In this context, the albumin–globulin ratio (AGR), serving as an indicator of immune status and inflammation levels, might be closely related to the pathogenesis and progression of OAB. Albumin, predominantly produced by the liver and the most plentiful protein in the human body, plays crucial roles in maintaining plasma osmotic pressure, transporting nutrients, and regulating immune responses [10]. Globulins include various immunoglobulins, such as IgA and IgG, which are key in combating disease and infection [11]. Changes in AGR might reflect alterations in immune status, such as diminished immune function or increased inflammatory response, thereby impacting health conditions [12]. Recent studies have linked AGR not only with the incidence and prognosis of chronic diseases but also with the development of neurological and immune system disorders [13–17]. For instance, one investigation demonstrated a positive correlation between AGR and cognitive performance, where higher AGR was associated with improved overall cognitive scores [18].

However, to date, no studies have investigated the connection between AGR and OAB. Therefore, this research aims to systematically assess the relationship between AGR and OAB by analyzing data from the National Health and Nutrition Examination Survey (NHANES) database and further explore potential moderating factors. Through this study, we aim to reveal the possible role of AGR in the development of OAB and also offer fresh perspectives and evidence for its diagnosis, prevention, and treatment.

Methods

Study population

This cross-sectional research utilized records gathered by NHANES on a biennial basis between 2007 and 2018. After receiving approval from the National Center for Health Statistics' Ethics Review Board, participants provided their written informed consents [19]. Complying with established protocols and standards, and based on precise criteria for inclusion and exclusion in the study, 59,842 candidates were initially evaluated. Individuals under the age of 20 (25,072 people), those lacking historical information on OAB (4983 people), those missing critical data on AGR (1568 people), and those without essential covariate information (3799 people) were excluded. Consequently, 24,420 individuals met the inclusion criteria and were subsequently included in the final assessment (Fig. 1).

Calculation of AGR

The concentrations of serum albumin (g/dL) and globulin (g/dL) were assessed using the DcX800 system, described as a digital biochemical endpoint technique. The AGR was determined by dividing the value of albumin by that of globulin.

Diagnosis of OAB

OAB is characterized as a disorder with symptoms that include urinary frequency, urgency urinary incontinence (UUI), and nocturia. In this research, data were gathered through direct interviews and questionnaires, carried out by experts with professional training [20]. The assessment of UUI was based on the question posed to participants: 'Over the last year, have you dealt with involuntary urine leakage caused by a sudden urge to urinate or pressure, and were unable to make it to the toilet in time?' The intensity of the condition was further assessed by asking about the frequency of such occurrences. Nocturia was assessed by asking, 'In the last 30 days, how often have you typically had to wake up to urinate during the night?' In addition, the Overactive Bladder Symptom Score (OABSS) was employed to quantify the severity of OAB, with scores of 3 or above indicating an OAB diagnosis [21] (refer to Fig. 2).

Definition of covariates

In this study, we considered a comprehensive range of covariates related to AGR and the risk of OAB, categorized into three main groups: demographic indicators, lifestyle factors, and health status. Demographic indicators included age, gender, race, marital status, educational level, and poverty rate. Lifestyle factors encompassed alcohol consumption (categorized into lifetime non-drinkers with less than 12 instances, past drinkers who had consumed 12 times or more but not in the past year, and current drinkers who had consumed 12 times or more lifetime and at least once in the past year) [22], smoking status (defined as having smoked over 100 cigarettes), sedentary time (whether seated for more than 5 h daily), and physical activity levels (assessed by the weekly duration of moderate to vigorous exercises lasting a minimum of 10 min per session).

Health indicators were collected through standardized questionnaires and clinical assessments, and included Body Mass Index (BMI), estimated Glomerular Filtration Rate (eGFR), diabetes, hypertension, hyperlipidemia, and cardiovascular diseases (CVD). Hyperlipidemia is defined as having total cholesterol levels of ≥200 mg/dL, triglyceride levels of ≥150 mg/dL, low-density lipoprotein levels of ≥130 mg/dL,

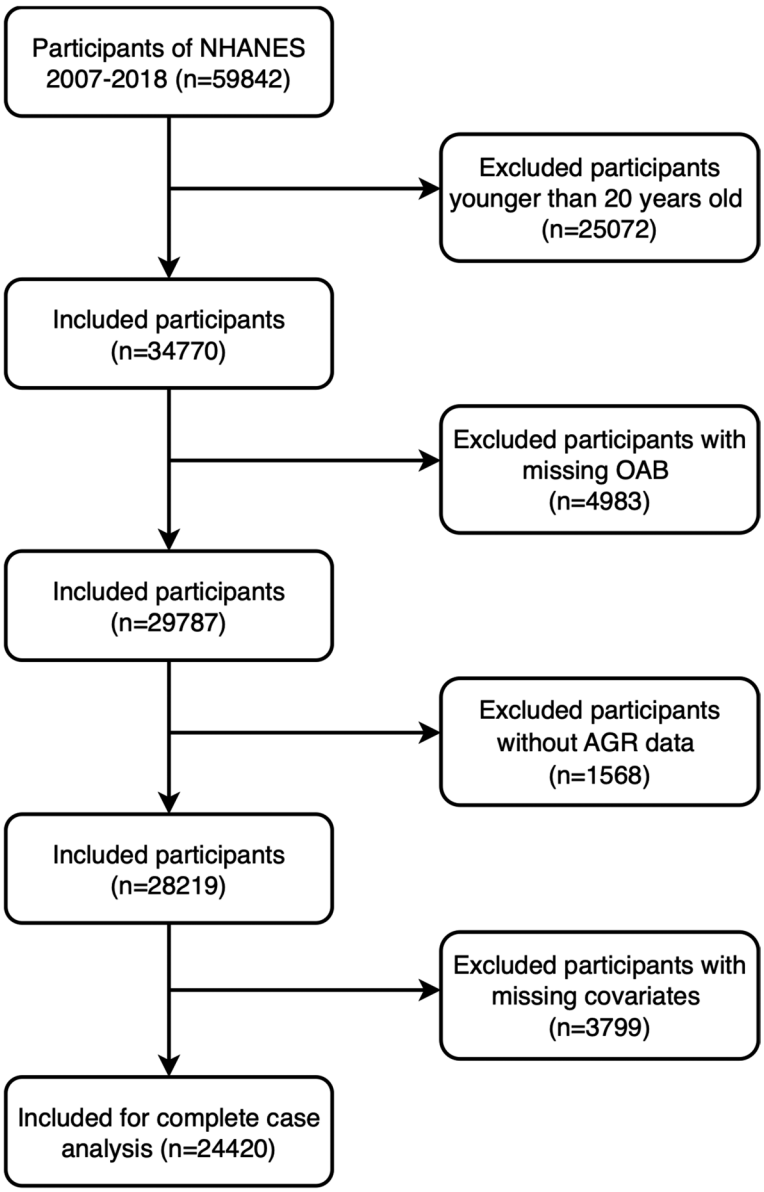

Fig. 1 Participant flow diagram

or high-density lipoprotein levels of ≤50 mg/dL for women and ≤40 mg/dL for men [23]. Individuals who use cholesterol-lowering medication are also classified under this condition [24]. For CVD, the definition is based on self-reported or physician-confirmed diagnoses. Questions such as "Has a doctor or other health professional ever told you that you have a heart attack, coronary heart disease, angina, congestive heart failure, or stroke?" help identify CVD cases. Affirmative responses classify a participant as having CVD, while responses indicating uncertainty are excluded from this category [25].

Statistical analysis

In this analysis, we accounted for NHANES sampling weights to estimate values for statistical analysis. For continuous variables, weighted averages and standard errors were presented, whereas for categorical variables, weighted counts and percentages were reported, analyzed using weighted linear regression and weighted chi-square tests, respectively. To explore the relationship

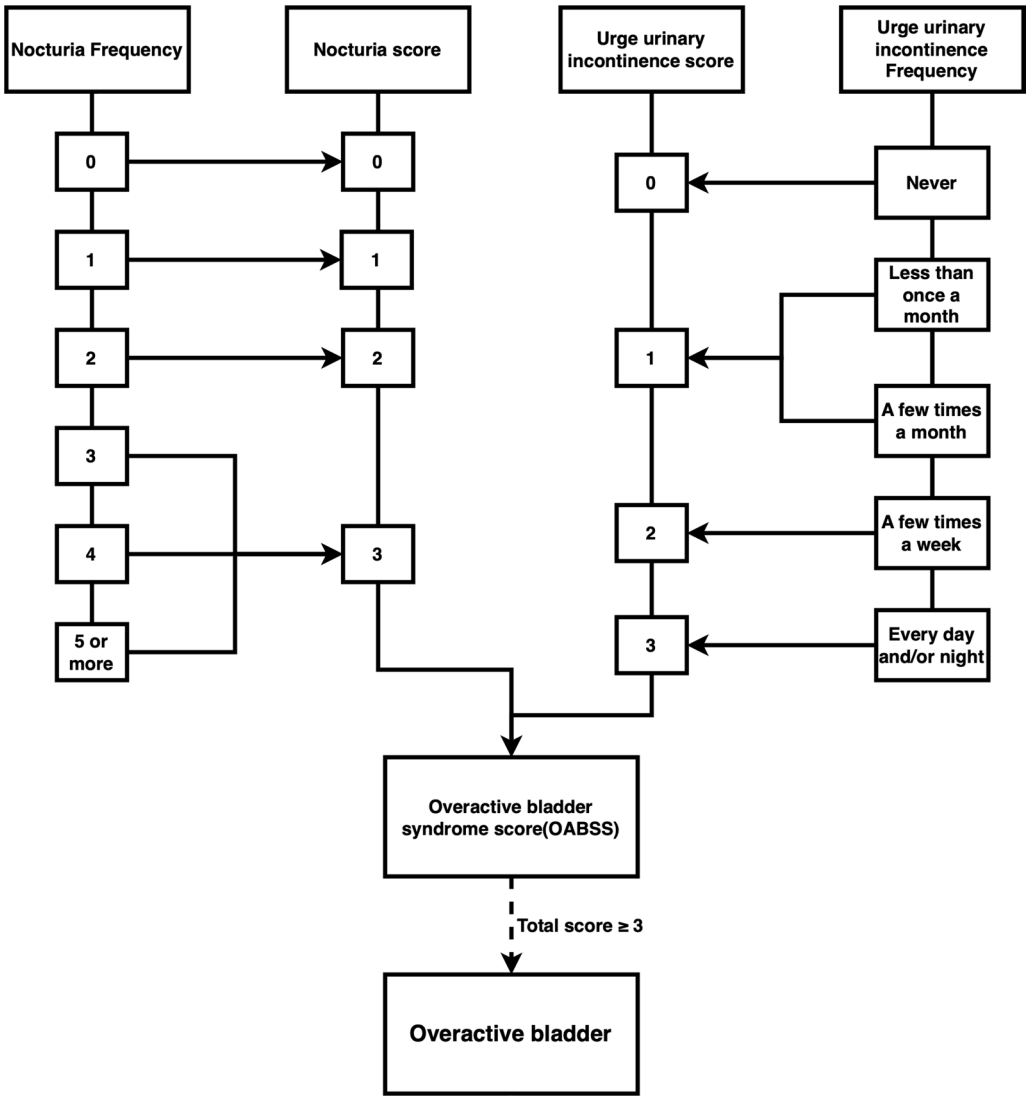

Fig. 2 Flowchart for diagnosing overactive bladder syndrome based on overactive bladder syndrome scores

between AGR and the incidence of OAB, we applied multivariate logistic regression models, calculated the odds ratios (ORs) along with their 95% confidence intervals (CIs) for AGR, and treated AGR quartiles as categorical variables [26]. Crude Model was unadjusted; Model 1 included adjustments for factors, such as age, gender, race, educational level, marital status, and income level; Model 2 further considered smoking status, alcohol use, BMI, eGFR, sedentary time, physical activity level, hypertension, diabetes, hyperlipidemia, and cardiovascular diseases. In addition, we utilized restricted cubic spline (RCS) regression models to examine the dose–response relationship between AGR and the risk of OAB, and conducted subgroup analyses to assess the robustness of our findings across different demographic characteristics and health conditions. All statistical analyses were conducted using R software (version 4.3.2), with a significance threshold established at $P < 0.05$.

Results

Baseline characteristics of participants

In this study, we analyzed data from 24,420 participants over six NHANES cycles from 2007 to 2018. Participants were segmented into four quartiles according to their AGR levels. Table 1 presents the demographic data of the study population: the mean age was 47.16 ± 0.26 years, 51.21% were female, and the weighted prevalence of OAB was 15.24%. Results indicated that participants with higher AGR tended to be male, non-Hispanic white, married/cohabiting, and better educated. They were also

Table 1 Baseline characteristics of the study population by quartiles of AGR

Variable	AGR quartiles					
	Overall	Q1 (≤1.30)	Q2 (1.31–1.48)	Q3 (1.49–1.67)	Q4 (≥1.68)	*P* value
Age, years, mean (SE)	47.16 (0.26)	47.63 (0.39)	47.66 (0.39)	47.20 (0.31)	46.51 (0.39)	0.05
Age strata, years, *n* (%)						0.19
20–39	8315 (36.73)	1852 (35.55)	1883 (35.60)	2189 (36.51)	2391 (38.40)	
40–59	8121 (37.78)	2164 (38.49)	2003 (37.84)	2089 (38.19)	1865 (36.96)	
≥60	7984 (25.49)	2234 (25.96)	1935 (26.56)	1988 (25.30)	1827 (24.64)	
Sex, *n* (%)						<0.0001
Female	12,407 (51.21)	4036 (67.39)	3185 (58.10)	2907 (48.22)	2279 (39.22)	
Male	12,013 (48.79)	2214 (32.61)	2636 (41.90)	3359 (51.78)	3804 (60.78)	
Race, *n* (%)						<0.0001
Mexican American	3604 (8.16)	1046 (11.35)	1013 (10.26)	929 (8.05)	616 (4.86)	
Non-Hispanic White	10,715 (69.07)	1663 (49.44)	2215 (63.24)	3018 (71.89)	3819 (82.56)	
Non-Hispanic Black	4907 (10.13)	2162 (22.83)	1298 (12.50)	929 (7.05)	518 (3.43)	
Other Hispanic	2452 (5.39)	716 (7.68)	620 (6.13)	646 (5.36)	470 (3.51)	
Other race	2742 (7.26)	663 (8.70)	675 (7.87)	744 (7.65)	660 (5.63)	
Marital status, *n* (%)						<0.0001
Divorced/separated/widowed	5341 (18.01)	1667 (21.87)	1384 (20.08)	1266 (17.85)	1024 (14.39)	
Married/living with a partner	14,640 (63.91)	3423 (59.41)	3435 (62.00)	3916 (65.44)	3866 (66.65)	
Never married	4439 (18.08)	1160 (18.72)	1002 (17.91)	1084 (16.72)	1193 (18.96)	
Education levels, *n* (%)						<0.0001
High school and below	11,073 (37.11)	3205 (44.56)	2741 (39.34)	2823 (37.54)	2304 (30.69)	
Above high school	13,347 (62.89)	3045 (55.44)	3080 (60.66)	3443 (62.46)	3779 (69.31)	
Poverty ratio, *n* (%)						<0.0001
<1.3	7601 (20.80)	2347 (28.62)	1894 (22.70)	1830 (19.77)	1530 (15.64)	
1.3–3.5	9219 (35.44)	2425 (38.38)	2246 (36.07)	2343 (35.25)	2205 (33.39)	
>3.5	7600 (43.75)	1478 (33.00)	1681 (41.23)	2093 (44.99)	2348 (50.97)	
BMI, *n* (%)						<0.0001
<25	6932 (29.21)	1191 (18.93)	1469 (25.02)	1935 (29.95)	2337 (37.69)	
25–29.99	8050 (32.99)	1733 (26.03)	1928 (31.98)	2179 (34.45)	2210 (36.66)	
≥30	9438 (37.80)	3326 (55.03)	2424 (43.00)	2152 (35.60)	1536 (25.64)	
Smoke, *n* (%)						<0.0001
No	13,537 (55.77)	3696 (59.61)	3350 (58.01)	3346 (53.66)	3145 (53.69)	
Yes	10,883 (44.23)	2554 (40.39)	2471 (41.99)	2920 (46.34)	2938 (46.31)	
Alcohol user, *n* (%)						<0.0001
Never	3370 (10.43)	1137 (15.65)	872 (10.80)	770 (9.33)	591 (7.94)	
Former	3809 (12.69)	1093 (14.40)	909 (13.18)	962 (12.53)	845 (11.43)	
Now	17,241 (76.89)	4020 (69.95)	4040 (76.02)	4534 (78.13)	4647 (80.63)	
Moderate recreational activity, *n* (%)						<0.0001
No	12,450 (44.71)	3818 (57.59)	3101 (47.76)	3057 (43.98)	2474 (35.44)	
Yes	11,970 (55.29)	2432 (42.41)	2720 (52.24)	3209 (56.02)	3609 (64.56)	
Sitting time, *n* (%)						0.03
<5	9940 (36.87)	2568 (38.18)	2425 (37.71)	2588 (37.36)	2359 (35.07)	
≥5	14,480 (63.13)	3682 (61.82)	3396 (62.29)	3678 (62.64)	3724 (64.93)	
Hypertension, *n* (%)						<0.0001
No	15,680 (68.38)	3568 (62.03)	3657 (66.87)	4172 (68.94)	4283 (72.80)	
Yes	8740 (31.62)	2682 (37.97)	2164 (33.13)	2094 (31.06)	1800 (27.20)	
Diabetes, *n* (%)						<0.0001
No	20,780 (88.55)	4969 (82.53)	4875 (87.51)	5474 (89.73)	5462 (91.90)	
Borderline	575 (2.06)	152 (2.09)	171 (2.50)	131 (1.93)	121 (1.86)	

Table 1 (continued)

Variable	AGR quartiles					
	Overall	Q1 (≤1.30)	Q2 (1.31–1.48)	Q3 (1.49–1.67)	Q4 (≥1.68)	*P* value
Yes	3065 (9.39)	1129 (15.38)	775 (9.99)	661 (8.34)	500 (6.24)	
Hyperlipidemia, *n* (%)						<0.0001
No	6960 (29.62)	1605 (26.10)	1508 (26.71)	1886 (31.19)	1961 (32.42)	
Yes	17,460 (70.38)	4645 (73.90)	4313 (73.29)	4380 (68.81)	4122 (67.58)	
CVD, *n* (%)						<0.0001
No	23,681 (97.75)	5973 (96.18)	5640 (97.61)	6104 (98.01)	5964 (98.57)	
Yes	739 (2.25)	277 (3.82)	181 (2.39)	162 (1.99)	119 (1.43)	
eGFR (mL/min), mean (SE)	94.69 (0.34)	97.02 (0.55)	95.12 (0.46)	94.34 (0.38)	93.26 (0.47)	<0.0001
AGR, mean (SE)	1.55 (0.01)	1.16 (0.00)	1.39 (0.00)	1.57 (0.00)	1.89 (0.01)	<0.0001
UUI frequency, *n* (%)						<0.0001
Never	18,944 (80.29)	4406 (72.67)	4450 (78.83)	5064 (82.35)	5024 (84.16)	
Less than once a month	2464 (9.56)	794 (12.41)	603 (10.12)	550 (8.84)	517 (8.06)	
A few times a month	1742 (6.12)	564 (8.48)	470 (6.70)	373 (5.03)	335 (5.23)	
A few times a week	778 (2.56)	293 (3.98)	174 (2.70)	180 (2.48)	131 (1.66)	
Every day and/or night	492 (1.47)	193 (2.46)	124 (1.65)	99 (1.31)	76 (0.90)	
Nocturia frequency, *n* (%)						<0.0001
0	7633 (34.48)	1471 (25.96)	1751 (33.49)	2106 (35.80)	2305 (39.20)	
1	9260 (40.52)	2208 (37.57)	2179 (39.70)	2465 (41.82)	2408 (41.76)	
2	4482 (15.91)	1397 (20.83)	1129 (17.05)	1082 (15.03)	874 (12.88)	
3	2082 (6.45)	757 (10.37)	533 (6.94)	432 (5.42)	360 (4.61)	
4	659 (1.85)	286 (3.80)	159 (2.00)	120 (1.26)	94 (1.05)	
5 or more?	304 (0.80)	131 (1.47)	70 (0.83)	61 (0.66)	42 (0.50)	
OAB, *n* (%)						<0.0001
No	19,598 (84.76)	4454 (75.74)	4633 (83.66)	5262 (87.26)	5249 (88.85)	
Yes	4822 (15.24)	1796 (24.26)	1188 (16.34)	1004 (12.74)	834 (11.15)	

AGR albumin–globulin ratio, *eGFR* estimated glomerular filtration rate; *BMI* body mass index, *CVD* cardiovascular disease, *OAB* overactive bladder, *UUI* urgency urinary incontinence

likely to have a higher income-to-poverty ratio, lower BMI, and longer sedentary periods. In addition, these participants were more likely to be smokers, current drinkers, and physically active, but less prone to having a history of hypertension, diabetes, hyperlipidemia, or cardiovascular disease. Furthermore, higher AGR levels were significantly associated with reduced incidence of OAB, UUI, and nocturia ($P<0.05$).

Correlation between AGR and OAB

Table 2 shows a significant negative correlation between AGR and OAB risk, whether considered as a continuous or a categorical variable. Preliminary unadjusted analyses indicated that for every unit increase in AGR, the risk of OAB decreased by 67% (95% CI 0.27–0.41, $P<0.0001$). This association remained significant in the fully adjusted Model 2, with an OR of 0.69 (95% CI 0.56–0.85, $P<0.001$). In the quartile-based model with full adjustments, risk reductions were observed when compared to the lowest quartile: 27% (95% CI 0.65–0.83, $P<0.0001$) in the second quartile, 37% (95% CI 0.55–0.73, $P<0.0001$) in the third quartile, and 34% (95% CI 0.56–0.76, $P<0.0001$) in the fourth quartile. Furthermore, analysis using the restricted cubic spline (RCS) regression model revealed a potential dose–response relationship, exhibiting a nonlinear correlation with an inflection point at 1.62 (Fig. 3).

Stratified analysis

Figure 4 presents the outcomes of the stratified analysis, revealing a significant negative association between AGR and OAB prevalence across various populations. Notably, significant interactions between AGR and OAB risk were observed across different age groups, races, educational levels, levels of physical activity, presence of hyperlipidemia, and history of cardiovascular disease ($P<0.05$). No notable interactions were found in other groups ($P>0.05$), and the effect estimates remained uniform across all subgroups.

Table 2 Association of the quartiles of AGR with OAB

Exposure	Crude model		Model 1		Model 2	
	OR (95% CI)	*P* value	OR (95% CI)	*P* value	OR (95% CI)	*P* value
AGR	0.33 (0.27, 0.41)	<0.0001	0.53 (0.43, 0.65)	<0.0001	0.69 (0.56, 0.85)	<0.001
AGR quartile						
Q1 (≤1.30)	1 (Ref.)		1 (Ref.)		1 (Ref.)	
Q2 (1.31–1.48)	0.61 (0.54, 0.68)	<0.0001	0.68 (0.60, 0.76)	<0.0001	0.73 (0.65, 0.83)	<0.0001
Q3 (1.49–1.67)	0.46 (0.40, 0.52)	<0.0001	0.56 (0.48, 0.64)	<0.0001	0.63 (0.55, 0.73)	<0.0001
Q4 (≥1.68)	0.39 (0.34, 0.45)	<0.0001	0.54 (0.46, 0.62)	<0.0001	0.66 (0.56, 0.76)	<0.0001
P for trend		<0.0001		<0.0001		<0.0001

Crude model: unadjusted model

Model 1: Adjusted for age, sex, race, education levels, marital status, poverty ratio

Model 2: Additionally adjusted for BMI, smoking, alcohol user, recreational activity, sitting time, eGFR, hypertension, diabetes, hyperlipidemia and CVD

AGR albumin-to-globulin ratio, *OR* odds ratio, *CI* confidence interval

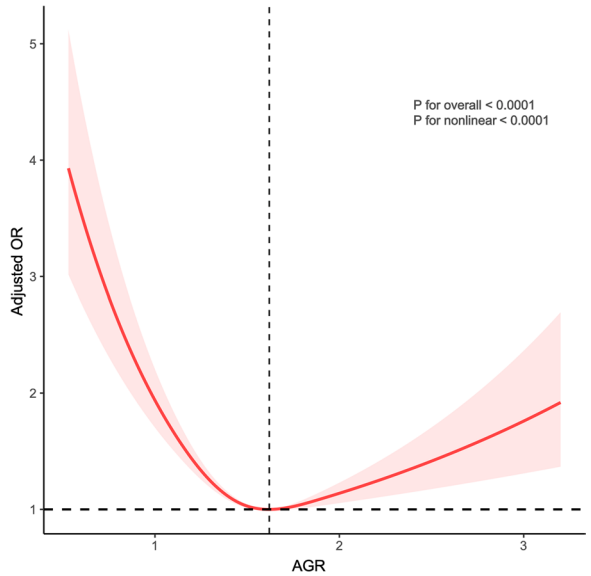

Fig. 3 Illustrates the correlation between AGR and the prevalence of OAB. The ORs, depicted by solid lines, were adjusted for age, sex, ethnicity, marital status, education levels, poverty ratio, BMI, smoking, alcohol user, recreational activity, sitting time, eGFR, hypertension, diabetes, hyperlipidemia and CVD. Corresponding 95% CIs are represented by shaded areas

Discussion

In this observational study, data from NHANES collected between 2007 and 2018 were examined to uncover the association between the AGR and OAB in adults. Our findings revealed a notable observation that AGR levels are inversely related to the prevalence of OAB, characterized by a nonlinear negative correlation that remains stable across different populations. This study provides preliminary epidemiological evidence that AGR levels may influence bladder function, although previous studies have not explored this specific connection.

First, we hypothesize that AGR may reflect the body's immune status and level of inflammation, which could be instrumental in the development of OAB. Abnormal activation of the immune system and the release of inflammatory mediators might lead to inflammatory responses in the bladder wall, thereby affecting bladder function [27]. Previous research has shown that immune-mediated inflammation is closely associated with the development of OAB [8]. Emerging evidence suggests that inflammation plays a crucial role in the pathogenesis of OAB. Inflammatory mediators can affect bladder function by altering urothelial function, increasing bladder sensation, and modulating smooth muscle activity [28]. Studies have shown that systemic inflammatory markers are often elevated in patients with OAB, indicating that systemic inflammation could contribute to the onset and severity of OAB symptoms [29]. For example, a study found that patients with higher levels of systemic inflammatory markers had a significantly increased risk of OAB, underscoring the potential role of inflammation in this condition [30]. By reflecting a balance between albumin and globulins, AGR may serve as a proxy for systemic inflammation and immune status, providing a plausible link to OAB.

In addition, AGR may indicate the body's nutritional and muscle status, which are essential for maintaining proper bladder and pelvic floor function. Albumin, a protein primarily synthesized by the liver, may indicate the body's nutritional status [31]. Lower levels of albumin, a marker of nutritional deficiency, have been associated with poor muscle strength and mass [32], factors that can contribute to bladder dysfunction. On the other hand, globulins, which include immunoglobulins, play a role in maintaining immune function and overall muscle health [33, 34]. Research has demonstrated a correlation between lower albumin levels and

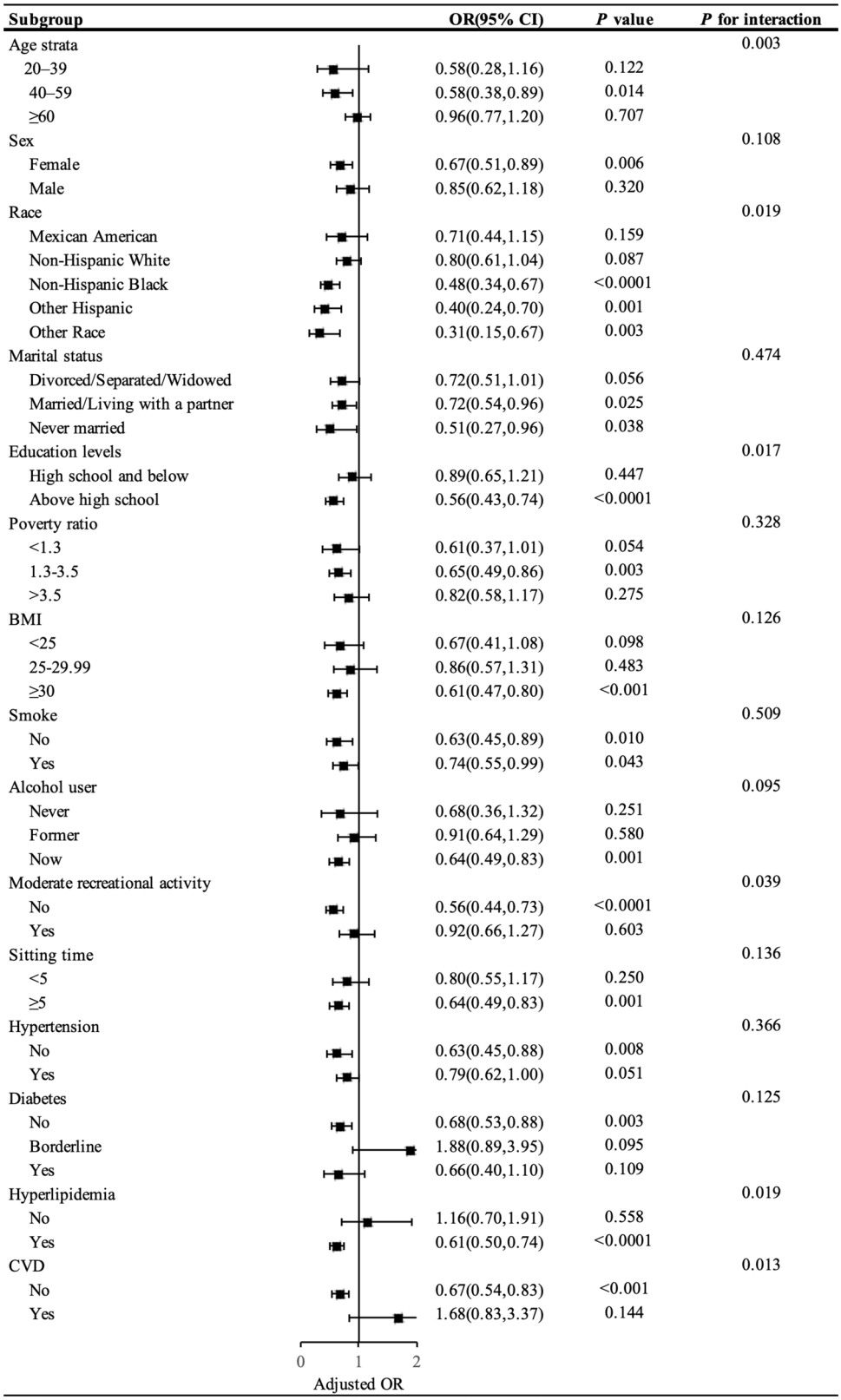

Fig. 4 Presents a stratified analysis of AGR and OAB

increased OAB symptoms in cirrhotic patients [35], further supporting the importance of nutritional status in OAB pathophysiology.

In addition to the body's immune and nutritional statuses, lifestyle factors, chronic diseases, and medication usage could also influence AGR levels and subsequently affect OAB risk. Dietary habits and exercise frequency may modify the body's immune status and nutritional levels [36, 37], potentially impacting AGR levels. Chronic conditions like diabetes are known to alter inflammation and metabolic profiles, which could reflect in altered AGR levels [38]. Furthermore, medications, including hormones and immunosuppressants, can influence protein synthesis and immune function [39, 40], thus affecting AGR levels. Exploring these connections could deepen our understanding of how AGR interacts with various physiological and pathological processes to influence OAB.

This study is constrained by its cross-sectional design, which inhibits our ability to establish causality between the serum AGR and OAB. While providing valuable cross-sectional data, the NHANES data set does not capture longitudinal changes or detailed medication histories, which are crucial as certain medications can significantly influence both the manifestation of OAB symptoms and the systemic conditions reflected in AGR. In addition, the exclusion of comprehensive medication use information, particularly the effects of pharmaceuticals on AGR and OAB, poses a significant limitation as these factors could confound the observed associations. Despite these limitations, our findings contribute to the broader understanding of OAB but must be interpreted with caution. Future research should not only employ longitudinal designs to confirm these relationships but also include detailed accounts of medication usage, lifestyle factors, and other potential confounders to fully elucidate the complex interactions affecting AGR and OAB. Such comprehensive studies will enhance our understanding of the pathogenesis of OAB and improve clinical management and preventive strategies.

Finally, the implications of our findings for clinical practice are significant. Using AGR as an indicator to assess the risk of OAB in patients can help identify high-risk individuals early and take preventative measures. In addition, exploring the relationship between AGR and the pathogenesis of OAB can aid in developing new treatment strategies and personalized interventions, improving treatment effectiveness and enhancing the living standards for those afflicted with OAB.

Conclusions

This study demonstrates that a higher Serum AGR is significantly linked to a reduced risk of OAB. This observation suggests that systemic factors related to AGR may influence OAB. However, due to the multifactorial influences on AGR, these results should be interpreted with caution, highlighting the need for further research into the complex interactions affecting OAB. This study contributes to the understanding of how broader health conditions might relate to OAB, providing directions for future exploratory research.

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Author contributions
DYZ, LJH, ZFC: Contributed to paper design, data processing, involved in data collection and drafted the manuscript. ZQ, GJ: Revised the manuscript.

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Availability of data and materials
All data used in this study are available in the NHANES database, accessible at https://www.cdc.gov/nchs/nhanes/index.htm.

Declarations

Ethics approval and consent to participate
The studies involving human participants were reviewed and approved by NCHS Research Ethics Review Board (ERB). Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Consent for publication
Relevant data from participants were collected from the publicly accessible NHANES database, eliminating the need for obtaining additional consent.

Competing interests
The authors declare no competing interests.

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