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Novel anthropometric indices are superior adiposity indexes to portend visual impairment in middle-aged and older Chinese population

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ABSTRACT

Objective To investigate differential associations of traditional and novel adiposity indices with visual impairment (VI) in the middle-aged and older Chinese population.

Methods and analysis Based on the China Health and Retirement Longitudinal Study, 7750 Chinese older adults aged over 45 were included at baseline 2011, and 4133 participants who accomplished all three interviews from 2011 to 2015 were adapted for longitudinal analyses. We enrolled six adiposity indices, including the body mass index (BMI), waist-to-height ratio (WHtR), weight-adjusted-waist index (WWI), a body shape index (ABSI), body roundness index (BRI) and conicity index (ConI). Visual status and other covariates included sociodemographic characteristics, medical supports and lifestyle-related factors. Cross-sectional correlations were assessed using univariate and multivariate logistic regression analyses. For longitudinal analysis, generalised linear models with generalised estimating equations were used to determine the association between time-varying adiposity and visual status.

Results Higher levels of WHtR/WWI/ABSI/BRI/ConI were significantly associated with an increased prevalence of VI, whereas a higher BMI was associated with a decreased prevalence of VI. Only WWI was significantly related to the prevalence of VI after adjustment for multiple confounders in both cross-sectional and longitudinal analyses (all p values <0.05). The multivariable-adjusted OR (95% CI) of VI associated with the highest (vs lowest) quintile of WWI was 1.900 (1.407 to 2.565).

Conclusion WWI is a reliable alternative adiposity index that exhibits a dose–response association with the prevalence of VI in the Chinese population. The WWI-VI correlation may eliminate the obesity paradox in the ophthalmic epidemiological area and indicate the detrimental impact of changes in body composition on VI.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Obesity and dyslipidaemia have been considered risk factors for many age-related vision-threatening ocular disorders. Hence, the adiposity index can become a screening tool for filtering the ageing population prone to visual impairment (VI). However, the body mass index (BMI)-based obesity paradox also occurs in the ophthalmic area, based on previous controversial results on the BMI-VI relationship from population-based studies. Considering the natural deficit of BMI, novel adiposity indexes, especially those that represent central obesity, deserve investigation into their correlations with VI for developing alternative screening routines in vulnerable and ageing populations.

WHAT THIS STUDY ADDS

⇒ Based on the China Health and Retirement Longitudinal Study, which is the very first nationally representative and longitudinal survey that aims to provide the most up-to-date cohort datasets for studying the health and well-being status of the middle-aged and older population in the Chinese mainland, we first verify the BMI-based paradox from a national level that a higher BMI correlates to a decreased prevalence of VI in our ageing population. Among the several filtered adiposity indexes, the weight-adjusted waist index (WWI) exhibits a significant dose–response association with the prevalence of VI.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ As a simple anthropometric indice, WWI could be considered a valuable and reliable alternative marker of obesity, and the WWI-VI correlation could eliminate the BMI-based obesity paradox in future epidemiological studies in the ophthalmic area. The WWI-VI correlation also indicates the potential roles of abdominal obesity, excessive fat mass and changes in body composition in VI among the ageing population. This sheds light on future exploration of such detrimental associations.

INTRODUCTION

Vision impairment (VI) is one of the most devastating morbidities affecting billions of individuals worldwide. As for the ageing population, VI is a widespread sensory dysfunction that could lead to multiple adverse events, both physically and mentally, such as physical dysfunctions, cognitive decline and all-cause mortality.[1–4] Along with its consequent accidental injury events like falls,[5] VI may also jeopardise social participation and well-being status in the ageing population.[6 7] Therefore, identifying probable risk factors for VI and developing easy-to-spread screening tools to discern individuals more prone to VI have been considered pivotal public health approaches to preventing low vision and consequent adverse events in the ageing population.

Obesity has long been considered a risk factor for various adverse events in ageing life.[8–10] Among numerous obesity and its comorbidities-related studies, the body mass index (BMI), a popular anthropometric and conventional adiposity index, has been widely accepted and serves as a standard obesity evaluation metric. However, there have been increasing concerns about the 'obesity paradox' over the past decades, which refers to when particular chronic diseases, especially in the ageing population, exhibit surprising and 'paradoxically protective' associations between BMI and clinical outcomes.[11] One principal reason for these obesity paradoxes lies in the natural deficit of BMI. BMI is inadequate in providing information on body fat distribution, especially central obesity, which is a determining factor in predicting metabolic deterioration and obesity-related comorbidities.[12]

Such obesity paradox also occurs in previous studies, especially population-based epidemiological research in the ophthalmic area. Obesity could exert specific influences on many age-related and vision-threatening ocular diseases, such as age-related macular degeneration, diabetic retinopathy and glaucoma.[13–16] Therefore, BMI has been investigated in its association with VI in numerous clinical and epidemiological surveys as a medical parameter or clinical characteristic of body obesity.[15] However, studies focusing on BMI-VI association have yielded controversial results.[17–25] These widely divergent conclusions not only bring doubts about whether obesity and adiposity indexes could be considered risk factors or screening tools of VI but also challenge whether BMI is applicable to hold its representative role of body adiposity index in VI-related surveys.

Novel adiposity indexes derived from novel anthropometry assessments exhibit excellent correlations with abdominal adipose tissue and have been considered more accurate body adiposity assessments for predicting obesity-related disorders than BMI.[26 27] Recent studies also proposed that body composition and fat distribution could more accurately assess poor metabolic characteristics.[28 29] Therefore, several novel adiposity indexes have been suggested as alternative indicators of obesity coexisting morbidities, including diabetes, cardiometabolic morbidity and mortality,[30–33] with explicit advantages over the conventional BMI. However, the correlations between these novel anthropometric indices and VI occurrence are yet to be investigated. The application of novel adiposity indexes in VI-related population-based and epidemiological surveys still needs to be explored. From our considered perspective, a noteworthy observation in the existing body of literature is the limited attention afforded to the population with central obesity, instead primarily focusing on general obesity.

China is the most populous developing country, and it shares a considerable proportion of the obesity population and the ageing population suffering from VI.[34–39] This study acquired data from the China Health and Retirement Longitudinal Study (CHARLS). CHARLS is the first nationally representative and longitudinal survey that aims to provide the most up-to-date cohort datasets for studying the health and well-being status of the middle-aged and older population in the Chinese mainland. With simple calculation using weight, height and waist circumference, six adiposity indices including the BMI, weight-adjusted-waist index (WWI), waist-to-height ratio (WHtR), body roundness index (BRI), a body shape index (ABSI) and conicity index (ConI) were enrolled and investigated in their correlations with VI among middle-aged and older Chinese population from a national level in the current study.

METHODS

Participants and public involvement

The CHARLS is the very first cohort dataset that aims to be representative of senior residents (≥45 years) living in the Chinese mainland. The CHARLS provides extensive information for scientific research on the ageing Chinese population. CHARLS is harmonised with several famous international surveys based on the Health and Retirement Study model to ensure best practices and its international comparability. To ensure its national representativeness, CHARLS covered 450 villages/communities in 150 countries/districts across 28 provinces over the Chinese mainland, eventually involving 10 257 households at the baseline survey in 2011. With the original response rate over 80% and the response rates of the panel sample remaining higher than 80% in the follow-up waves, CHARLS are highly compared with many other famous HRS-type surveys. The current study enrolled 17 708 participants in CHARLS 2011 (wave 1, baseline), 18 254 participants in CHARLS 2013 (wave 2) and 20 273 participants in CHARLS 2015 (wave 3). CHARLS datasets are publicly available to researchers all over the world and accessible at http://charls.pku.edu.cn/. Detailed description and sharing policies have been previously reported.[40] For the present study, we downloaded the most updated version, at the end of December 2023.

Main outcome

The primary outcome in the present study is the visual status. In CHARLS, near and distal visual statuses were assessed by questioning the participants about whether they thought their eyesight was poor, fair, good, very good or excellent when seeing things close or at a distance. The reporting of eyesight as poorer than good level (fair or poor) was classified as near or distal VI. Such categorisation of VI assessment has been widely accepted in studies using CHARLS datasets.

In the ageing population, many cases of VI owing to reversible vision-threatening ocular disorders could be reversed by clinical interventions such as cataract surgery or vice versa; the visual status could worsen due to natural ageing or another pathological progression. Therefore, along with the visual status at baseline in CHARLS 2011, we also investigated the time-varying records of visual status during 5 years of follow-up (CHARLS 2013 and 2015).

Novel anthropometric indices for adiposity assessment

Anthropometry is a simple, widely used, inexpensive and easy-to-spread technique essential in population-based surveys and epidemiological investigations. In the current study, the interviewers measured anthropometric and other physical measurements, including waist circumstance, height and weight. According to the anthropometric data available from CHARLS, six body adiposity indexes were selected in the current study using the following formulas for calculation:

$$\text{BMI (body mass index)}=\frac{\text{Weight (kg)}}{\text{Height (m)}^2}$$

$$\text{WHtR}\ \left(\text{waist to height ratio}\right) = \frac{\text{WC (cm)}}{\text{Height (cm)}}$$

$$\text{WWI}\ \left(\text{weight} - \text{adjusted} - \text{waist index}\right) = \frac{\text{WC (cm)}}{\sqrt{\text{Weight (kg)}}}$$

$$\text{ABSI}\ \left(\text{a body shape index}\right) = \frac{\text{WC (m)}}{\text{BMI}^{2/3}\text{Height (m)}^{1/2}} \times 1000$$

$$\text{BRI}\ \left(\text{body roundness index}\right) = 364.2 - 365.5 \times \sqrt{1 - \frac{(\text{WC (m)}/2\pi)^2}{(0.5\times\text{Height (m)})^2}}$$

$$\text{ConI}\ \left(\text{conicity index}\right) = \frac{\text{WC (m)}}{0.109\sqrt{\text{Weight (kg)}/\text{Height (m)}}}$$

Control variables

Gender was considered a binary variable. Age was considered as a continuous variate. Marital status refers to the living status of participants who are accompanied or living alone. The response of never married, divorced, separated or widowed was considered 'living alone'. Participants who responded that married or partnered were regarded as 'living with a partner'. Living area referred to places where the participant lived. Educational level indicated the general socioeconomic status of the respondents. Educational level was categorised into five groups (up to low): high school or above, middle school, elementary school, less than elementary school and illiterate. Medical insurance coverage represented the approach to health support. Lifestyle included drinking habits and smoking status. Drinking was treated as a three-category variate that indicates the frequency of alcohol consumption: more than once a month, less than once a month or none. Smoking status was classified as never smoked or current/former smoker.

Statistical analysis

We used SAS, V.9.4 (SAS Institute, Cary, NC, USA) to perform statistical analysis in the current study. The primary exposures of interest were the six adiposity indexes, while the other independent variates served as control variates. Comparisons of essential characteristics among participants categorised by visual status depend on the t-test, Mann-Whitney U tests or χ^2 test analyses based on the types of the obtained data. A logistic regression model was performed to evaluate the associations between adiposity indexes, multiple covariables and VI at baseline for cross-sectional analysis in CHARLS 2011. Associations between time-varying adiposity and VI over time (CHARLS 2011 and 2013 and 2015) were assessed using generalised linear models with generalised estimating equations (GEEs), which applied an unstructured correlation structure controlled for the intraindividual correlation between repeated measurements. To examine whether VI was dependent on the adiposity, adjustment of multiple potential confounders mentioned earlier was employed in progressive models.

Furthermore, GEE analysis was employed to estimate OR (with 95% CI) of VI associated with quintiles of adiposity indexes, using the lowest quintile as a reference. We then performed linear trend tests using quintiles of the adiposity indexes as continuous variate by assigning the median value of each quintile to the variate.

Estimates of parameters were presented with their 95% CIs. A two-sided p value of <0.05 was considered statistically significant.

RESULTS

In total, 7750 participants aged 45 years or older were deemed eligible for the cross-sectional analysis in the current study from CHARLS 2011, among which 4133 accomplished the following two interviews in 2013, and 2015 were adapted in the longitudinal analyses (figure 1). The baseline demographic and socioeconomic characteristics, medical conditions, lifestyle-related factors and six adiposity indexes of the study sample were grouped by visual status and shown in table 1. Participants free from VI appeared to have a lower status of all six adiposity indexes.

We first ran a univariate logistic regression to indicate potential confounders before performing a multivariate regression analysis. We discovered that gender, age, marital status, educational level, living area, drinking habit and smoking status would probably confound the correlation between obesity index and visual status (online supplemental table 1). To our surprise, according to univariate logistic regression, we first noticed that the conventional adiposity index, BMI, was not positively associated with VI (OR: 0.994, 95% CI 0.979 to 1.009, table 2). The other five novel adiposity indexes showed profound and positive associations with VI (all p values <0.0005, table 2). To

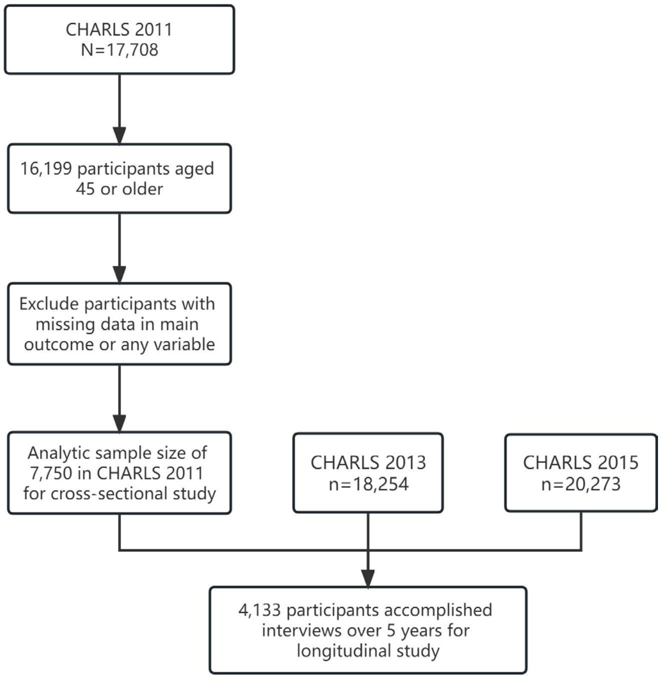

Figure 1 Sample screening of the present study. CHARLS, China Health and Retirement Longitudinal Study.

further clarify these cross-sectional associations between adiposity indexes and VI, we analysed their relevance by controlling for various covariables (model 1 to model 5, table 3, complete version with 95% CI shown in online supplemental table 2). By this point, only WWI showed significant and detrimental impacts on visual status after being adjusted for multiple confounders (table 3, model 1–4, all p values <0.05). Even after adjustment of BMI, such correlation remained robust (table 3, model 5, p=0.0538).

We first tested the associations between time-varying WWI and VI over time in longitudinal observation. Consistent with cross-sectional analyses, we found that WWI was still significantly associated with VI, even after being adjusted for various confounders, including the BMI (table 4, all p values <0.0001). Moreover, WWI exhibited a robust dose–response association with the prevalence of VI since the OR values increased linearly with the increasing quintile of WWI, even after adjustment (p value for linear trend <0.0001) (online supplemental figure 1). In the fully adjusted model (model 5), including the BMI as one of the confounders, the OR (with 95% CI) of VI associated with the second, third, fourth and fifth (vs first) WWI quantile was 1.228 (1.000 to 1.508), 1.330 (1.070 to 1.653), 1.578 (1.275 to 1.954) and 1.900 (1.407 to 2.565), respectively.

DISCUSSION

In the current population-based cross-sectional and longitudinal study of a nationally representative sample of middle-aged and older Chinese adults, we found that novel anthropometric indices, including WHtR, WWI, ABSI, BRI and ConI, were associated with increased prevalence of VI. Among these, WWI exhibited a robust correlation with the prevalence of VI, which indicated that WWI could be considered an independent risk factor of VI. In contrast, other adiposity indexes were not associated with VI after adjustment of demographics, socioeconomic, lifestyle-related factors, chronic health conditions and even the conventional adiposity index, BMI. Notably, WWI also exhibited a robust dose–response association with the prevalence of VI according to longitudinal observation across 5 years, which indicated WWI as a superior adiposity index to portend VI in the ageing Chinese population than other adiposity indices. To the best of our knowledge, the current study is the first population-based study to perform horizontal comparisons of associations between various adiposity indices and the prevalence of VI among the ageing population.

There are two main subtypes of body obesity: general and central obesity. Although BMI is the most widely used assessment and classification of general obesity in epidemiological and clinical studies,[41] it cannot capture the distribution features of body fat, especially in senior adults.[12] Since ageing contributes to distasteful changes in body fat distribution, researchers have long considered that BMI may not be a reliable and representative indicator for body adiposity in the ageing population. On the other hand, BMI has also long been criticised for the limitation of distinguishing the amounts of fat-free mass (lean mass) and fat mass, which leads to severe misclassification of individuals with excess body fat or with some chronic conditions such as diabetes.[42] Consequently, the BMI-based obesity paradox could probably bias the actual relationship of adiposity with VI in the ageing population. Although such a paradox could be found according to previous studies, limited concern has been attached to further investigation.[22–24] Based on this nationally representative survey and our results of higher BMI associated with decreased prevalence of VI in ageing Chinese adults, we propose that the conventional adiposity index, BMI, may not be suitable to denote body adiposity in VI-related surveys.

WWI was recently developed to eliminate the obesity paradox of BMI for mortality by adjusting waist circumstances for body weight.[33] Previous studies have indicated its better correlations to cardiometabolic morbidity and related mortality.[33 43] According to the present study, we also discovered the linear association of WWI with the prevalence of VI in the ageing Chinese population. Our results proved that WWI was superior to the general adiposity index (eg, BMI) when examining their associations with the prevalence of VI. On the other hand, WWI also exhibits more robust correlations to VI compared with other abdominal obesity indexes (eg, ABSI, WHtR). This may be explained by the fact that, along with its ability to assess fat and muscle mass reciprocally,[44] WWI also correlates to bone mass in older adults,[45] so WWI has been considered an excellent anthropometric index of a comprehensive evaluation of body composition, which could echo the changes in body composition by

Table 1 Baseline characteristics of participants in the present study sample from CHARLS 2011

Baseline characteristics of participants of the present study sample from CHARLS 2011				
Variables	**Total**	**Non-visual impairment**	**Visual impairment**	**P value**
Gender				
Male	3867 (49.90)	965 (56.20)	2902 (48.10)	<0.0001
Female	3883 (50.10)	752 (43.80)	3131 (51.90)	
Age				
45–59	2931 (37.82)	789 (45.95)	2142 (35.50)	<0.0001
60–74	3661 (47.24)	705 (41.06)	2956 (49.00)	
75+	1158 (14.94)	223 (12.99)	935 (15.50)	
Marital status				
Living alone	2036 (26.27)	416 (24.23)	1620 (26.85)	0.0293
Live with partner	5714 (73.73)	1301 (75.77)	4413 (73.15)	
Education				
Illiterate	1971 (25.43)	357 (20.79)	1614 (26.75)	<0.0001
Less than elementary school	3320 (42.84)	652 (37.97)	2668 (44.22)	
Elementary school	1598 (20.62)	425 (24.75)	1173 (19.44)	
Middle school or vocational school	727 (9.38)	226 (13.16)	501 (8.30)	
High school and above	134 (1.73)	57 (3.32)	77 (1.28)	
Living area				
Urban area	1571 (20.27)	434 (25.28)	1137 (18.85)	<0.0001
Rural area	6179 (79.73)	1283 (74.72)	4896 (81.15)	
Smoke				
Yes	3238 (41.78)	756 (44.03)	2482 (41.14)	0.0322
No	4512 (58.22)	961 (55.97)	3551 (58.86)	
Drinking status				
Drink more than once a month	1949 (25.15)	466 (27.14)	1483 (24.58)	0.0129
Drink but less than once a month	627 (8.09)	155 (9.03)	472 (7.82)	
No drink	5174 (66.76)	1096 (63.83)	4078 (67.59)	
Insurance covering				
Yes	7206 (92.98)	1589 (92.55)	5617 (93.10)	0.4234
No	544 (7.02)	128 (7.45)	416 (6.90)	
BMI	23.4206±3.6063	23.4828±3.5687	23.4029±3.6171	0.4178
WHtR	0.5384±0.0650	0.5334±0.0633	0.5399±0.0654	0.0002
WWI	11.1389±0.8048	11.0204±0.7840	11.1726±0.8076	<0.0001
ABSI	0.0829±0.0050	0.0824±0.0050	0.0831±0.0050	<0.0001
BRI	4.1898±1.3551	4.0838±1.2967	4.2199±1.3699	0.0002
ConI	1.2844±0.0818	1.2768±0.0809	1.2866±0.0819	<0.0001

ABSI, a body shape index; BMI, body mass index; BRI, body roundness index; CHARLS, China Health and Retirement Longitudinal Study; ConI, conicity index; WHtR, waist-to-height ratio; WWI, weight-adjusted-waist index.

ageing. Abdominal obesity has been proven to correlate to vision-threatening ocular disorders, including diabetic retinopathy, age-related macular degeneration and the risk of glaucoma, which are prevalent in the ageing population. Greater body fat deposition is associated with narrower retinal arterioles and broader retinal venules,[46 47] and changes in retinal vascular calibre have been proven to correlate with retinal senescence, diabetic retinopathy and age-related macular degeneration.[48–50] On the other hand, higher WWI could also indicate osteopenic obesity and sarcopenic obesity. However, these concepts have been barely investigated or noticed in the ophthalmic area. Therefore, our findings may highlight the essential roles of abdominal obesity, excessive fat mass and changes in body composition in visual dysfunction among the ageing population,

Table 2 Univariate logistic regression analyses of six adiposity indexes and visual impairment

Univariate logistic regression analyses of adiposity indexes and visual impairment			
Adiposity index	OR	95% CI	P value
BMI	0.994	(0.979 to 1.009)	0.4162
WHtR	1.168	(1.074 to 1.270)	0.0003
WWI	1.271	(1.188 to 1.361)	<0.0001
ABSI	1.320	(1.183 to 1.472)	<0.0001
BRI	1.079	(1.036 to 1.124)	0.0002
ConI	4.338	(2.244 to 8.386)	<0.0001

ABSI, a body shape index; BMI, body mass index; BRI, body roundness index; ConI, conicity index; WHtR, waist-to-height ratio; WWI, weight-adjusted-waist index.

which will light future exploration of such detrimental associations.

Compared with WWI, ABSI is further adjusted by height in the denominator. Similarly, other adiposity indexes, including WHtR/BRI/ConI, were also derived from waist and height. According to our statistical work, although these indexes showed significance with VI in univariate regression, such associations were less robust than WWI-VI associations after the adjustment of confounders. Compared with body weight and BMI, body height may have a stronger correlation to axial length,[50] and longer axial length is apparently associated with moderate to high myopia and ocular complications, which may lead to VI among the older population.[51–54] Previous studies also reported a direct correlation between body height and VI among younger adults.[55] From a statistical view, owing to the fact that other adiposity indexes were further adjusted by height in the denominator and had positive correlations with VI, the statistical power may consequently be attenuated by the body height in the denominator. Accordingly, we failed to observe significant correlations between these adiposity indexes and VI in the current study. Such a hypothesis warrants investigation in future exploration.

Table 3 Cross-sectional logistic regression analyses of novel adiposity indexes and visual impairment

Cross-sectional logistic regression analyses of novel adiposity indexes and visual impairment					
	Model 1	Model 2	Model 3	Model 4	Model 5
	OR	OR	OR	OR	OR
WHtR	1.056	1.084	1.089	1.033	1.183
WWI	1.099*	1.087*	1.089*	1.089*	1.087
ABSI	1.098	1.082	1.080	1.063	1.063
BRI	1.026	1.039	1.041	1.041	1.091
ConI	1.614	1.757	1.771	1.769	1.689

The results of the logistic regression models were expressed as ORs and 95% CIs. The analytic sample size was 7750. Model 1: adjusted for demographic factors including age and gender; model 2: adjusted for factors in model 1, as well as socioeconomic including marital status, educational level and living area; model 3: adjusted for factors in model 2, as well as life style factors including smoking status and alcohol consumption; model 4: adjusted for factors in model 3, as well as medical insurance covering; model 5: adjusted for factors in model 4, as well as body mass index.

*p<0.05.

ABSI, a body shape index; BRI, body roundness index; ConI, conicity index; WHtR, waist-to-height ratio; WWI, weight-adjusted-waist index.

Table 4 Longitudinal logistic regression analyses of time-varying weight-adjusted-waist index (WWI) and visual impairment, 2011–2015

Longitudinal GEE analyses of WWI and visual impairment, 2011–2015			
	OR	95% CI	P value
Model 1	1.1649	(1.1002 to 1.2334)	<0.0001
Model 2	1.1618	(1.0972 to 1.2302)	<0.0001
Model 3	1.1630	(1.0982 to 1.2315)	<0.0001
Model 4	1.1631	(1.0983 to 1.2316)	<0.0001
Model 5	1.2351	(1.1592 to 1.3158)	<0.0001

The results of the generalised estimating equation (GEE) models were expressed as ORs and 95% CIs. The analytic sample size was 4133. Model 1: adjusted for demographic factors including age and gender; model 2: adjusted for factors in model 1, as well as socioeconomic including marital status, educational level and living area; model 3: adjusted for factors in model 2, as well as life style factors including smoking status and alcohol consumption; model 4: adjusted for factors in model 3, as well as medical insurance covering; model 5: adjusted for factors in model 4, as well as body mass index.

Strengths and limitations

Our study is the first to verify cross-sectional and longitudinal associations between novel adiposity indexes and VI, eliminate the BMI-based obesity paradox, and investigate the actual relationship of body adiposity with VI in the ageing Chinese population. We obtained data from a nationally representative and longitudinal survey (CHARLS), which indicates that our findings could be generalised to the entire country. Furthermore, within the scope of the CHARLS datasets, multiple confounders were analysed and adjusted, which could otherwise confound the actual relationship between adiposity indexes and VI. Nevertheless, our study also has limitations. Although we indicated that the unfavourable fat distribution indicator, WWI, could be a novel clinical marker for VI, and we made a detailed discussion of its associations with various vision-threatening ocular disorders accordingly, the identification of the exact reason for VI, such as specific fundus disease or other ocular disorders, which depends on diagnosis based on detailed slit lamp or fundus examination is limited, owing to our secondary analysis design. Other early visual dysfunction evaluations, such as contrast sensitivity, were also beyond the CHARLS datasets. The CHARLS questionnaire depends on many self-reported items, such as the self-estimated visual status, which might be subject to reporting bias and cultural differences in conceptualisation, and also limits direct comparison with other population-based surveys that accept examination-defined visual status. Although the self-reported-item study designs and methods have been widely accepted in other well-known population-based studies such as the National Health Interview Survey and the National Health and Nutrition Examination Survey, researchers applying secondary analysis to public datasets have to admit this natural deficit in epidemiological surveys and properly interpret statistical results in a particular careful manner.

CONCLUSION

In conclusion, we propose a novel adiposity index, WWI, as a valuable and reliable alternative marker of obesity, which exhibits a robust dose–response association with VI in the ageing Chinese population. Such a finding may eliminate the BMI-based obesity paradox from epidemiological studies in the ophthalmic area. The WWI-VI correlation indicates the potential roles of abdominal obesity, excessive fat mass and changes in body composition in VI among the ageing population, which shed light on future exploration of such detrimental associations.

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Contributors QP, YW and JL designed the research. WS and YH collected the data. KA and FS analysed the data. YZ, QC and JD drafted the manuscript. CW, QC, FS revised the manuscript. YZ, QC, KA and CW contributed equally to this research and should be considered as equivalent authors. QP should be considered as corresponding authors who take the full responsibility of the manuscript. All authors have read and approved the final manuscript.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and the current study is a secondary analysis of CHARLS data. The conduct of CHARLS was approved by the Biomedical Ethics Review Committee of Peking University (approval number: IRB00001052-11015). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available in a public, open access repository. The current study is a secondary analysis of public data of CHARLS. The original dataset of CHARLS is accessible on http://charls.pku.edu.cn/.

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