Prevalence and risk factors of myopia in Han and Yugur older adults in Gansu, China—a cross-sectional study

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Research article

Keywords: Myopia, High Myopia, Han and Yugur ethnicity, Risk Factors, Prevalence

Posted Date: August 6th, 2019

DOI: <https://doi.org/10.21203/rs.2.12463/v1>

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Abstract

Background Few studies have investigated the prevalence of myopia in Northwest China. This study aimed to investigate the prevalence and risk factors of myopia and high myopia in adults aged 40-80 years in Han and Yugur ethnicities living in Gansu Province, Northwest China. **Methods** The cross-section study is part of the China National Health Survey (CNHS), which was conducted in 2016, Gansu Province. We compared the age- and sex-standardized prevalence of myopia, high myopia and hyperopia in Han and Yugur participants. Risk factors for myopia and high myopia were identified using multivariable logistic regression models. **Results** 3845 participants were included. The overall adjusted prevalence of myopia (spherical equivalent (SE) <-0.5 D), high myopia (SE <-6.0 D) and hyperopia (SE $>+0.5$ D) were 16.4%, 0.7% and 26.2% in Yugur, and 34.3%, 5.0% and 19.2% in Han. In the multivariable logistic regression model, Han ethnicity (Odds Ratio(OR),0.56; 95% confidence interval (CI): 0.45-0.69), $P<0.001$), birth in rural areas (OR,0.69; 95%CI: 0.56-0.85, $P<0.001$), higher education level (OR,1.48; 95%CI:1.18-1.85, $P=0.001$ for middle/high school group and OR, 3.62; 95%CI:2.73-4.82, $P<0.001$ for Undergraduate/graduate group), indoor work (OR, 0.64; 95%CI: 0.51-0.80, $P<0.001$), smoking history (OR, 0.69; 95%CI: 0.52-0.90, $P=0.007$) and a family history of myopia (OR,2.83; 95%CI: 1.22-6.51, $P=0.015$ for one patient) were found to be associated with myopia. The risk factors of high myopia included Han ethnicity (OR, 0.33; 95%CI: 0.15-0.73, $P=0.006$), 50-59 age group (OR, 0.65; 95%CI:0.43-1.0, $P=0.049$), 60-69 age group (OR,0.49; 95%CI: 0.25-0.97, $P=0.039$), birth in rural area (OR, 0.61; 95%CI: 0.40-0.94, $P=0.025$) and a family history of myopia (OR, 4.32; 95%CI: 1.74-10.7, $P=0.002$ for one patient; OR, 22.3; 95%CI: 2.41-206.1, $P=0.006$ for both patients). **Conclusion** The prevalence of myopia and high myopia in Han adults aged 40-80 was significantly higher than that in Yugur. The risk factors of myopia included Han ethnicity, birth in rural area, higher education level, indoor work and a family history of myopia. This study provided valuable information on risk factors of myopia and revealed an ethnic disparity on the susceptibility of myopia, which would be useful in identifying high-risk population and initiating more targeted strategies preventing myopia in China.

Background

Refractive error, especially myopia, is a common ocular abnormality. Complications associated with high myopia have become an important cause of low vision in adolescents[1, 2]. The prevalence of myopia differs by region. Many studies have shown that the prevalence of myopia is high in East Asia [3–6]. In China, the prevalence of myopia among school-age children in urban areas is 12.7–35.8%[7, 8], and 70–87.7%[8–10] in people aged over 17. Variations in the prevalence of myopia among Chinese and other ethnic groups in the same area have been reported[11, 12]. However, previous studies indicated that myopia was more related to environmental factors (early learning[13], near work[14], and lack of outdoor activities[15, 16]). Some studies have found that the prevalence of myopia among immigrants was the same as the local ethnicity[17, 18]. Therefore, it is still debatable whether Chinese individuals are more susceptible than other ethnicities for myopia.

China is a multi-ethnic country composed of Han ethnicity and 55 other ethnicities, which result in differences in health and clinical profiles. The differences in the prevalence of myopia in different ethnicities in China have been studied in teenagers[19, 20]. The prevalence of myopia among subjects aged 4–19 years of the Han ethnicity (27%) was significantly higher than those of the Hui (18%) and Uyghur (13%) ethnicities in Turpan, China[20]. One study among adults of the Han and Yi ethnicities in Yunnan Province showed that, Yi ethnicity had a lower prevalence of myopia (8.1% vs. 10.3%; $P = 0.02$) [21]. However, among these epidemiological studies, the study population were from well-developed areas in East China (except for the Yunnan Minority Eye Study[21]). Our study is the first to investigate the prevalence of myopia and hyperopia in Gansu Province, Northwest China. The ethnic differentiation among the Han and Yugur ethnicities will be investigated.

Gansu Province is in Northwest China with an area of 424,900 square kilometres and a population of 25,575,000 (the data were based on the sixth population census of China in 2010)[22]. Yugur population is a unique minority in Gansu Province. This is the main consideration when we chose representative minorities in Gansu Province. Yugur ethnicity is a population mainly engaged in animal husbandry, with a total population of 14387[22]. Yugur and Han populations have distinct living environments and habits. In addition, the diversity of ethnic population and their varied genetic backgrounds may contribute to disparity in disease prevalence as well as associated factors. Data on adult myopia and high myopia is sparse, especially in population with diversity of ethnicity in China, deriving from data from CNHS, which has been described elsewhere[23], this study aimed to address the gap in current knowledge on prevalence of myopia profiles and risk factors within the Yugur adults and investigate the disparities between Yugur and Han groups to facilitate the development of ethnic-specific and more targeted disease intervention strategies.

Methods

Study Population

Our study is part of the CNHS in Gansu Province, Northwest China. The CNHS is an ongoing cross-sectional study to evaluate the national health status using a multistage cluster sampling method, conducted by the Chinese Academy of Medical Sciences[23]. Survey in Gansu Province was from June to August in 2016. The criteria for participant recruitment were: 1) aged 40–80; 2) with Yugur or Han ethnicity; 3) local resident for at least one year. The exclusion criteria were: 1) women who are currently pregnant; 2) soldiers in service; 3) disabled individuals (who maybe not able to complete the whole physical examination) and 4) individuals with severe mental disorders. Considering the ethnic distribution, the Han and Yugur subjects were recruited from 6 centres: the Gansu Disease Control Centre; 3 county centres for Disease Control (Sunan Yugur autonomous county, Zhangye, Gao Tai county) and 2 village health centres (Lianhua village, Minghua township, Sunan county; Kangle township, Sunan county). Individuals resident in the selected areas were all invited to participate in the study.

Previous studies have indicated a myopia prevalence in older Chinese adults from 18.2% to 31.4% [24–26]. We used the lowest prevalence of 18.2% to estimate the minimum required sample size. The following formula was used:

$$N = Z^2 pq / d^2$$

Alpha (α): the significance level; p : the prevalence of myopia; $q = 1 - p$; d : the error tolerance. Calculating based on this formula, to achieve a significance level of 0.05 and error tolerance of 0.15, the minimum sample size was 767. Additional 20% to the minimum sample size was added, avoiding possible noncompliance rate.

This study was approved by the institutional review board of Institute of Basic Medical Sciences, Chinese Academy of Medical Sciences. All participants provided written informed consent.

Measurements

All the participants were invited to the study center for a face-to-face interview by experienced interviewers and a routine physical examination. The study questionnaire contained demographic and lifestyle and health-related information, and included questions on the birthplace, current address, ethnicity, education level, occupation, smoking status, alcohol consumption, physical exercise level, medical history (day of diagnosis and treatment for diabetes and hypertension) and myopia family history. The physical examination included height, weight and blood pressure. Body mass index (BMI) was defined as weight (kg)/height (m)². Educational level was divided into three groups (primary school or below, high school, undergraduate and above). The occupational group included outdoor and indoor work. Occupational physical labour was divided into light, medium and heavy. Exercise status was divided into 5–7 days a week [at least 20 minutes per day], 3–4 days a week, 1–2 days a week, less than 3 days a month, and never exercise. According to the degree of physical labour and exercise status, the total activity level was divided into three groups: low, moderate and high [27]. The time spent in rural areas was calculated according to the place of residence and the time at which the subjects became residents of the area. Smoking or alcohol consumption was divided into never-smoker/drinker and ever-smoker/drinker. Ever smoker/drinker included past and current smoker/drinker.

Assessment of Refractive Error

We performed noncycloplegic autorefractometry and corneal curvature radius measurements using an autorefractor (ARK-510A, Nidek Co., Ltd., Tokyo, Japan). An examination of the anterior segment of the eye was performed with a hand-held slit lamp (KJ5S2, Suzhou Kangjie Medical Co. Ltd., Jiangsu, China). Uncorrected visual acuity and best corrected visual acuity were measured by a logarithmic E chart (Wehen Co., Ltd., Guangzhou, China). We use spherical equivalent (SE) to evaluate the refractive error data, which was defined as a sphere plus half cylinder. In our study, emmetropia, low myopia, moderate myopia and high myopia were defined as $-0.5 \leq SE \leq 0.5$, $-3.0 \leq SE < -0.5D$, $-3.0D < SE \leq -6.0D$, and $SE < -6.0D$, respectively. Hyperopia was defined as $SE > +0.5D$.

Statistical Analyses:

After excluding those who had eye diseases, including glaucoma, pterygium, cataracts, retina disease, and eye surgical histories or eye injury histories, the refractive error portion of the CNHS in Gansu Province includes 4599 participants 40 to 80 years of age (July 2016 to August 2016). Finally, a total of 3845 participants provided a perfect examination data and questionnaire information. The response rate was 83.6%. As the correlation coefficients for SE in the left and right eye were high (Spearman correlation test, $r = 0.89$), only data of right eye was reported. The age- and sex- specific prevalence of low myopia, moderate myopia, high myopia and hyperopia was calculated. Chi-square tests were used to compare the demographic, lifestyle-related information and physical examination data between Han and Yugur subjects. The difference in refractive error prevalence between Han and Yugur populations was analysed using a general linear regression model. Risk factors for myopia and high myopia were identified by multivariable logistic regression models. A P -value <0.05 (two-tailed) was considered statistically significant. Age- and sex-standardization was performed by direct method using the 6th national census (2010) data of Chinese population as the standard population. Analyses were performed using Stata version 13.1 (StataCorp, USA) and Statistical Analysis System (SAS Institute Inc, Cary, NC, USA).

Results

Characteristics of the Han and Yugur populations

Of the entire study sample, 3845 participants aged 40–80 years completed the questionnaire, physical examination and refractive error assessment. There were 2788 Han participants (1190 men; 42.7%) and 1057 Yugur participants (507 men; 48.0%). Compared with Han participants, the Yugur subjects spent more time in rural areas ($P<0.001$), had lower education levels (primary school or below: men 52.1% vs. 24.5%, $P<0.001$; women: 72.2% vs. 38.8%, $P<0.001$), were more engaged in outdoor work ($P<0.001$) and had higher activity levels ($P<0.001$). More subjects in the Yugur group were ever-smoker ($P<0.001$) and ever-drinker (men $P = 0.008$; women $P<0.001$) than that in Han. There were also differences between Han and Yugur participants in the prevalence of hypertension (men: 35.3% vs. 44.4% $P<0.001$, respectively; women: 28.5% vs. 34.9%, $P = 0.005$, respectively) and the prevalence of diabetes in the men group (11.9% vs. 7.3% $P = 0.004$) (Table 1).

Prevalence of myopia in Han and Yugur participants

The crude and age- and sex-specific prevalence of low myopia, moderate myopia, high myopia, emmetropia and hyperopia in Han and Yugur ethnicity among different age groups were presented in Table 2. The overall age-adjusted prevalence of myopia (SE <-0.5 D) and high myopia (SE <-6.0 D) was 16.4% and 0.7% in Yugur ethnicity, and it was 34.3% and 5.0% in Han ethnicity. In both ethnicities, the prevalence of low and moderate myopia decreased in the 50–59 age group ($P<0.001$) and increased in the 70–80 age group ($P = 0.041$). The prevalence of high myopia decreased with ageing in the 50–59 and 60–69 age groups ($P = 0.039$ – $P = 0.049$) (Figure 1). Overall, comparing with Han adults, Yugur

people had a lower prevalence of myopia (men: 15.8% vs. 32.1%, $P<0.001$; women: 14.9% vs. 33.4%, $P<0.001$) and high myopia (men: 0.2% vs. 3.7%, $P<0.001$; women: 1.1% vs. 5.6%, $P<0.001$). The prevalence of emmetropia was higher in Yugur participants (men 57.0% vs. 46.8%, $P<0.001$; women 62.0% vs. 47.9%, $P<0.001$). Moreover, there was a mild difference between the prevalence of hyperopia in Yugur and Han ethnicities in both male and female groups (men: 26.8% vs. 21.1%, $P = 0.012$; women: 23.1% vs. 18.7%, $P = 0.026$) (Table 3).

Risk factors for myopia and high myopia

The influencing factors of myopia yielded by the logistic regression model were presented in Table 4. We found that an age of 50–59 years was a protective factor for myopia [OR, 0.71; 95%CI: 0.60–0.86, $P<0.001$], and an age of 70 years and older was a risk factor for myopia [OR, 1.64; 95%CI: 1.02–2.63, $P = 0.041$]. Yugur ethnicity [OR, 0.56; 95%CI: 0.45–0.69, $P<0.001$], birth in rural places (OR, 0.69; 95%CI: 0.56–0.85, $P<0.001$), work outdoors (OR, 0.64; 95%CI: 0.51–0.80, $P<0.001$), and no smoking history (OR, 0.69; 95%CI: 0.52–0.90, $P = 0.007$) significantly reduced the risk of myopia. High educational level was a significant risk factor for myopia, with an OR of 1.48 (95%CI: 1.18–1.85, $P = 0.001$) for the middle/high school group and an OR of 3.62 (95%CI: 2.73–4.82, $P<0.001$) for the undergraduate/graduate group compared with primary school or less group. There was a mild relationship between myopia and a family history of myopia in only one parent (OR, 2.83; 95%CI: 1.22–6.51, $P = 0.015$). However, for high myopia, the risk factors include only race (OR, 0.33; 95%CI: 0.15–0.73, $P = 0.006$), age (OR, 0.65, 95%CI: 0.43–1.00, $P = 0.049$ in the 50–59 age group; OR, 0.49, 95%CI: 0.25–0.97, $P = 0.039$ in the 60–69 age group), birthplace (OR, 0.61; 95%CI: 0.40–0.94, $P = 0.025$) and family history of myopia (OR, 4.32, 95%CI: 1.74–10.7, $P = 0.002$ in one myopic parent group; OR, 22.30, 95%CI: 2.41–206.1, $P = 0.006$ in both myopic parents group). Sex, activity level, medical history of hypertension and diabetes had no relationship with myopia or high myopia in our study.

Discussion

Our study explored the prevalence of myopia in Han and Yugur adults aged 40–80 years in Gansu Province, Northwest China. In our study, the age-sex-adjusted prevalence of low and moderate myopia decreased with age but mildly increased in the 70–80-year age group (Figure 1). The U-shape curve of myopia prevalence was consistent with previous studies in China[24, 28]. Subjects with distinct cataracts were excluded from our study, the relatively minute elevation of the U-shape curve might be related to the mildly increased crystal density, which was not excluded by anterior segment examination[29]. However, the prevalence of high myopia did not increase with age (Table 2). This result implied that mildly increased lens density may not influence the prevalence of high myopia compared to low and moderate myopia in adults over 70 years old. After excluding participants diagnosed with cataracts, the prevalence of hyperopia increased with age in both ethnic groups. The age-related change in prevalence was also concluded in previous studies [26, 30, 31].

As Han is the predominant ethnicity in China, surveys focusing on the prevalence of myopia in Han population has been carried out worldwide. To eliminate the effects of noncycloplegic refraction, we compared the prevalence of myopia in the Han ethnicity in the 50–59 age group (30.8%) with other studies. We found that the prevalence of myopia in our study was higher than that in He J's study in Shanghai (23.2%)[26] the Handan eye study (18.2%)[25] and the Yunnan minority eye studies (5.0%)[21] in the same age group but lower than that in the Chinese American study (36.1%)[30] the Tajimi study (49.6%)[32], the Hong Kong vision study (40%)[33], the Singapore epidemiology of eye disease study (38.9%)[11], Korea national health and nutrition examination survey (55.2% in 45–49 age group)[34], and close to values from the Liwan study (31.7%) [24, 31] and The Kumejima study (29.4%)[35] Table. 5. The prevalence of high myopia in the Han ethnicity in the 50–59 age group was 5.0%, which was higher than the prevalence in the Handan Eye study (1.8%)[25], the Andhra Pradesh eye disease study (4.8%)[36] and the Kumejima study (0.8%)[35], but lower than that in the Liwan Study (5.3%)[24], The Shanghai Eye study (5.23%)[26] the Chinese American study (7.4%)[30], the Singapore epidemiology of eye disease study (5.1%)[11] and the Tajimi study (8.7%)[32]. We noticed that in the 50–59 age group, the prevalence of myopia and high myopia was higher in studies conducted in well-developed countries, such as the Chinese American study, the Hong Kong study, and the Singapore epidemiology of eye disease study. The prevalence was lowest in the rural area in the Yunnan minority eye study, in which the participants were recruited only from the outer suburbs and had access to lower education. The relationship between the prevalence of myopia and population density has been studied recently. A study in Guangdong Province revealed that higher population density was significantly associated with myopia ($P = 0.003$)[37]. Kai Yip Choi's study of ocular axial length and refractive error in Hong Kong indicated that longer ocular axial length and more negative refractive error were found among those living in higher population density districts and those living in smaller homes[38]. The acceleration of urbanization, educational level and increasing population density in urban areas are all risk factors that need to be included when studying the increasing prevalence of myopia in China.

The site of additional file1: Table 5

In our study, the prevalence of myopia in the Yugur ethnicity was significantly lower than that of well-developed areas. This result may be related to the differences between the Yugur and Han ethnicities in many lifestyle and environmental factors. However, the influence of genetic differences among different ethnicities may also be attribute to this disparity. At present, there is no consensus on whether the Han population is more susceptible to myopia compared to other ethnicities. Some studies concluded that Han people had higher risk of myopia. A multi-ethnic study in Singapore found that the prevalence of myopia and high myopia was higher and the ocular axial length was longer in Chinese subjects compared to those of Indians and Malays[11]. Investigations of the prevalence of myopia in a multi-ethnic study in America also indicated that the prevalence of myopia was highest in the Chinese population (37.2%) compared to White, Black and Hispanics among adults more than 45 years and Chinese ethnicity was found to be a risk factor for myopia (OR: 1.64) and high myopia (OR, 3.33; 95%CI: 2.08–5.36)[12]. However, Chen-Wei Pan's survey of the prevalence of myopia among Yi and Han ethnicities in Yunnan Province, China, found that the risk of myopia was not related to ethnicity (OR: 0.79;

95%CI: 0.61–1.02)[21]. The CNHS study conducted in Yunnan Province among the Yi and Han ethnicities found that the Han population had a higher prevalence of myopia (31.50% vs. 16.80%, $P < 0.001$) and high myopia (3.34% vs. 1.31%, $P = 0.049$). However, after adjusting for potential confounders, Han ethnicity was not found to be a risk factor for myopia[31]. In addition, since 2000, the prevalence of myopia among Europeans and Americans over 40 years has increased (approximately 1/3—even if $< -1.0D$ is stipulated as the standard of myopia[12, 39–41])—which is close to the prevalence in East Asia in the same age group. Although increasing numbers of genetic loci for myopia have been identified, no genomic studies have found evidence of susceptibility for myopia in the Han population. The occurrence and development of myopia is the result of the combination of genetic and environmental factors [42, 43]. The causes of the higher prevalence of myopia among Han ethnicities and whether the genetic factors of Han ethnicity will accelerate the influence of environmental factors on myopia development more obviously in well-educated populations than other ethnicities require further laboratory and aetiological research.

Except for the Han ethnicity, environmental and lifestyle were also found to be risk factors of myopia, such as birth in urban areas, a higher educational level and indoor work. Birth in rural areas imply more outdoor activities. People with higher educational level and indoor work maybe more likely to keep a high near-work activity. A high level of outdoor activity is a protective factor for myopia[44, 45], while a high level of near-work is a risk factor for myopia occurrence[46]. We noticed that, there was a mild relationship between smoking and myopia. The results of studies on the impact of cigarette smoking on myopia are inconsistent. A study including 1334 Chinese children from three schools in Singapore found no significant association between parental smoking and refractive error[47]. The CNHS study in Yunnan Province revealed that smoking history was not associated with myopia (OR, 1.27; 95%CI: 0.76–2.13)[31]. However, some studies indicated that current smoking was a protective factor for myopia (OR, 0.7; 95%CI:0.5–0.9)[25]. However, myopia formation happens mainly in teenagers, but cigarette smoking usually starts in adults—the conclusion of relationship between myopia and smoking needs more cautious. The nicotinic cholinergic receptor is one of the main acetylcholine receptors distributed in the retina[48]. The impact of these ion channel receptors on myopia development requires further laboratory studies.

High myopia is an important cause of eye problems that need to be paid attention to in the clinic[49]. In our study, the risk factors for high myopia and myopia were different. The risk factors of high myopia were more correlated with myopia family history and ethnicity. Among the environmental factors, high myopia was not related to higher education level or indoor work. This finding indicated that in adults over 40 years of age, compared with low and moderate myopia, high myopia may be more closely affected by genetic factors. This is consistent with a previous understanding of the relationship between genes and myopia[50]. An increasing number of genes associated with high myopia have been found[51–54]. In the study of myopia among children and adolescents, the prevalence of high myopia was close to 20% in areas with a high prevalence of myopia[55, 56]. The dramatic increase in the prevalence of high myopia can no longer be explained by genetic changes, which are more likely consequences of the sharp increase in the prevalence of low and moderate myopia. The risk factors revealed in our study for high myopia are

not applicable to school-aged children because the high prevalence of myopia may change the reaction of environmental and genetic factors for myopia development. Birth in rural areas was also a protective factor for high myopia. Influence of birth place may include many aspects, such as differences in gene and childhood nutrition. Further studies are needed to confirm this hypothesis.

Our study has some strengths, including a large multi-ethnic population-based sampling strategy, a detailed questionnaire and a high response rate. The limitations of the present should also be acknowledged. First, the nature of the cross-sectional design limited the study to conclude a causal-effect of risk factors on myopia.

Second, the study population was only older adults in Gansu Province, the external validity was limited. Third, cycloplegia refraction was not performed in our study and ocular axial length and other biometric data were not measured either so we are unable to study the relationship between these factors and other biometric measurements.

Conclusions

For the first time, we described the prevalence of myopia in Gansu Province among adults 40–80 years of age. The prevalence of myopia in the Han ethnicity was significantly higher than that in the Yugur ethnicity. Several environmental and life-style factors were found to be significantly related to myopia, while high myopia was only associated with Han ethnicity, birthplace and a family history of myopia. These findings present a rough impression of the prevalence of myopia in Gansu Province. Our study has important implications for myopia prevention and control in Northwest China.

Notes

XW and HH have contributed equally; JM and YZ have contributed equally.

Abbreviations

OR: Odds Ratio; Confidence Interval: CI; BMI: Body mass index; CNHS: China National Health Survey; RE: Refractive error; SAS: Statistical Analysis System; SE: Spherical equivalent

Declarations

Ethics approval and consent to participate

Our study was conducted according to the tenets of the Declaration of Helsinki. Ethics approval was received from the bioethics committee of the Institute of Basic Medical Sciences, the Chinese Academy of Medical Sciences. Written informed consent was obtained from every Han or Yugur participant.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

We declare that no competing interests were involved in our study.

Funding

This study was supported by the National Science and Technology Pillar Program during the 12th 5-year plan period (2012BAI37B02) and the Key Basic Research Program of the Ministry of Science and Technology of China (2013FY114100). The funders had no role in the design of the study, data collection and analysis, or preparation of the manuscript.

Authors' contributions

XW analysed the data and drafted this manuscript. HH revised the manuscript detailly. XW, XT, JL, HZ and XR assisted with the acquisition of the data. GS, YZ, and JM designed the study. MW and ZP developed the statistical method. All authors read and approved the final manuscript.

Acknowledgements

The authors wish to acknowledge all investigation members for their generous contribution to the physical and refractive error data used in this study. We thank Zhouxian Pan and Meng Wang for data analysis and statistics work.

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Tables

Table 1. Characteristics of Han and Yugur participants in Gansu Province, China, 2016.

	Male		<i>P</i>	Female		<i>P</i>
	Han	Yugur		Han	Yugur	
	n=1190	n=507		n=1598	n=550	
Age (year)	55.1±8.7	53.0±8.4	<0.001	53.9±8.0	52.3±7.9	<0.001
Age group			<0.001			0.014
40-49	400(33.6)	239(47.1)		579(36.4)	241(43.8)	
50-59	430(36.1)	162(32.0)		630(39.7)	198(36.0)	
60-69	292(24.5)	98(19.3)		333(21.0)	97(17.6)	
70-80	68(5.7)	17(3.4)		56(3.5)	14(2.5)	
Height (cm)	168.7±5.9	169.40±5.7	0.021	157.5±5.1	158.4±5.8	0.001
Weight (kg)	69.7±10.2	71.2±11.6	0.008	58.8±8.0	64.3±12.0	<0.001
BMI (kg/m²)	24.5±3.1	24.7±3.5	0.086	23.7±2.9	25.6±4.2	<0.001
Birthplace			<0.001			<0.001
Urban	278(23.4)	25(4.9)		553(34.6)	44(8.0)	
Rural	912(76.6)	482(95.1)		1045(65.4)	506(92.0)	
Occupation			<0.001			<0.001
Outdoor	451(37.9)	342(67.5)		529(33.1)	346(62.9)	
Indoor	739(62.1)	165(32.5)		1069(66.9)	204(37.1)	
Time spent in rural areas (year)	32.0±23.9	43.5±18.1	<0.001	26.5±23.8	42.6±18.4	<0.001
Education			<0.001			<0.001
Primary school or below	292(24.5)	264(52.1)		620(38.8)	397(72.2)	
High school	572(48.1)	173(34.1)		694(43.4)	111(20.2)	
Undergraduate/graduate	326(27.4)	70(13.8)		284(17.8)	42(7.6)	
Hypertension	420(35.3)	225(44.4)	<0.001	455(28.5)	192(34.9)	0.005
Diabetes	142(11.9)	37(7.3)	0.004	89(5.6)	21(3.8)	0.108
Smoking status			<0.001			<0.001
Never-smoke	301(25.8)	88(17.4)		1588(99.9)	519(94.4)	
Ever-smoke	889(74.2)	419(82.6)		10(0.1)	31(5.6)	
Alcohol consumption			0.008			<0.001
Never-drink	138 (11.6)	37(7.3)		1071(67.0)	279(50.7)	
Ever-drink	1051(88.4)	470(92.7)		527(33.0)	271(49.3)	
Physical activity level			<0.001			<0.001
Light	107(9.0)	28(5.5)		207(13.0)	57(10.4)	
Moderate	882(74.1)	340(67.1)		1188(74.3)	360(65.5)	
Heavy	201(16.9)	139(27.4)		203(12.7)	133(24.2)	

Note: BMI: Body mass index was defined as weight (kg)/height (m)². 1) 125 participants had missing values on refractive error data; 2) 51 participants had missing values on birth place information; 3) 65 participants had missing values on education or work information. The Chi-square test was used to evaluate the demographic and life-style factors differences between Han and Yugur people.

	N	Prevalence							
		Crude P (95% CI)		Adjusted P (95% CI)		Age group			
						40-49	50-59	60-69	70-80
Myopia									
Overall	1080	28.1%	(26.7-29.5)	28.8%	(27.4-30.3)	35.6%	26.3%	18.3%	25.8%
Han ethnicity	916	32.9%	(31.1-34.6)	34.3%	(32.5-36.1)	44.3%	30.8%	19.8%	25.8%
Yugur ethnicity	164	15.5%	(13.3-17.7)	16.4%	(14.2-18.7)	17.4%	13.3%	13.3%	25.8%
Men	464	27.3%	(25.2-29.5)	28.3%	(26.2-30.4)	33.8%	26.4%	18.5%	27.1%
Women	616	28.7%	(26.8-30.6)	29.4%	(27.4-31.3)	37.0%	26.3%	18.1%	24.3%
Low myopia									
Overall	757	19.7%	(18.4-20.9)	20.1%	(18.8-21.4)	23.0%	19.3%	14.6%	19.4%
Han ethnicity	619	22.2%	(20.7-23.7)	22.9%	(21.3-24.4)	27.4%	21.8%	15.4%	19.4%
Yugur ethnicity	138	13.1%	(11.0-15.1)	13.6%	(11.5-15.7)	13.8%	11.9%	12.3%	19.4%
Men	372	21.9%	(20.0-23.9)	20.4%	(18.5-22.4)	22.5%	20.6%	15.6%	20.0%
Women	415	19.3%	(17.7-21.0)	19.7%	(18.1-21.4)	23.3%	18.4%	13.7%	18.6%
Moderate myopia									
Overall	182	4.7%	(4.1-5.4)	5.1%	(4.4-5.8)	7.2%	3.8%	2.0%	5.2%
Han ethnicity	163	5.8%	(5.0-6.7)	6.4%	(5.5-7.3)	9.5%	4.7%	2.2%	4.8%
Yugur ethnicity	19	1.8%	(1.0-2.6)	2.2%	(1.3-3.1)	2.3%	1.1%	1.0%	6.5%
Men	77	4.5%	(3.5-5.5)	5.0%	(3.9-6.0)	7.1%	3.5%	1.5%	5.9%
Women	105	4.9%	(4.0-5.8)	5.2%	(4.2-6.1)	7.2%	4.0%	2.3%	4.3%
High myopia									
Overall	141	3.7%	(3.1-4.3)	3.6%	(3.0-4.2)	5.4%	3.2%	1.7%	1.3%
Han ethnicity	134	4.8%	(4.0-5.6)	5.0%	(4.2-5.9)	7.5%	4.2%	2.2%	1.6%
Yugur ethnicity	7	0.7%	(0.2-1.2)	0.7%	(0.2-1.2)	1.3%	0.3%	0.0%	0.0%
Men	45	2.7%	(1.9-3.4)	2.8%	(2.0-3.6)	4.1%	2.2%	1.3%	1.2%
Women	96	4.5%	(3.6-5.3)	4.5%	(3.6-5.4)	6.5%	4.0%	2.1%	1.4%
Emmetropia									
Overall	1953	50.8%	(49.2-52.4)	49.9%	(48.4-51.5)	56.2%	53.5%	40.5%	30.3%
Han ethnicity	1323	47.5%	(45.6-49.3)	46.5%	(44.7-48.4)	50.3%	51.3%	39.8%	30.6%
Yugur ethnicity	630	59.6%	(56.6-62.6)	57.3%	(54.3-60.3)	68.6%	59.7%	42.6%	29.0%
Men	846	49.9%	(47.5-52.2)	49.4%	(47.0-51.7)	57.5%	53.2%	37.9%	24.7%
Women	1107	51.5%	(49.4-53.7)	50.5%	(48.4-52.6)	55.2%	53.6%	42.8%	37.1%
Hyperopia									
Overall	812	21.1%	(19.8-22.4)	21.2%	(19.9-22.5)	8.2%	20.2%	41.2%	43.9%
Han ethnicity	549	19.7%	(18.2-21.2)	19.2%	(17.7-20.6)	5.4%	17.9%	40.3%	43.5%
Yugur ethnicity	263	24.9%	(22.3-27.5)	26.2%	(23.6-28.9)	14.0%	26.9%	44.1%	45.2%
Men	387	22.8%	(20.8-24.8)	22.3%	(20.3-24.3)	8.7%	20.4%	43.6%	48.2%
Women	425	19.8%	(18.1-21.5)	20.1%	(18.4-21.8)	7.8%	20.0%	39.1%	38.6%

Table 2. Adjusted-prevalence of myopia and other refractive errors among adults aged 40-80 in Gansu, China, 2016.

Note: CI, confidence interval. Prevalence of All subjects were adjusted by age and sex. Prevalence of Han ethnicity, Yugur ethnicity, Men and Women were adjusted by age.

Table 3 Crude prevalence in Han and Yugur adults aged 40-80 in Gansu Province, China, 2016.

	Han		Yugur		<i>P</i>
	N	%*	N	%*	
Myopia					
Men	382	32.1	80	15.8	<0.001
Women	534	33.4	82	14.9	<0.001
Low myopia					
Men	270	22.7	72	14.2	<0.001
Women	349	21.8	66	12.0	<0.001
Moderate myopia					
Men	68	5.7	9	1.8	<0.001
Women	95	5.9	10	1.8	<0.001
High myopia					
Men	44	3.7	1	0.2	<0.001
Women	90	5.6	6	1.1	<0.001
Emmetropia					
Men	557	46.8	289	57.00	<0.001
Women	766	47.9	341	62.00	<0.001
Hyperopia					
Men	251	21.1	136	26.8	0.012
Women	298	18.7	127	23.1	0.026

Note: The difference in crude refractive error prevalence between Han and Yugur populations was analyzed using a general linear regression model.

Table 4. Multivariable regression of myopia in Han and Yugur adults aged 40-80 in Gansu, China, 2016.

	Myopia				High myopia			
	Odds Ratio	95% CI lower	95% CI upper	<i>P</i>	Odds Ratio	95% CI lower	95% CI upper	<i>P</i>
	1.00	NA	NA	NA	1.00	NA	NA	NA
Age	0.56	0.45	0.69	<0.001	0.33	0.15	0.73	0.006
Gender	1.00	NA	NA	NA	1.00	NA	NA	NA
Male	0.71	0.60	0.86	<0.001	0.65	0.43	1.00	0.049
Female	0.84	0.65	1.09	<0.185	0.49	0.25	0.97	0.039
	1.64	1.02	2.63	0.041	0.27	0.06	1.20	0.085
	1.00	NA	NA	NA	1.00	NA	NA	NA
Education level	0.83	0.63	1.08	0.168	1.06	0.59	1.91	0.838
Primary school or below	1.00	NA		NA	1.00	NA	NA	NA
High school	1.48	1.18	1.85	0.001	0.59	0.31	1.15	0.125
Postgraduate/graduate	3.62	2.73	4.82	<0.001	0.62	0.30	1.30	0.205
	1.00	NA	NA	NA	1.00	NA	NA	NA
Marital status	0.69	0.56	0.85	<0.001	0.61	0.40	0.94	0.025
Married	1.00	NA	NA	NA	1.00	NA	NA	NA
Single	1.48	1.18	1.85	0.001	0.59	0.31	1.15	0.125
Divorced	3.62	2.73	4.82	<0.001	0.62	0.30	1.30	0.205
	1.00	NA	NA	NA	1.00	NA	NA	NA
Smoking status	0.64	0.51	0.80	<0.001	0.57	0.28	1.15	0.117
Non-smoker	0.88	0.74	1.04	0.137	0.95	0.64	1.41	0.800
Smoker	1.00	NA	NA	NA	1.00	NA	NA	NA
	0.69	0.52	0.90	0.007	0.61	0.32	1.16	0.132
Blood pressure	1.00	NA	NA	NA	1.00	NA	NA	NA
Normal	1.17	0.97	1.40	0.092	1.01	0.66	1.56	0.954
Hypertension	1.00	NA	NA	NA	1.00	NA	NA	NA
	1.01	0.74	1.37	0.948	1.71	0.91	3.23	0.098
Family history	1.00	NA	NA	NA	1.00	NA	NA	NA
No family history	2.83	1.22	6.51	0.015	4.32	1.74	10.7	0.002
Family history	4.67	0.52	42.3	0.170	22.3	2.41	206.1	0.006

Note: CI, confidence interval. High Myopia was defined as SE<-6.0D. Myopia was defined as SE<-0.5D. Myopia family history: 0: no parent was myopic; 1: only one parent was myopic; 2: both parents were myopic. Activity level was defaulted to be continuous variables for statistics.

Figures

Figure 1

Prevalence of myopia and high myopia in different age groups in Han and Yugur populations. Adjusted-prevalence (vertical axis) of different age groups (horizontal axis) are plotted against different myopia group in Yugur and Han ethnicities.

Supplementary Files

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