Abstract

To report the rationale, design, and baseline demographic characteristics of TuYou-County Pediatric Eye study, which mainly aimed to determine the retinal microvascular changes with optical coherence tomography angiography (OCTA) and its association with eye abnormalities in school aged children and adolescents at suburban location in Northern China.

TuYou-County Pediatric Eye study was a school-based survey conducted in TuYou-County. Multi-ethnic (Mongol, Han, and Hui) participants will be followed up for 5 years. Standardized ophthalmological examinations include visual acuity, ocular biometry, retinal photography, and OCTA. A questionnaire survey was conducted to collect variables regarding to eye disease such as parental history of eye diseases, near work, outdoor activities, living and eating habits, etc.

After sampling, 687 participants were eligible for investigation, and 20 students did not attend the investigation, leaving 667 (response rate, 97.1%) students completed questionnaires and all ocular examinations. The average age of all participants was 14.9 ± 5.11.

TuYou-County Pediatric Eye study is the first large-scale school-based multi-ethnic survey in suburban site of Northern China. Continuous identification of retinal microvascular changes with eye diseases will provide new insights into the control related diseases in school-age children and adolescents.

Abbreviations: OCTA = optical coherence tomography angiography, TYPE = TuYou-County Pediatric Eye, VI = visual impairment.

Keywords: microvascular changes, ocular diseases, optical coherence tomography angiography, school-based study

1. Introduction

Visual impairment (VI) remains the most important disorders cause of handicapping conditions in childhood today. As one of the most common causes of VI in school age children, refractive errors, has become a significant public health issue worldwide, especially in eastern Asia. Previous studies have revealed that the incidence of refractive eye disease in China and the global Chinese population is high, and still increased year by year.
To date, myopia is the eye disease with the highest in prevalence among adolescents, and there are significant racial differences in refractive errors.\(^6,7\) According to recent work, it is estimated that by 2050, myopia prevalence among children and adolescents aged 3 to 19 years would be about 84% and high myopia has seriously threatened Chinese health as well as life.\(^8\) There are some population-based investigations on Children’s refractive status at suburban locations in China (western and eastern of China),\(^9,10\) while the epidemic studies of refractive status among school age population are limited and the prevalence and incidence of myopia in children is still an uncertain issue. Therefore, such a wide spread in accurate occurrence and progression of refractive error among suburban Chinese children needs long-term observation.

In addition, fundus diseases are becoming more and more prominent, becoming the most important blinding eye disease of working-age people\(^11,12\). However, there is little clinical knowledge about the ocular fundus diseases that adolescents may suffer from, and reports on these diseases are limited. Further, description on retinal blood flow by optical coherence tomography angiography (OCTA) and other common ocular abnormalities such as dry eye among Chinese children and adolescents are unclear, thus, there is a need to conduct a survey on these data in order to improve students’ visual quality.

Generally, the TuYou-County Pediatric Eye (TYPE) Study was designed to investigate the retinal microvascular changes with optical coherence tomography angiography (OCTA) and its association with eye diseases among school age children aged 11 to 18 years. Subsequently, TYPE study will also investigate the prevalence, incidence, and the risk factors of refractive error as well as other ocular diseases among school age children and adolescents. These children and adolescents living in suburban areas of TuYou County, Inner Mongolia autonomous region, in Northern China, will be followed-up annually for 5 years. The objective of this article is to summarize the study rationale, design, and demographic characteristics of the TYPE study.

2. Methods

2.1. Specific aims

The specific aims of the TYPE study included:

1. to describe microvascular characteristics in eyes defined by the OCTA measured as the vessel density;
2. to investigate the association between retinal microvascular changes with eye abnormalities;
3. to determine the prevalence and incidence of refractive errors in multi-ethnic school age children;
4. to investigate the prevalence of other ocular diseases such as amblyopia, strabismus, color blindness, dry eye, and so on;
5. to document the possible cause-specific factors for those ocular diseases so as to provide strategies for intervention.

2.2. Study area

TuYou County, located in the central and western part of the Inner Mongolia Autonomous Region (40°N, 110°E) and belongs to a semi-arid mid-temperate continental monsoon climate, with a population of 0.36 million and an area of 2600 km\(^2\), was identified as the study area due to its demographic and socio-economic characteristics are similar to the national average, and has multi-ethnic population (Mongol, Han, and Hui). The compulsory education system is well executed in TuYou County with enrollment rate of 99.6% in middle schools, respectively.

2.3. Sampling method and sample size

TYPE study used a stratified cluster sampling method by a coordination meeting which was held by the local city government before the recruitment. Officials from city governments, the health, and the education departments of TuYou County provide the detail information on demographic and geographic characteristics of TuYou County. First, 1 district were randomly selected according to the method of random number table from the 9 districts of the county of TuYou. Among the eligible district, the school was defined as the sampling unit. One junior and 1 senior middle school were randomly selected as sample sources. Secondly, the extracted middle schools are stratified from grade 1 to grade 6, and each grade randomly draws 2 classes, and a total of 687 both junior and senior school students form the final sample. The estimate of the sample size is calculated according to formula (1).

\[
N = \frac{t_{p}^2pq}{d^2}
\]

In the formula, \(N\) represents the sample size; \(p\) represents the expected prevalence of the sample; \(t_{p}\) represents the t value when the degree of freedom is infinite, when \(a=0.05\); \(d\) represents the difference between the prevalence of the sample and the population;

\[
q = 1 - p;
\]

According to the incidence of myopia in Chinese children from a previous cohort study, the cumulative incidence of myopia was ranging from 10.6% to 23.5%\(^13,14\). Here we set it as 15%. Assuming a design effect of 2.0, a tolerated error of 0.1 times the myopia incidence and loss of follow-up of 10%, the number of samples were 650.

Inclusion criteria:

1. registry in the sampling school;
2. student participants aged 11 to 18 years; and
3. parent or legal guardian agrees childhood to participate in this investigation.

Exclusion criteria:

1. students who did not complete the questionnaire or eye examinations;
2. students who did not hope to attend this survey.

2.4. Ethical approval

Our investigation was performed according to the Declaration of Helsinki and approved by the Institutional Review Board (IRB) of Baotou Chaoju Eye Hospital (No.CHAOJU-BT-2020003). Written informed consent was obtained from parents or legal representatives of all participating children.

2.5. Questionnaires

The investigation team included 1 Chief Physician, 1 Attending Physician, 2 Residents, 1 Senior Optometrist, and 2 Optomet-
The data of questionnaire survey and clinical examination are 2.9. Data processing and statistical analysis. The Chi-Squared test. Multivariable analysis, including the general linear model and linear regression model will be used to assess the significance of associations between a range of exposures and prevalent myopia at baseline. Multiple logistic regression is used to determine adjusted risk ratios. A P value less than .05 was considered statistically significant.

3. Results
Among the eligible 687 participants, 20 students did not attend the investigation, living 667 (response rate, 97.1%) students completed questionnaires and all ocular examinations. The average age of 667 participants is 14.9 ± 5.11. The demographic characteristics of including participants were shown in Table 1. Furthermore, Table 2 showed other demographic characteristics as the distribution of study population by age. There was no significant statistic on age between boys and girls.

4. Discussion
Currently, we reported the rationale, methodology, and demographic characteristics data of refractive errors and other eye conditions in school age children and adolescents cohort in TuYou County. To date, there were 8 main population-based or school-based surveys on eye conditions among children and adolescents (Table 3). At present, China’s urbanization process is very fast, and China’s urbanization rate reached 60.60% in 2019. However, the reports on suburban school age children’s ocular conditions are limited. Unlike many other large-scale studies of children ocular diseases epidemiology, our TYPE study firstly investigated the distribution of ocular conditions among Chinese suburban participants with multi-ethnic, large sample size, and further aims to fill the gap on childhood dry eye and OCTA features using school-based survey. Similar to our TYPE study, the Gobi Desert Children Eye Study was also in the Inner Mongolia, while it located in Desert with extremely arid a condition which is different with TuYou County.

In 2017, according to data from Inner Mongolia Bureau of Statistics, the disposable income per capita of TuYou County is 24,101 Yuan, which is in the middle of Inner Mongolia (https://tieba.baidu.com/p/5908224943?pv=1&traceid=). This will adjust income level to cover a strong representation.

The major strengths of TYPE study include first focus on the retinal microvascular changes with OCTA and its association with eye abnormalities in school aged children and adolescents, using a randomized sampling at baseline, comprehensive ocular data, high response rate, and standardized protocol of most of the ocular examinations and questionnaires. These advantages made it possible to achieve specific aims of TYPE. There are still some limitations to the TYPE study. Firstly, some of the variables might be inaccurate according to the self-reported questionnaires from the children and their parents, even though the questionnaires used in the TYPE study were calibrated for Mongolian such as lifestyle. Secondly, there was relative small
## Table 1
Demographic characteristics of study participants.

|                                | Overall          | Boys             | Girls            | P     |
|--------------------------------|------------------|------------------|------------------|-------|
| **Demographic characteristics of study participants.** |                  |                  |                  |       |
| **Age**                        | 14.9 ± 5.11      | 14.81 ± 6.96     | 14.99 ± 2.58     | .647* |
| **Nationality (%)**            |                  |                  |                  |       |
| Han                            | 623 (93.40)      | 296 (47.51)      | 327 (52.49)      | .053* |
| Mongolian                      | 32 (4.80)        | 11 (34.37)       | 21 (65.63)       |       |
| Hui                            | 11 (1.65)        | 2 (18.18)        | 9 (81.82)        |       |
| Others                         | 1 (0.15)         | 1 (100)          | 0 (0)            |       |
| Daily homework, reading or magazines (weekday, %) |                  |                  |                  |       |
| <2 hours                       | 261 (39.13)      | 143 (54.79)      | 118 (45.21)      | .002* |
| 2–5 hours                      | 363 (54.42)      | 149 (41.05)      | 214 (58.95)      |       |
| >5 hours                       | 43 (6.45)        | 18 (41.86)       | 25 (58.14)       |       |
| Daily homework, reading or magazines (weekend, %) |                  |                  |                  |       |
| <2 hours                       | 193 (28.94)      | 110 (56.99)      | 83 (43.01)       | .002* |
| 2–5 hours                      | 336 (50.37)      | 146 (43.45)      | 190 (56.55)      |       |
| >5 hours                       | 138 (20.69)      | 54 (39.13)       | 84 (60.87)       |       |
| Watch TV, cell phone or touch screen every day (weekday, %) |                  |                  |                  |       |
| <2 hours                       | 476 (71.36)      | 209 (43.91)      | 267 (56.09)      | .043* |
| 2–5 hours                      | 163 (24.44)      | 83 (50.92)       | 80 (49.08)       |       |
| >5 hours                       | 28 (4.20)        | 18 (64.29)       | 10 (35.71)       |       |
| Watch TV, cell phone or touch screen every day (weekend, %) |                  |                  |                  |       |
| <2 hours                       | 321 (48.13)      | 156 (48.60)      | 165 (51.40)      | .046* |
| 2–5 hours                      | 138 (20.64)      | 59 (39.13)       | 79 (60.87)       |       |
| >5 hours                       | 111 (16.64)      | 59 (53.15)       | 52 (46.85)       |       |
| Daily outdoor exercise time (weekday, %) |                  |                  |                  |       |
| <2 hours                       | 422 (63.27)      | 182 (43.13)      | 240 (56.87)      | .002* |
| 2–5 hours                      | 186 (27.89)      | 88 (47.31)       | 98 (52.69)       |       |
| >5 hours                       | 59 (8.84)        | 40 (67.80)       | 19 (32.20)       |       |
| Daily outdoor exercise time (weekend) |                  |                  |                  |       |
| <2 hours                       | 251 (37.63)      | 89 (35.46)       | 162 (64.54)      | <.001*|
| 2–5 hours                      | 297 (44.53)      | 138 (46.46)      | 159 (53.54)      |       |
| >5 hours                       | 119 (17.84)      | 83 (69.75)       | 36 (30.25)       |       |
| Sleeping time (school day, h)  | 7.31 ± 1.13      | 7.37 ± 1.06      | 7.25 ± 1.19      | .178* |
| Sleeping time (weekend, h)     | 8.99 ± 1.43      | 8.94 ± 1.57      | 9.03 ± 1.29      | .930  |
| Reading or study time, intermittent overlooking or rest to relax the eyes (Yes, %) |                  |                  |                  |       |
|                                | 317 (47.60)      | 143 (45.11)      | 174 (54.89)      | .743  |
| When using eyes, the distance between eyes and books and screen is more than 30 cm (Yes, %) |                  |                  |                  |       |
|                                | 391 (58.62)      | 177 (45.27)      | 214 (54.73)      | .407  |
| The distance of watching TV is more than 2 meters (Yes, %) |                  |                  |                  |       |
|                                | 548 (82.16)      | 268 (48.91)      | 280 (51.09)      | .006  |
| Frequent consumption of dairy products (%) |                  |                  |                  |       |
|                                | 334 (50.23)      | 171 (51.20)      | 163 (48.80)      | .010  |
| Staple food (%)                |                  |                  |                  |       |
| Rice                           | 544 (81.68)      | 251 (46.14)      | 293 (53.86)      | .112  |
| Cooked wheaten food            | 98 (14.72)       | 51 (52.04)       | 47 (47.96)       |       |
| Other                          | 24 (3.60)        | 7 (23.17)        | 17 (70.83)       |       |
| Main course (%)                |                  |                  |                  |       |
| Vegetables                     | 381 (57.12)      | 141 (37.01)      | 240 (62.99)      | <.001*|
| Meat                           | 274 (41.08)      | 163 (59.49)      | 111 (40.51)      |       |
| Fish                           | 12 (1.80)        | 6 (50.00)        | 6 (50.00)        |       |
| Meat (%)                       |                  |                  |                  |       |
| Pork                           | 483 (72.41)      | 233 (48.24)      | 250 (51.76)      | .002* |
| Beef                           | 47 (7.05)        | 24 (51.06)       | 23 (48.94)       |       |
| Mutton                         | 25 (3.75)        | 17 (68.00)       | 8 (32.00)        |       |
| Other                          | 112 (16.70)      | 36 (32.14)       | 76 (67.86)       |       |
| Flavor (%)                     |                  |                  |                  |       |
| Sweet                           | 399 (59.82)      | 176 (44.11)      | 223 (55.89)      | .133  |
| Salt                           | 268 (40.18)      | 134 (50.00)      | 134 (50.00)      |       |
| Do you like fruit (Yes, %)     | 624 (93.93)      | 282 (45.19)      | 342 (54.81)      | .011  |
| Do you like wearing glasses or do you think wearing glasses is fun (Yes, %) |                  |                  |                  |       |
| Current eye diseases (%)       |                  |                  |                  |       |
| Myopia                         | 331 (49.70)      | 130 (39.27)      | 201 (60.73)      | .001  |
| Hyperopia                      | 11 (1.65)        | 5 (45.45)        | 6 (54.55)        |       |
| Amblyopia                      | 6 (0.90)         | 2 (33.33)        | 4 (66.67)        |       |
| Strabismus                     | 8 (1.20)         | 7 (87.50)        | 1 (12.50)        |       |
| Normal                         | 225 (33.78)      | 123 (54.67)      | 102 (45.33)      |       |
| Unclear                        | 65 (12.76)       | 42 (49.41)       | 23 (50.59)       |       |

(continued)
Table 1
(continued).

| Current treatment (%)                      | Overall | Boys | Girls | \( P \) |
|--------------------------------------------|---------|------|-------|--------|
| Wearing glasses                            | 299 (44.89) | 114 (38.13) | 185 (61.87) | <.001* |
| Corneal plastic lens (contact lens)        | 10 (1.50)  | 1 (10.00)   | 9 (90.00)   |        |
| Traditional Chinese medicine treatment     | 1 (0.15)  | 1 (100.00)  | 0 (0)       |        |
| Untreated                                  | 356 (53.45) | 193 (54.21) | 163 (45.79) |        |

TV = television.

* By Student’s t test.

† By Kruskal–Wallis test.

Table 2
Distribution of study population by age.

| Overall | %   | Boys | %   | Girls | %   | \( P \) |
|---------|-----|------|-----|-------|-----|--------|
| 11 year | 3   | 0.45 | 2   | 66.67 | 1   | 33.33  |
| 12 year | 34  | 5.14 | 15  | 44.12 | 19  | 55.88  |
| 13 year | 151 | 22.81| 68  | 45.03 | 83  | 54.97  |
| 14 year | 78  | 11.78| 32  | 41.03 | 46  | 58.97  |
| 15 year | 53  | 8.01 | 22  | 41.51 | 31  | 58.49  |
| 16 year | 120 | 19.49| 69  | 53.49 | 60  | 46.51  |
| 17 year | 142 | 21.45| 68  | 47.89 | 74  | 52.11  |
| 18 year | 62  | 9.36 | 28  | 45.16 | 34  | 54.84  |

* By Kruskal–Wallis test.

Table 3
Observational studies of ocular diseases among children in China.

| References | Location | Investigation year | Rural or urban | Study design | Sample size | Age range (years) | Primary outcomes | Other outcomes |
|------------|----------|-------------------|----------------|--------------|-------------|------------------|------------------|----------------|
| Our study  | TuYou (Inner Mongolia, northern of China) | 2019 | Rural + Suburban | School-based | 6–18 | Myopia |
| Li[15]     | Anyang (Henan, middle of China) | October–December 2011 for grade 7 | Rural | School-based | Grade 1 (3112), and grade 7 (2363) | Grade 1 (5.7–9.3), Visual acuity and grade 7 (10.0–15.9) | Refractive errors, dry eye, ocular biometry, fundus diseases, OCTA features, strabismus and amblyopia, amblyopia and strabismus, ocular biometry, OCT features, retinal diseases |
| Xiang[16]  | Guangzhou (Guangdong, southern of China) | 2006 | Urban | Population-based | 2567 | 7–15 | Myopia |
| Zhao[17]   | Shunyi district (Beijing, northern of China) | 1998 | Urban | Population-based | 4662 | 5–13 | Refractive error |
| He[17]     | Shanghai (eastern of China) | October–November 2016 | Urban | School-based | 6295 | 6–9 | Myopia |
| Zhu[18]    | Nanting (Jiangsu, eastern of China) | 2011–2012 | Urban | Population-based | 5831 | 3–6 | Ocular alignment |
| Wu[19]     | Guanxian County and the city of Weihai | N.A. | Rural-Urban | School-based | 6384 | 4–18 | Refractive errors and causes of vision loss |
| Yang[20]   | Ejinaqi (western part of the Inner Mongolia, northern-west of China) | N.A. | the Gobi desert | School-based | 1911 | 6–21 | Intracocular Pressure |
| Pi LH[21]  | Yongchuan District (Chongqing, western China) | 2006–2007 | Suburban | Population-based | 3469 | 6–15 | Refractive Status |

IOP = intraocular pressure, N.A. = not applicable, OCT = optical coherence tomography, OCTA = optical coherence tomography angiography.
sample size in present study due to the difficulty on examination of OCTA among children.

5. Conclusion
Generally, data from the TYPE study will give us insight into pediatric retinal microvascular changes with optical coherence tomography angiography (OCTA) and its association with eye diseases among young, ethnic Chinese, and Mongolia school-children in the suburban of China.

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