Prevalence of reduced visual acuity among adolescents in Jiaocheng County, Shanxi Province

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Abstract

Purpose: To investigate the prevalence of reduced visual acuity among adolescents in Jiaocheng County, Shanxi Province.

Methods: Fourteen thousand fifty-one Jiaocheng County students aged 7 to 21 were chosen to engage in this research project in 2019. For uncorrected distance visual acuity (UCDVA) testing, a 5 m standard logarithmic visual sharpness E chart was utilized, and for diopter examination of those with reduced UCDVA, computerized optometry was used. The factors linked to reduced UCDVA in students were investigated using logistic regression analysis.

Results: In Jiaocheng County, Shanxi Province, the prevalence of reduced UCDVA among adolescents was 77.54% in 2019, with the highest rate of severely reduced UCDVA at 47.58% and myopia accounting for the highest proportion of reduced UCDVA, with myopia rates above 90% in all age groups. Girls, those who live in counties, those who are anxious about their studies, and those who dedicate more time to schoolwork are more prone to suffer from a decrease in UCDVA; those who spend more time outdoors and get adequate sleep are less likely to have reduced UCDVA, according to logistic regression analysis.

Conclusion: Adolescents in Jiaocheng County, Shanxi Province, have a high prevalence of reduced UCDVA, and interventions targeting key populations should be increased based on effective prevention and control of reduced UCDVA among local adolescents.

Keywords: Reduced visual acuity, Myopia, Adolescents

Introduction

The number of persons with reduced UCDVA has risen year after year, posing a serious threat to young people's health and becoming a significant public health problem globally [1]. Myopia is the most frequent kind of reduced UCDVA [2]. Some estimates predict that by 2050, the number of persons with myopia will have increased to 5 billion, accounting for over half of the global population [3]. Myopia impacts young people's academics, social lives, future employment prospects, and physical and emotional health. High myopia can cause irreversible vision loss due to retinal detachment, macular retinoschisis, and glaucoma [4, 5]. According to the literature, myopia rates in Asia are much greater than in other world regions, with high school pupils having roughly 90% myopia and 20% high myopia [6]. This study analyzed the reduced UCDVA of teenagers in Jiaocheng County, Shanxi Province, to create a scientific foundation for developing strategies and treatments to prevent and treat reduced UCDVA in students.
Subjects and methods

Subjects
Cross-sectional epidemiology research underpins this project. In 2019 (February 1--December 31), 14,051 students aged 7 to 21 (13.47 ± 3.13) from the county and suburban primary, middle, and high schools volunteered to participate in this survey research. Our researchers examine pupils in one school before moving on to the following one. Inclusion and exclusion criteria: Inclusion criteria: Age: 7–21 years old; High degree of cooperation and compliance from students during all tests. Exclusion criteria: Excluding students with keratoconus within 3 days; Excluding students with organic eye disease.

Methodology
A 5 m standard logarithmic visual acuity scale was used to assess students’ uncorrected distance visual acuity. The diagnostic criteria for reduced UCDVA were: ≥5.0 as normal, 4.8–4.9 as mildly reduced UCDVA, 4.6–4.7 as moderately reduced UCDVA, and ≤4.5 as severely reduced UCDVA. The diopter examination with a computerized optometer and myopia was diagnosed as SER ≤-0.50 D, hyperopia: SER> +0.75D. Other types of reduced UCDVA are classified as other.

Students were asked to fill out questionnaires on whether they felt pressured to study, how much time they spent on homework each day, how much time they spent resting each day, and how much time they spent outside.

Ethical approval
The Ethics Committee of The People's Hospital of Jiaocheng County, Shanxi Province, gave their approval to this study. We also got the permission of all of the pupils and their guardians.

Statistical analysis
The data were analyzed using the statistical application SPSS 26.0. The chi-square test was used to look for differences among groups. The factors connected to reduced UCDVA in students were investigated using logistic regression, with P<0.05 as a statistically significant difference.

Results

1 The overall prevalence of reduced UCDVA detection in a county in Shanxi Province

The number of adolescents with reduced UCDVA in Jiaocheng County, Shanxi Province, investigated in this study was 10,895, and the detection rate of reduced UCDVA was 77.54%. Myopia accounted for the highest proportion of reduced UCDVA, with myopia rates above 90% across all age ranges. Myopia wear also accelerates with aging. The highest prevalence of reduced UCDVA among county girls and the lowest prevalence of reduced UCDVA among suburban boys were found in all age groups, with 87.43 and 67.82%, respectively. (Table 1, Figs. 1 and 2).

2 Characteristics of changes in reduced UCDVA among adolescents in Jiaocheng County

Reduced UCDVA remained high among adolescents of all ages. The detection rate of reduced UCDVA increased gradually with age (χ²=3415.598, p<0.01), as did the rate of severely reduced UCDVA, with the highest rate of severely reduced UCDVA among girls in county areas and the lowest rate among boys in suburban areas, with probabilities of 60.77 and 36.34% respectively. (Table 2).

Logistic regression analysis was conducted with gender, county, suburb, study pressure, homework, outdoor activity, and sleep time as independent variables, with reduced UCDVA as the dependent variable (0 = normal, 1 = reduced UCDVA) and stratifying by age group. It discovered that girls were more inclined to have reduced UCDVA than boys in all age groups and that county students were more prone to have reduced UCDVA than suburban students. Those who

| Age group /years | County girls n % | County boys n % | Suburban girls n % | Suburban boys n % | Girls n % | Boys n % | Total n % |
|------------------|-------------------|------------------|------------------|------------------|----------|---------|----------|
| 7–9              | 154               | 202              | 196              | 182              | 350      | 384     | 734      |
| 10–12            | 502               | 547              | 1003             | 963              | 1505     | 1510    | 3015     |
| 13–15            | 1044              | 1092             | 1003             | 802              | 1876     | 1894    | 3770     |
| 16–18            | 818               | 636              | 415              | 469              | 1233     | 1105    | 2338     |
| 19–21            | 417               | 357              | 136              | 128              | 533      | 485     | 1038     |
| Total            | 2935              | 2834             | 2582             | 2544             | 5517     | 5378    | 10,895   |
were stressed about their studies were more inclined to have reduced UCDVA; those who consumed more than 2 hours on homework were more inclined to have reduced UCDVA; those who consumed more than 2 hours outdoors were less prone to have reduced UCDVA, and those who got enough sleep were less prone to have reduced UCDVA. (Table 3).
### Table 2 The prevalence of reduced UCDVA by county/suburb, gender, and age group

| Age group /years | n   | County girls/% | County boys/% | Suburban girls/% | Suburban boys% | Total/% |
|------------------|-----|----------------|---------------|------------------|----------------|--------|
|                  |     | Mild | Moderate | Severe | Mild | Moderate | Severe | Mild | Moderate | Severe | Mild | Moderate | Severe | Mild | Moderate | Severe |
|                  |     | Mild | Moderate | Severe | Mild | Moderate | Severe | Mild | Moderate | Severe | Mild | Moderate | Severe |
| 7–9              | 1422| 43.14| 9.80     | 7.45  | 37.86| 13.29     | 7.23   | 40.66| 7.42     | 5.77   | 27.13| 6.56     | 6.13   | 36.08| 9.00     | 6.54   |
| 10–12            | 4492| 31.15| 17.10    | 28.40 | 24.64| 14.64     | 25.83  | 27.00| 13.60    | 29.01  | 26.03| 11.89    | 23.97  | 26.83| 13.71    | 26.58  |
| 13–15            | 4445| 14.51| 10.75    | 66.00 | 15.43| 12.89     | 55.49  | 13.66| 9.38     | 63.71  | 14.63| 12.32    | 50.24  | 14.62| 11.45    | 58.74  |
| 16–18            | 2574| 5.87 | 6.33     | 81.93 | 8.15 | 8.00      | 73.17  | 12.30| 7.38     | 73.15  | 15.57| 9.71     | 60.62  | 9.67 | 7.69     | 73.47  |
| 19–21            | 1118| 5.07 | 6.22     | 84.79 | 6.20 | 8.27      | 77.78  | 9.03 | 3.47     | 81.94  | 6.54 | 5.88     | 71.24  | 6.17 | 6.53     | 80.14  |
| Total            | 14051| 16.47| 10.19    | 60.77 | 17.31| 11.87     | 49.80  | 21.94| 10.46    | 44.56  | 20.69| 10.88    | 36.34  | 19.12| 10.85    | 47.58  |
| $X^2$ linear by line | 75919| 657.30| 665.66 | 586.78 | 586.78| <0.01     | <0.01  | <0.01| <0.01    | <0.01  | <0.01| <0.01     | <0.01  | <0.01| <0.01     | <0.01  |

Multi-factor analysis of reduced UCDVA
### Discussion

The detection rate of reduced UCDVA among adolescents in Jiaocheng County, Shanxi Province, was 77.54% in 2019, higher than the national rate of reduced UCDVA among adolescents in 2014 [7]. The rate of severely reduced UCDVA was the highest, indicating that the situation of reduced UCDVA is complicated and must be addressed. Myopia was the most common cause of reduced UCDVA, with rates above 90% in all age categories, with the frequency of myopia increasing with age.

We found that reduced UCDVA is more common in county regions than in suburban areas, and it is more prevalent in girls than in boys. It is the same as most research [8, 9]. According to some research, people in cities are more likely to develop myopia, probably due to a crowded environment, a stronger emphasis on education, and more close-range activities [10]. Myopia prevalence is also related to gender, with girls developing earlier in adolescence and hormonal changes that may contribute to myopia [11], as well as boys and girls having different personalities, with girls preferring quiet indoor activities, studying harder, spending more time close and less time outdoors, and having a higher prevalence of myopia. In addition, myopia wear is common and gets worse as people age.

Outdoor activities, study time, education system, close work, and proper sleep have all been linked to the development of myopia [12–14]. Girls, county regions, longer homework time, and high school stress were also identified as risk factors for reduced UCDVA, while proper sleep and more time spent outside were found to be protective factors. According to some research, people who work at close ranges are more likely to be myopic, and children who use their eyes more closely or live in crowded situations are more likely to be myopic than their peers [15]. Myopia was shown to be more common in students who studied for more than 5 h each day, according to Mavracanas et al. [16] Myopia is more prevalent in terms of close reading, according to Ip et al. [17] Myopia is substantially more common in Singapore, Korea, and China than in other nations, presumably due to their high-pressure education systems [18], which require students to study intensively and under stress, increasing the frequency of myopia. Dirani et al. detected a relationship between myopia and outdoor activities in youngsters [19]. The more outdoor exercise was related to a reduced prevalence of myopia, according to Wu et al. [20] The consequences of our study are consistent with these conclusions.

### Conclusion

Even though our study has some limitations, such as the lack of dilated pupils to paralyze the ciliary muscle and the lack of sufficient evidence for myopia diagnosis, it still offers some scientific support for the prevention and control of myopia and reduced UCDVA among adolescents in Shanxi Province.

In conclusion, this study examines the current state of reduced UCDVA among adolescents in Shanxi Province’s Jiaocheng County, concluding that the rate of reduced UCDVA is significant. It is proposed that the government prioritize preventing and controlling reduced UCDVA among girls in urban areas, starting with younger students by focusing on prevention and control of reduced UCDVA, establishing good eye care and healthy eye use habits from an early age, reducing homework, strengthening outdoor exercise, ensuring adequate sleep, regularly monitoring visual acuity, and establishing graphic acuity standards.

### Abbreviations

UCDVA: uncorrected distance visual acuity.

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References

1. Hashemi H, Pakzad R, Ali B, Yekta A, Ostadimoghaddam H, Heravian
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2. Pan CW, Ramamurthy D, Saw SM. Worldwide prevalence and risk factors
   for myopia. Ophthalmic Physiol Opt. 2012;32(1):3–16.

3. Holden BA, Fricke TR, Wilson DA, et al. Global prevalence of myopia and
   high myopia and temporal trends from 2000 through 2050[J]. Ophthal-
   mology. 2016;123(5):1036–42.

4. Schneider J, Leeder SR, Gopinath B, and Mitchell P Frequency,
   course, and impact of correctable visual impairment (uncorrected refrac-
   tive error). Surv Ophthalmol. 2010;55(6):539–60.

5. Alvarez-Peregrina C, Sanchez-Tena MA, Andreu-Vázquez C, Villa-Collar C.
   Visual health and academic performance in school-aged children. Int J
   Environ Res Public Health. 2020;17(7):2346.

6. Morgan IG, French AN, Ashby RS, Guo Y, Ding X, He M, et al. The
   epidemics of myopia: aetiology and prevention. Prog Retin Eye Res.
   2018;62:134–49.

7. Song Y, Hu PJ, Dong YH, Zhang B, Ma J. Prevalence of reduced visual
   acuity among Chinese Han students in 2014. Beijing Da Xue Xue Bao.
   2017;49(3):433–8.

8. Liu Y, Zhang H, Gong Y, et al. Prevalence of and factors associated with
   myopia in primary school students in the Chaoyang District of Beijing,
   China [J]. Jpn J Ophthalmol. 2015;59:421–9.

9. Li Y, Liu J, Qi P. The increasing prevalence of myopia in junior high school
   students in the Haidian District of Beijing, China: a 10-year population-
   based survey [J]. BMC Ophthalmol. 2017;17:88.

10. Dandona R, Dandona L, Naduvilath TJ, et al. Refractive errors in an urban
    population in southern India: the Andhra Pradesh eye disease study.
    Invest Ophthalmol Vis Sci. 1999;40:2810–8.

11. Yip VC, Pan CW, Lin XY, et al. The relationship between growth
    spurt and myopia in Singapore children. Invest Ophthalmol Vis Sci.
    2012;53(13):7961–6.

12. Matsuda K, Yokoyama T. Analysis of secular trends in the propor-
    tion of students with poor visual acuity and the associated factors
    according to government statistics [J]. Nippon Ganka Gakkai Zasshi.
    2014;118(2):104–10.

13. Rudnicka AR, Kapetanakis VV, Wathern AK, et al. Global variations and
    time trends in the prevalence of childhood myopia, a systematic review
    and quantitative meta-analysis: implications for etiology and early pre-
    vention [J]. Br J Ophthalmol. 2016;100(7):882–90.

14. Saw SM, Wu HM, Seet B, Wong TY, Yap E, Chia KS, et al. Academic achieve-
    ment, close-up work parameters, and myopia in Singapore military
    conscripts. Br J Ophthalmol. 2001;85:855Y60.

15. Ip JM, Rose KA, Morgan IG, Burlutsky G, Mitchell P. Myopia and the urban
    environment: findings in a sample of 12-year-old Australian school chil-
    dren. Invest Ophthalmol Vis Sci. 2008;49:3858Y63.

16. Mav sankas TA, Mandalos A, Pefios D, Gollas V, Megalou K, Gregoriadou A,
    et al. Prevalence of myopia in a sample of Greek students. Acta Ophthal-
    mol Scand. 2000;78(6):656–9.

17. Ip JM, Saw SM, Rose KA, Morgan IG, Kifley A, Wang JJ, et al. Role of near
    work in myopia: findings in a sample of Australian school children. Invest
    Ophthalmol Vis Sci. 2008;49:2903Y10.

18. Lim LT, Gong Y, Ah-Kee EY, et al. Impact of parental history of myopia
    on the development of myopia in mainland China school-aged children.
    Ophthalmol Eye Dis. 2014;6:31–5.

19. Dirani M, Tong L, Gazzard G, Zhang X, Chia A, Young TL, et al. Outdoor
    activity and myopia in Singapore teenage children. Br J Ophthalmol.
    2009;93:997–1000.

20. Wu PC, Tsai CL, Hu CH, Yang YH. Effects of outdoor activities on
    myopia among rural school children in Taiwan. Ophthal mic Epidemiol.
    2010;17:338Y42.

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