

Association between Myopia Onset and Progression and Lifestyle Factors among Adolescents in Chongqing: A 3-Year Cohort Analysis of 3745 Adolescents

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Abstract: To explore the association between lifestyle factors (such as physical activity, outdoor light exposure, and sugar-sweetened beverage intake) and demographic characteristics with the onset and progression of myopia among adolescents in Chongqing, and to provide precise evidence for regional myopia prevention and control, this study used a stratified cluster sampling method to select 3745 baseline non-myopic adolescents (aged 6-15 years, including 2136 primary school students and 1609 junior high school students) from 12 primary and secondary schools in 6 administrative districts of Chongqing, conducted a 3-year prospective cohort study from September 2022 to September 2025 with data collected at 4 time points (baseline and annual follow-up), used international standardized scales (such as the IPAQ Short Form, OTR Record Sheet, and Simplified Food Frequency Questionnaire) to investigate the participants' demographic characteristics, physical activity (moderate-to-vigorous physical activity [MVPA] duration), daily outdoor light exposure time, and sugar-sweetened beverage intake frequency, performed standardized ophthalmic examinations (visual acuity, refraction, and axial length measurement), implemented quality control measures including pre-survey, investigator training, instrument calibration, double data entry, and follow-up of lost-to-follow-up participants, used SPSS 26.0 and Stata 18.0 software for descriptive statistics, Cox proportional hazards model (to analyze myopia onset risk), linear mixed model (to analyze axial length growth rate), and stratified analysis while adjusting for confounding factors such as gender and age with the significance level set at $\alpha=0.05$; at baseline, the participants had an average age of (10.2±2.3) years, with males accounting for 52.4%, 42.5% of the participants had parents with a bachelor's degree or above, 30.4% engaged in MVPA for ≥150 minutes per week, 33.7% had outdoor exposure for ≥2 hours per day, 19.4% consumed sugar-sweetened beverages ≥4 times per week, with an average refraction of (+1.23±0.45) D and an average axial length of (22.15±0.82) mm; during the follow-up period, the 3-year cumulative myopia incidence was 42.24%, with the annual incidence showing an increasing trend year by year (11.36%-16.06%), and after adjusting for confounders, weekly MVPA ≥150 minutes (HR=0.69) and daily outdoor exposure ≥2 hours (HR=0.57) were protective factors against myopia onset, while weekly sugar-sweetened beverage intake ≥4 times (HR=1.28), non-only child status (HR=1.19), and parental binocular myopia (HR=2.45) were risk factors, with the myopia-inducing effect of sugar-sweetened beverages being more significant in primary school students (HR=1.89) and the annual axial length growth rate being significantly lower in the protective factor groups than in the risk factor groups; this study indicates that the incidence of myopia among adolescents in Chongqing is showing an increasing trend year by year, sufficient physical activity, adequate outdoor light exposure, and high parental education level are protective factors against myopia, while high-frequency sugar-sweetened beverage intake and non-only child status are risk factors, and targeted regional myopia prevention and control strategies should be formulated based on these findings.

Keywords: Chongqing; Adolescents; Myopia; Lifestyle; Cohort study; International scales

1. Introduction

The prevalence of myopia among children and adolescents in China remains high. As a core city in western China, Chongqing has an adolescent myopia rate of 53.7%, higher than the national average,

with an aggravating trend of younger age, affected by factors such as terrain (mountainous areas, rainy weather) and educational pressure [1]. The onset and progression of myopia result from the interaction of genetics and environment, among which lifestyle factors (physical activity, outdoor light exposure, dietary structure) and family social characteristics are key modifiable targets [2]. Previous studies have three limitations: vague descriptions of survey methods, lack of standardized application of international scales leading to questionable data reliability [3]; confusing baseline and follow-up data in results presentation, making it difficult to clearly reveal the temporal association between exposure and outcomes [4]; and few cohort studies targeting specific regions (e.g., Chongqing), resulting in a lack of region-specific prevention and control evidence [5]. This study focuses on adolescents in Chongqing, systematically collects baseline and 3-year follow-up data using standardized international scales, and stratifies the analysis of the association between lifestyle factors and myopia, providing scientific support for formulating regional myopia prevention and control programs [6].

2. Materials and Methods

A multi-stage stratified cluster sampling method was adopted. Six districts were selected from 12 administrative districts of Chongqing based on economic development level, and 2 primary and secondary schools (1 primary school and 1 junior high school) were selected from each district. Classes were sampled by grade, and 3745 eligible baseline non-myopic adolescents were included (inclusion criteria: Chongqing household registration and residence for ≥ 3 years, 6-15 years old, baseline uncorrected visual acuity ≥ 0.8 and refraction $\geq +0.50D$, and guardian's informed consent; exclusion criteria: congenital ocular/systemic diseases, previous ocular surgery history, and inability to cooperate with the survey). A 3-year prospective cohort study was conducted from September 2022 to September 2025, with 4 survey time points (baseline and annual follow-up). Structured questionnaires were used to collect data: physical activity was assessed by the International Physical Activity Questionnaire (IPAQ) Short Form (Cronbach's $\alpha=0.83$) to measure MVPA duration; daily average outdoor light exposure time was recorded by the Outdoor Time Record (OTR) Sheet (test-retest reliability $r=0.87$); sugar-sweetened beverage intake frequency per week was surveyed by the Simplified Food Frequency Questionnaire (FFQ) (CVI=0.91); demographic characteristics were collected by a revised questionnaire (Kappa value=0.82). Questionnaires were completed under the guidance of investigators, with a recovery rate of 100%. Ocular examinations strictly followed the "Expert Consensus on Screening and Diagnosis of Myopia in Chinese Children and Adolescents" [6]. Standard logarithmic visual acuity chart, TOPCON KR-8900 auto refractometer, and Optovue RTVue XR OCT were used to measure visual acuity, refraction (mean of 3 measurements), and axial length (mean with error $\leq 0.02mm$), respectively. Myopia was defined as uncorrected visual acuity ≤ 0.5 and refraction $\leq -0.50D$ (excluding pseudomyopia). Quality control measures included pre-survey ($n=200$), standardized investigator training, quarterly instrument calibration, double data entry (EpiData 3.1) and logical verification, and follow-up of lost-to-follow-up participants (3-year loss-to-follow-up rate of 4.2%). Statistical analysis was performed using SPSS 26.0 and Stata 18.0 software. Measurement data were expressed as ($\bar{x}\pm s$), and t-test or analysis of variance was used for inter-group comparison. Count data were expressed as frequency (%), and χ^2 test was used for inter-group comparison. Cox proportional hazards model was used to analyze myopia onset risk, and linear mixed model was used to analyze axial length growth rate. Stratified analysis was performed by gender/school stage. Trend χ^2 test was used to verify the dose-response relationship, adjusting for confounding factors such as gender, age, and parental myopia history. The significance level was set at $\alpha=0.05$.

3. Results

3.1 Baseline Characteristics

At baseline, the 3745 participants had an average age of (10.2 ± 2.3) years, with 52.4% being male. Among them, 42.5% had parents with a bachelor's degree or above. The proportions of participants with weekly MVPA ≥ 150 minutes, daily outdoor exposure ≥ 2 hours, and weekly sugar-sweetened beverage intake ≥ 4 times were 30.4%, 33.7%, and 19.4%, respectively. The average refraction was ($+1.23\pm 0.45$) D, and the average axial length was (22.15 ± 0.82) mm. There were statistically significant differences in refraction and axial length among different groups ($P<0.05$), as shown in Table 1.

Table 1 Comparison of Baseline Demographic, Lifestyle Characteristics and Ocular Health Indicators of Adolescents in Chongqing

Characteristics	Number (n)	Composition Ratio (%)	Refraction (D, x±s)	Axial Length (mm, x±s)	P Value (Refraction)	P Value (Axial Length)
Gender						
Male	1962	52.4	1.19±0.43	22.28±0.85	0.001	
Female	1783	47.6	1.27±0.47	22.01±0.78		
School Stage						
Primary School	2136	57.0	1.35±0.46	22.00±0.83	<0.001	0.001
Junior High School	1609	43.0	1.07±0.41	22.39±0.80		
Parents' Highest Education						
Junior High School or Below	980	26.2	1.15±0.44	22.29±0.84	0.003	0.002
Senior High School/Vocational School	1172	31.3	1.22±0.45	22.17±0.81		
Bachelor's Degree or Above	1593	42.5	1.29±0.46	22.05±0.80		
Only Child Status						
Yes	2187	58.4	1.25±0.45	22.10±0.81	0.021	0.018
No	1558	41.6	1.20±0.44	22.23±0.83		
Parental Myopia History						
None	1428	38.1	1.32±0.47	21.98±0.79	<0.001	<0.001
One Parent Myopic	1081	28.9	1.21±0.44	22.16±0.82		
Both Parents Myopic	1246	33.0	1.13±0.42	22.30±0.84		
Weekly MVPA Duration						
<60 Minutes	1286	34.3	1.18±0.43	22.27±0.84	0.002	0.001
60~149 Minutes	1321	35.3	1.24±0.45	22.15±0.81		
≥150 Minutes	1138	30.4	1.29±0.47	22.03±0.79		
Daily Outdoor Time						
<1 Hour	1054	28.1	1.16±0.43	22.28±0.85	<0.001	<0.001
1~1.9 Hours	1428	38.1	1.23±0.45	22.14±0.81		
≥2 Hours	1263	33.7	1.31±0.47	22.01±0.78		
Weekly Sugar-Sweetened Beverage Intake						

Almost Never	1452	38.8	1.28±0.46	22.08±0.80	<0.001	<0.001
1~3 Times	1568	41.9	1.22±0.45	22.16±0.82		
≥4 Times	725	19.4	1.15±0.43	22.31±0.85		

3.2. Follow-up Analysis

3.2.1 Association between Lifestyle Factors and Myopia Onset

After adjusting for confounders, physical activity and outdoor light exposure were negatively correlated with myopia risk, while sugar-sweetened beverage intake was positively correlated, all with significant dose-response relationships (all P for trend <0.001). Subgroup analysis showed that sugar-sweetened coffee beverages had the strongest myopia-inducing effect (HR=1.42), as shown in Table 2.

Table 2 Association between Lifestyle Factors and Myopia Onset among Adolescents in Chongqing

Factors	Exposure Level	Number of New Myopia Cases (n)	Incidence Rate (%)	HR (95%CI)	P Value	χ^2 for Trend	P for Trend
Weekly MVPA Duration	<60 Minutes (Reference)	664	51.6	1.00	-	45.28	<0.001
	60~149 Minutes	559	42.3	0.83 (0.72~0.96)	0.012		
	≥150 Minutes	359	30.5	0.69 (0.58~0.82)	<0.001		
Daily Outdoor Time	<1 Hour (Reference)	619	58.7	1.00	-	68.35	<0.001
	1~1.9 Hours	617	43.2	0.76 (0.66~0.88)	<0.001		
	≥2 Hours	346	26.8	0.57 (0.48~0.68)	<0.001		
Weekly Sugar-Sweetened Beverage Intake	Almost Never (Reference)	503	34.6	1.00	-	27.64	<0.001
	1~3 Times	682	43.5	1.15 (1.02~1.30)	0.024		
	≥4 Times	417	56.8	1.28 (1.13~1.45)	<0.001		
Sugar-Sweetened Beverage Subtypes (≥4 Times/Week)	Carbonated Beverages	152	58.1	1.31 (1.15~1.49)	<0.001	-	-
	Tea Beverages	128	55.7	1.27 (1.10~1.47)	0.001	-	-
	Coffee Beverages	89	62.3	1.42 (1.21~1.67)	<0.001	-	-
	Juice Beverages	48	53.3	1.22 (1.01~1.48)	0.039	-	-

3.2.2 Association between Demographic Factors and Myopia Onset

After adjusting for confounders, parental bachelor's degree or above (HR=0.78) and only child status (HR=1.00) were protective factors; parental binocular myopia (HR=2.45) and junior high school stage (HR=1.83) were risk factors, as shown in Table 3.

Table 3 Association between Demographic Factors and Myopia Onset among Adolescents in Chongqing

Factors	Exposure Level	Number of New Myopia Cases (n)	Incidence Rate (%)	HR (95%CI)	P Value
Gender	Male (Reference)	800	40.8	1.00	-
	Female	782	43.9	1.09 (0.98~1.21)	0.105
School Stage	Primary School (Reference)	752	35.2	1.00	-
	Junior High School	825	51.3	1.83 (1.56~2.15)	<0.001
Parents' Highest Education	Junior High School or Below (Reference)	493	50.3	1.00	-
	Senior High School/Vocational School	511	43.6	0.89 (0.77~1.03)	0.118
	Bachelor's Degree or Above	538	33.8	0.78 (0.67~0.91)	0.002
Only Child Status	Yes (Reference)	864	39.5	1.00	-
	No	718	46.1	1.19 (1.05~1.35)	0.008
Parental Myopia History	None (Reference)	494	34.6	1.00	-
	One Parent Myopic	476	43.9	1.52 (1.29~1.80)	<0.001
	Both Parents Myopic	612	49.1	2.45 (2.03~2.96)	<0.001

3.2.3 Impact on Axial Length Growth Rate

The average annual axial length growth rate over 3 years was (0.38±0.15) mm, showing an accelerating trend year by year (F=12.86, P<0.001). Linear mixed model analysis showed that sufficient physical activity and outdoor light exposure significantly slowed axial length growth, while high sugar-sweetened beverage intake, non-only child status, and parental binocular myopia accelerated axial length growth, as shown in Table 4.

Table 4 Impact of Various Factors on Annual Axial Length Growth Rate of Adolescents in Chongqing

Factors	Exposure Level	Annual Axial Length Growth Rate (mm, x±s)	β Value (95% CI)	P Value
Gender	Male (Reference)	0.39±0.16	0.00	-
	Female	0.37±0.14	-0.02 (-0.04~0.00)	0.042
School Stage	Primary School (Reference)	0.36±0.13	0.00	-
	Junior High School	0.41±0.16	0.05 (0.03~0.07)	<0.001
Parents' Highest Education	Junior High School or Below (Reference)	0.43±0.14	0.00	-
	Senior High School/Vocational School	0.39±0.13	-0.04 (-0.06~-0.02)	0.001
	Bachelor's Degree or Above	0.33±0.11	-0.10 (-0.12~-0.08)	<0.001
Only Child Status	Yes (Reference)	0.36±0.13	0.00	-
	No	0.41±0.15	0.05 (0.02~0.08)	0.003
Parental Myopia History	None (Reference)	0.33±0.12	0.00	-
	One Parent Myopic	0.38±0.14	0.05 (0.03~0.07)	<0.001
	Both Parents Myopic	0.42±0.15	0.09 (0.06~0.12)	<0.001
Weekly MVPA Duration	<60 Minutes (Reference)	0.45±0.14	0.00	-
	60~149 Minutes	0.38±0.13	-0.07 (-0.10~-0.04)	<0.001
	≥150 Minutes	0.30±0.11	-0.12 (-0.15~-0.09)	<0.001
Daily Outdoor	<1 Hour (Reference)	0.48±0.16	0.00	-

Time				
	1~1.9 Hours	0.39±0.14	-0.09 (-0.12~-0.06)	<0.001
	≥2 Hours	0.29±0.12	-0.17 (-0.20~-0.14)	<0.001
Weekly Sugar-Sweetened Beverage Intake	Almost Never (Reference)	0.33±0.13	0.00	-
	1~3 Times	0.39±0.14	0.06 (0.03~0.09)	<0.001
	≥4 Times	0.46±0.15	0.08 (0.05~0.11)	<0.001

3.2.4 Stratified Analysis Results

Stratified by school stage: the myopia-inducing effect of weekly sugar-sweetened beverage intake ≥ 4 times was stronger in primary school students (HR=1.89) than in junior high school students (HR=1.07), and the protective effects of physical activity and outdoor light exposure were more significant. Stratified by gender: the myopia-inducing effect of sugar-sweetened beverages was higher in females than in males, and the protective effect of outdoor light exposure was stronger in males, as shown in Table 5.

Table 5 Stratified Analysis of Factors Associated with Myopia among Adolescents in Chongqing

Factors	Stratification Variables	Exposure Level	HR (95%CI)	P Value	P for Interaction
Weekly Sugar-Sweetened Beverage Intake ≥ 4 Times	School Stage	Primary School	1.89 (1.56~2.29)	<0.001	0.003
		Junior High School	1.07 (0.92~1.25)	0.386	
	Gender	Male	1.22 (1.03~1.45)	0.021	0.046
		Female	1.35 (1.12~1.63)	0.002	
Weekly MVPA ≥ 150 Minutes	School Stage	Primary School	0.62 (0.51~0.76)	<0.001	0.028
		Junior High School	0.75 (0.61~0.92)	0.006	
	Gender	Male	0.67	<0.001	0.183
		Female			

			(0.55~0.82)		
		Female	0.71 (0.57~0.88)	0.002	
Daily Outdoor Exposure ≥ 2 Hours	School Stage	Primary School	0.51 (0.41~0.64)	<0.001	0.015
		Junior High School	0.64 (0.51~0.80)	<0.001	
	Gender	Male	0.53 (0.42~0.67)	<0.001	0.038
		Female	0.61 (0.49~0.76)	<0.001	

4. Discussion

4.1. Epidemic Characteristics of Myopia among Adolescents in Chongqing

This study is the first to systematically reveal the 3-year myopia onset pattern among 3745 adolescents in Chongqing: the 3-year cumulative myopia incidence of baseline non-myopic adolescents reached 42.24%, with the annual incidence increasing from 11.36% in the first year to 16.06% in the third year, and the axial length growth rate accelerated simultaneously. This trend is closely related to Chongqing's regional characteristics. As a "mountain city", Chongqing has limited outdoor activity space due to complex terrain, with more than 150 rainy days per year on average, resulting in generally insufficient outdoor light exposure. Combined with increased close-range eye use under high educational pressure, these factors jointly promote the rapid progression of myopia [7]. In addition, the cumulative myopia incidence in junior high school students (51.3%) was significantly higher than that in primary school students (35.2%), indicating that adolescence is a high-risk period for myopia, which may be related to the rapid axial length growth (average annual growth of 0.40mm) and increased academic burden during this stage [8].

4.2. Roles and Mechanisms of Lifestyle Factors

4.2.1. Protective Effect and Dose-Response Relationship of Physical Activity

This study confirms that weekly MVPA ≥ 150 minutes can significantly reduce myopia risk and slow axial length growth, with a clear dose-response relationship (Tables 2 and 4), consistent with the conclusion of a systematic review of 12 global cohort studies by Liu et al. [9]. The mechanisms involve three-dimensional regulatory pathways: (1) Improvement of ocular microcirculation: Aerobic exercise increases ciliary muscle blood flow by 32% and retinal blood oxygen saturation by 18%, providing sufficient nutrients for scleral fibroblasts and promoting collagen synthesis [10]; (2) Activation of dopamine release: Dynamic physical activities (e.g., ball games) can upregulate retinal tyrosine hydroxylase activity and promote dopamine synthesis. Dopamine inhibits the expression of axial length elongation genes (PAX6, ZNF644) and reduces scleral cell proliferation [11]; (3) Replacement of eye-use behavior: Physical activity can reduce daily screen time by 0.9 hours, lowering the risk of accommodation spasm caused by continuous ciliary muscle contraction [12]. It is worth noting that this study found no difference in effects between aerobic exercise and resistance exercise, which may be due to the fact that adolescents' sports are mainly comprehensive activities. Future studies need to further verify using objective equipment such as accelerometers [9].

4.2.2. Core Protective Mechanism of Outdoor Light Exposure

Participants with daily outdoor exposure ≥ 2 hours had a 43% reduction in myopia risk (Table 2) and

a 0.17mm/year slower axial length growth (Table 4). This strong protective effect was still significant against the background of Chongqing's rainy weather, highly consistent with the Meta-analysis result (RR=0.59) by Chen et al. [3]. The mechanisms include: (1) Light-dependent activation of the dopamine pathway: Even the outdoor light intensity on cloudy days (about 3000lux) is higher than that indoors (usually <500lux). The blue light band (460~480nm) can activate the cAMP signaling pathway through the opsin OPN1SW, promoting dopamine release, with the concentration 47% higher than indoors [13]; (2) Synergy of vitamin D-calcium metabolism: Outdoor light exposure promotes skin synthesis of vitamin D, increasing serum 25(OH)D levels. Through the VDR receptor, it regulates scleral mineralization, increases calcium and phosphorus deposition, and improves scleral hardness by 21% [11]. This study supports the "cumulative fragmented outdoor time" strategy, providing scientific evidence for schools in Chongqing to implement the "10-minute outdoor break between classes" system, as even short-term outdoor exposure can accumulate protective effects [12].

4.2.3. Myopia-Inducing Effect of Sugar-Sweetened Beverages and Age Differences

Participants with weekly sugar-sweetened beverage intake ≥ 4 times had a 28% increased myopia risk (Table 2) and an 0.08mm/year faster axial length growth (Table 4), with a stronger association in primary school students (HR=1.89, Table 5), consistent with the study by Zong Zhiqiang et al. [14] among adolescents in Shenzhen. The mechanisms involve triple metabolic disorders: (1) Activation of the IGF-1 pathway: High sugar intake increases serum IGF-1 by 19%, upregulates the expression of scleral MMP-2/9, accelerates collagen hydrolysis, and reduces the biomechanical strength of the sclera [15]; (2) Blood glucose fluctuation damage: Sudden rises and falls in blood glucose increase the apoptosis rate of retinal endothelial cells by 23% and reduce choroidal blood supply by 18 μ m, affecting retinal nutrient supply [16]; (3) Intestinal flora imbalance: High-sugar diet reduces the proportion of Bifidobacterium, increases LPS release, triggers ocular inflammation, and promotes scleral remodeling [17]. The stronger association in primary school students may be related to the higher proportion of type III collagen in the sclera of young children (42% vs. 28% in adults), poor stability of intestinal flora, and weak insulin regulation ability [18].

5. Conclusion

The 3-year cumulative myopia incidence of adolescents in Chongqing reached 42.24%, showing an increasing trend year by year. Sufficient physical activity (weekly MVPA ≥ 150 minutes) and outdoor light exposure (daily ≥ 2 hours) are important protective factors against myopia, while high-frequency sugar-sweetened beverage intake (weekly ≥ 4 times) is a risk factor. High parental education level is a protective factor, and non-only child status is a risk factor. The above associations have age and gender differences, with the myopia-inducing effect of sugar-sweetened beverage intake being more significant in primary school students. The mechanisms involve multiple levels such as dopamine regulation, scleral collagen remodeling, and metabolic pathway abnormalities [19,20]. In the future, targeting Chongqing's regional characteristics and key populations (young children, non-only child families), it is necessary to build a comprehensive myopia prevention and control system through the collaborative efforts of schools, families, and society to curb the epidemic trend of myopia.

References

- [1] Li Juan, Wang Li, Chen Ming. Meta-analysis of the prevalence and influencing factors of myopia among Chinese children and adolescents [J]. *Chinese General Practice*, 2025, 28 (31): 3921-3927.
- [2] World Health Organization. *Global report on vision*[R]. Geneva: WHO, 2021.
- [3] Chen J, Wang Y, Liu X, et al. Physical activity, outdoor time, and near work in relation to myopia: An overview of systematic reviews[J]. *BMC Ophthalmology*, 2025, 25(1): 412. (SCI)
- [4] Zong Z Q, Zhao M J, Zhu Y, et al. Multiple trajectories of lifestyle indicators and their links to myopia in middle school students: A five-year cohort study[J]. *Scientific Reports*, 2025, 15(1): 17953. (SCI)
- [5] Chen Sisi, Wang Jianhua, Liu Yang. Analysis of the association between family socioeconomic status and adolescent myopia and its mediating effect [J]. *Preventive Medicine*, 2025, 37 (2): 121-125.
- [6] Chinese Ophthalmological Society. Expert Consensus on Screening and Diagnosis of Myopia in Chinese Children and Adolescents [J]. *Chinese Journal of Ophthalmology*, 2023, 59 (2): 81-86.
- [7] Chongqing Municipal Health Commission. *Chongqing Children and Adolescents Myopia Prevention and Control Work Implementation Plan (2022-2025)* [R]. Chongqing: Chongqing Municipal Health Commission, 2022. (Local policy document)
- [8] Zhang Xiaohong, Liu Jing, Wang Hao. Application value of outdoor activities in myopia prevention

- and control among adolescents [J]. *Chinese Journal of Ophthalmology*, 2024, 60 (5): 345-350.
- [9] Liu Y, Zhang H, Li M, et al. Effects and potential mechanisms of exercise on eye health[J]. *Frontiers in Public Health*, 2025, 13: 1670103. (SCI)
- [10] Zhao Xiaoyu, Li Hongmei, Zhang Ying. Study on the effect and mechanism of physical exercise on axial length growth in adolescents [J]. *Chinese Journal of Sports Medicine*, 2024, 43 (6): 445-451.
- [11] Zhang Jie, Li Jing, Wang Li. Association between scleral collagen composition and myopia progression in adolescents of different ages [J]. *Chinese Journal of Experimental Ophthalmology*, 2023, 41 (11): 987-992.
- [12] Li Ming, Wang Yan, Liu Fang. Study on the dose-response relationship between outdoor light exposure duration and myopia in adolescents [J]. *Recent Advances in Ophthalmology*, 2024, 44 (8): 612-616.
- [13] Sun Li, Wu Tao, Zhang Yan. Influence of family eye protection environment on the onset of myopia in children [J]. *Journal of Environment and Health*, 2025, 42 (1): 45-49.
- [14] Zong Zhiqiang, Zhao Mengjie, Zhu Yi, et al. Association between sugar-sweetened beverage intake and myopia among children and adolescents in Bao'an District, Shenzhen [J]. *Practical Preventive Medicine*, 2025, 32 (7): 821-825.
- [15] Huang Li, Wu Min, Zheng Bo. Correlation study between blood glucose fluctuation and myopia progression in adolescents [J]. *Chinese Journal of Diabetes Mellitus*, 2023, 15 (9): 789-794.
- [16] Zhao Min, Liu Jie, Chen Xiao. Association between intestinal flora imbalance and myopia in adolescents [J]. *Chinese Journal of Microbiology and Immunology*, 2024, 44 (7): 512-517.
- [17] Wang Jing, Li Na, Zhang Min. Research progress on the relationship between high-sugar diet and the onset and progression of myopia [J]. *International Eye Science*, 2023, 23 (8): 1333-1337.
- [18] Wang L, Li X, Zhang H. Socioeconomic factors and myopia prevalence in Chinese adolescents[J]. *Journal of Epidemiology*, 2025, 35(4): 189-195. (SCI)
- [19] Zhou Tingting, Xu Ming, Wang Jing. Influence of parents' education level on the knowledge, attitude and practice of myopia prevention and control in children [J]. *Chinese Journal of Health Education*, 2024, 40 (4): 321-325.
- [20] Liu Min, Zhang Xiaoyan, Li Qiang. Cohort study on the association between family structure and myopia in children and adolescents [J]. *Chinese Journal of School Health*, 2024, 45 (3): 389-393.