Vision and the Foundation phase

Jannie Ferreira

Listening at the debate around the 2022 matric results for public schools in South Africa it is very obvious that we are faced with major challenges in our school system. Add to this the drive to introduce electronic devices in the Foundation Phase, like elsewhere in the world, and the situation can become catastrophic. Sadly, it seems that everybody is talking about this, but nobody is listening. I talk to parents almost on a daily basis and in the majority of cases they admit that they have very little control over their children, even those under 5 years of age.

The obvious question is: What does this have to do with Optometry? Over the years I have been a strong advocate of the role of Optometry as a Primary Health Care Profession. This goes back many years and was the cornerstone of the introduction of the Eye Care train. Most of you may only know it as the Phelophepa. Visual screening of children in the rural areas became an integral part of the visual services that were provided. I am fully aware of the all the challenges that many children in our beloved country faces. With this article I will endeavour to convince you how critical vision is for children in the Foundation Phase and how dealing with visual deficiencies can help these children to also cope better with their other challenges.

Before you decide this is not for me “I don’t do paediatrics” please consider the following:

Digital technologies have become an essential part of people’s lives and affect all sectors of society, including education. It is for this reason, that the DoE identified the need to introduce the implementation of technology in all phases in the education system Venketsamy, R. & Hu, Z., (2022). The e-Education policy was introduced to all South African public schools in 2004 to transform education and to prepare learners for the 21st -century demands and needs. One of the primary goals of this policy was the emphasis and obligation placed on education to use technology for the improvement of learning outcomes and skills development. (DoE, 2004). Despite the policy mandate, teachers are challenged and reluctant to use technology for teaching and learning (Vandeyar, 2013). The closure of schools due to the COVID-19 pandemic and the urgency to find alternative ways of supporting learners, prompted many schools to adopt technology for teaching and learning. Most teachers in South Africa and globally held the view that technology will revolutionise the field of education and alter the way they will teach and instruct learners. Despite this knowledge and awareness not all teachers were equally enthusiastic about using technology as part of their instruction. The COVID-19 pandemic placed most teachers in a compromising situation whereby they were forced to use technology for teaching and learning. Teachers were introduced to new technology which they were unfamiliar. They lacked the necessary skills and knowledge on how to use technology for teaching and learning. As a result of this phenomena many teachers in the foundation phase experienced high levels of stress and anxiety.

The DoE (2004) policy was developed and aligned to the Mishra and Koehler’s (2006) Technological Pedagogical and Content Knowledge (TPACK) model. This model emphasised the importance of technological content knowledge (TCK) for teaching and learning. Although there is much emphasis on capacity building and relevant and appropriate training for the implementation of technology for teaching and learning, there is a huge gap between teachers abilities, knowledge and understanding to implement technology for teaching and learning (Vandeyar, 2013). The TPACK model clearly articulate the importance of content knowledge (CK), pedagogical content knowledge (PCK) and TCK (Mishra & Koehler, 2006) which is lacking in most South African foundation phase teachers (Ramorola, 2010). According to Powers & Blubaugh (2016), they state that all teachers should have the ability, knowledge, und

VISUAL DEVELOPMENT IN YOUNG CHILDREN

Thus the question remains: How does all of this affect our eyes, and is it detrimental to the visual system? **CVS** and **VFS** is considered to be similar to other repetitive motion injuries, such as [carpal tunnel syndrome](http://www.webmd.com/pain-management/carpal-tunnel/default.htm). Working on computers involve continuous focus and refocus as well as tracking and convergence activities. The eyes need to constantly adjust to changing images on the screen to allow the brain to process what you’re seeing. All these jobs require a lot of effort from your eye muscles. And to make things worse, unlike a book or piece of paper, the screen adds contrast, flicker, and glare. Computer work gets even harder as we age and reach presbyopia.

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Headaches, Eye Strain and Fatigue are mostly associated with squinting and repetitive ocular muscle actions. Burning, Itchy, Red and Watery Eyes results mainly from staring at a screen. The result is a significant reduction in blink rate causing a dry eye. This seems to be the most common symptom reported by patients. Add to this that quite often we work in places that are running air conditioning and the dry eye only gets worse, more so for people wearing contact lenses. Loss of focus and blurred vision at near relates to fatigue in the accommodative system. Blurred vision at distance may be a little bit more complex. The literature suggests that this is the result of a short-term myopic far point shift immediately following a sustained near visual task. This is known as near work-induced transient myopia (NITM). Overall, studies reported myopic shifts, with a mean of approximately 0.40 D and a range from 0.12 to 1.30 D While the precise aetiology remain unclear, I am quite convinced that this “pseudo myopia” can evolve in a more “permanent” myopia and that this is a significant factor in the global increase in

GUIDELINES AND RECOMMENDATION

ROLE OF OPTOMETRY

# **New WHO guidance: Very limited daily screen time recommended for children under 5**

**MAY 6, 2019**

Recommendations and concerns about digital devices should be shared with parents, doctor of optometry says.

The World Health Organization (WHO) is recommending children under age 5 spend one hour or less on digital devices and those under age 1 spend no time at all on a daily basis.

WHO released its recommendations, [**"WHO Guidelines on Physical Activity, Sedentary Behaviour and Sleep for Children under 5 Years of Age,"**](https://apps.who.int/iris/bitstream/handle/10665/311664/9789241550536-eng.pdf?sequence=1&isAllowed=y) on April 24. Among its other recommendations: children should spend more time engaged in physical activity and getting enough sleep. The WHO study refers to sedentary screen time, which includes watching television or videos, or playing computer games.

Here are WHO's screen time recommendations by age:

* Infant (less than 1 year of age): Screen time is not recommended.
* 1-2 years of age: No screen time for a 1-year-old. No more than an hour for 2-year-olds, with less time preferred.
* 3 to 4 years old: No more than one hour.

Sedentary behavior by youngsters has been identified as a risk factor in global mortality and has contributed to the rise in obesity, the guidelines say.

"Achieving health for all means doing what is best for health right from the beginning of people's lives," WHO Director-General Tedros Adhanom Ghebreyesus said upon the guidelines' release. "Early childhood is a period of rapid development and a time when family lifestyle patterns can be adapted to boost health gains."

Said Fiona Bull, WHO programme manager for surveillance and population-based prevention of noncommunicable diseases: "Improving physical activity, reducing sedentary time and ensuring quality sleep in young children will improve their physical, mental health and wellbeing, and help prevent childhood obesity and associated diseases later in life."

## **Link between vision and inactivity**

Developing the ability to "use" vision starts at birth, says Glen Steele, O.D., professor of pediatric optometry at Southern College of Optometry in Memphis, Tennessee. When a baby watches a parent form words or point to objects, their actions lead to development of a baby's "looking" process, which fosters their internal curiosity, he says. That curiosity leads to the baby wanting to get to an object out of reach and a desire to move toward it.

"When an infant sees a parent looking at an object and follows their gaze to that object by 12 months of age, they will be able to identify 335 words by 18 months of age," Dr. Steele says. "When they do not follow the parent's gaze, they will only be able to identify 197 words by 18 months of age. Huge difference. This work was done by Andrew Meltzoff, Ph.D., at the University of Washington. Vision triggers curiosity, which triggers movement and exploration."

Hands-on exploration is one of the ways children learn.

## **Consequences of too much screen time, being sedentary**

Studies also have shown that being sedentary can have significant developmental consequences, Dr. Steele says. Among them:

* Children are less likely to have the fine motor skills necessary for writing when entering kindergarten.
* Vocabulary, communication skills and eye contact are reduced.
* Developmental delays are documented with increased device use. Screen time, for instance, has been linked to ADHD symptoms (self-regulation).
* Attention, decision-making and cognitive control are reduced.
* Creativity also suffers. Screen time interferes with problem solving.
* Psychiatric disorders reported.
* A premature thinning of the cortex based on brain scans.

Canadian researchers found in a [**study**](https://jamanetwork.com/journals/jamapediatrics/article-abstract/2722666) published online Jan. 28 in JAMA Pediatrics that 2- and 3-year-old children watched television for respectively 2.4 and 3.6 hours a day. Further, the authors linked excessive TV watching to "poorer performance on developmental screening tests," which may partially explain why children are not developmentally ready for starting school.

Although excessive screen time is not solely an "eye problem," its effects are readily apparent during a [**comprehensive eye examination**](https://www.aoa.org/healthy-eyes/caring-for-your-eyes/eye-exams) through observation of pupil size and assessment of accommodative function, Dr. Steele says. When noted, doctors of optometrys should be prepared to have discussions with parents, he adds. He used the term "**[technoference](https://www.ncbi.nlm.nih.gov/pubmed/28493400" \t "_blank" \o "Technoference: Parent Distraction With Technology and Associations With Child Behavior Problems.)**," which refers to how technology can interfere in relationships (parent and child).

According to the AOA's 2018 American Eye-Q® survey, three-quarters of parents are concerned their children may damage their eyes due to prolonged use of electronic devices. In the survey, 4 in 5 parents reported their child spends at least an hour a day using a computer or mobile device.

## **Conversations with parents**

Dr. Steele has developed a brief guide doctors of optometry can provide parents at the conclusion of the examination.

"It includes the WHO information and also a recommendation for taking breaks," says Dr. Steele, who will be presenting more detailed information on screen time at the AAO annual conference in October. "The 20-20-20 rule (take a 20-second break every 20 minutes and view something 20 feet away) was developed in the 1990s and, at the time, it was sufficient because we were using CRT (cathode ray tube) screens that were larger and farther away. Now, the kids are using phones very close to their faces, which is a completely different mode of operation.

"The goal is not to take away screens but to help parents manage time on screens and frequency of breaks," he says. "More frequent breaks are step No. 1 in aiding in this process."

[**Access**](https://store.aoa.org/Product/viewproduct/?ProductId=1317655) the AOA resource for patient education, "Healthy Vision Using Digital Devices."

[**CLINICAL EYE CARE**](https://www.aoa.org/news/clinical-eye-care)

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* [Health and Wellness](https://www.aoa.org/news/clinical-eye-care/health-and-wellness)

Research shows that between 50% and 90% of people who work at a computer screen have at least some symptoms. But most vision experts say we can rest assured, as long as we apply common sense rules then there is really nothing to be concerned about. Herein lays the problem since many people have jobs that require staring at a computer screen for hours at a time. Add to this the introduction of hand held devices such as tablets and smart phones and also 3D screens and common sense flies out of the window.

Since the introduction of concepts such as **Computer vision syndrome (CVS)** and **Visual Fatigue Syndrome (VFS)** in the early 1990’s, that warned against eye strain and general visual fatigue, we have seen a dramatic increase on time spend on these devices. Janvier sums it up quite nicely when he states: “Most of us work at least eight hours a day and during this time many of us spend five to six of those hours staring at a computer screen. Now we get home, and what do we do? Check our e-mails, WhatsApp’s, pay bills online, shop online, and go to Facebook. Add to that a few more hours at the video games (X-box, Wii, PlayStation, etc.). So now we have been staring at some type of computer or hand-held visual screen for 10-12 hours.

The point here is that we spend a great deal of time on any given day staring at some type of visual screen, whether for work or entertainment. This not only applies to working adults, but also the children: computers at school, smart phones in hand, and hours on the entertainment screen of choice. The large computer screens are bad enough, but now we are also using much smaller visual screens with smaller displays, and not well-formed lettering (fewer pixels). This is placing even greater strain on the eyes and visual system”.

Thus the question remains: How does all of this affect our eyes, and is it detrimental to the visual system? **CVS** and **VFS** is considered to be similar to other repetitive motion injuries, such as [carpal tunnel syndrome](http://www.webmd.com/pain-management/carpal-tunnel/default.htm). Working on computers involve continuous focus and refocus as well as tracking and convergence activities. The eyes need to constantly adjust to changing images on the screen to allow the brain to process what you’re seeing. All these jobs require a lot of effort from your eye muscles. And to make things worse, unlike a book or piece of paper, the screen adds contrast, flicker, and glare. Computer work gets even harder as we age and reach presbyopia.

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Double vision relates to a fatigue in the convergence system [more so in people with significant phorias] and because of the near triade [convergence, accommodation and pupil response] often appears with blurred vision and photophobia. Neck and shoulder pain simply results from poor posture. There are also studies that suggest electronic devices give off high-energy, short-wavelength, blue and violet light, which may affect vision and even prematurely age the eyes. Early research shows that overexposure to blue light could contribute to eye strain and discomfort and may lead to serious conditions in later life such as age-related macular degeneration (AMD). There is no real hard evidence yet but “blue light coatings” is becoming common practice.

**Guidelines for use of electronic devices**

In line with a more holistic approach in dealing with visual problems our emphasis should be to prevent rather than cure [or compensate]. In addition to the risk of computer vision syndrome, visual fatigue syndrome and myopia, we should be aware of the concerns that excessive use of hand-held devices may have on our general everyday life. Several organisations have now reviewed the current scientific literature about this and published a number of guidelines to minimise the effect on the visual system.

1. Try mix of tasks throughout the day. People should take frequent breaks from computer use and take part in a variety of activities that involve postural changes and physical movement. Performing sedentary tasks using electronic media (computer use, watching TV, texting, etc.) should be accompanied with regular breaks. To be safe we should take a 60-second break every 20 minutes and at least 10 minutes after two hours of staring at a screen. Because dry eyes seem to be such a common symptom, people should be encouraged to blink regularly, especially if they wear contact lenses. Tear supplements will also work wonders but the dry, irritated eye actually serves as a good warning sign that it is time for a break.

2. Encourage the use of proper postures when working at a desktop computer. Workstations should be designed to suit the user’s size and enable a range of suitable postures. Feet should be able to rest comfortably on the floor; desk height should be at elbow height; document holders should be used to position paper materials near the computer screen. The screen should be below eye level [20 cm] because it is much more comfortable and less strenuous looking down.

3. Encourage a comfortable working distance i.e. Harman’s distance for all hand-held devices and at least 50cm for desk top screens. The closer the screen the more strain there will be on the accommodative and convergence systems resulting in double vision and/or blurred vision. If possible increase the font size and adjust the screen resolution and contrast.

4. Ensure that proper lighting is provided. Distant or frontal light can cause a great deal more glare off screens, which makes focusing even more challenging. If possible, use ambient overhead lighting which provides good results. The screen should also be positioned and angled to avoid glare. And remember to clean your screen once in a while!

5. Teach yourself computing skills, including how to touch type with minimum force and how to use keyboard shortcuts to reduce mouse use.

6. Although the use of “computer glasses” is considered to be ineffective and controversial by some researchers, I have no doubt that they work well in reducing several symptoms. I also believe that they prevent NITM and even proper myopia. From my own experience single vision lenses works far better than multifocal or low plus lenses [+0.50]. As a rule of thumb add +1.00 to the distance script to obtain the required power of the lenses.

Computers and handheld devices will dominate our lives for the foreseeable future and dealing with these signs and symptoms effectively will greatly enhance the ocular health of your patients.

Why did China limit screen time?

Beijing justified its tough screen time limits as necessary to combat a genuine social problem: Chinese minors' video gaming addictions. Out of China's 720 million gamers, around 110 million are under 18 years old, Daniel Ahmad, senior analyst at gaming research firm Niko Partners, told Fortune last September.13 Jul 2022

**By Jane Wakefield**

Technology reporter

**Children in China are to be banned from using their phones in school, the Ministry of Education has ruled.**

Pupils will not be allowed to bring mobiles to school without written parental consent.

The authorities say they want to protect young people's eyesight, improve their concentration and prevent internet addiction.

Schools are being encouraged to find other ways for parents to communicate with children during the school day.

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According to one of the country's newspapers, China Daily, there has been heated debate among parents over the whether the ruling is practical.

The vast majority of children and teenagers in China access the internet via their own smartphones - 74% of under-18s, according to the government-affiliated China Internet Network Information Centre.

But the authorities are concerned about how internet use is affecting the health of the nation's youth.

There have been rising levels of nearsightedness among children in China and in 2018, the authorities announced plans to regulate the gaming industry which was partially blamed for the problem. They also cited concerns that gaming addiction was damaging mental health.

The following year a curfew was imposed on under-18s, who were restricted to 90 minutes of gaming on weekdays and three hours on weekends and holidays.

## French ban

Many schools in China already restrict the use of mobile phones on their premises. In some extreme cases, phones have been smashed in front of students who have broken the rules.

The topic of a ban has become a major news item in China and on social media, with thousands discussing it on social media site Weibo.

Some 27,000 people voted in an online Sina News poll, with most saying there was no need for the new rules because of the widespread ban during school hours. Some pointed out that children may continue to over-use their phones when not in school.

A plan to stop schools setting homework tasks via phone has also been criticised. One teacher told state broadcaster CCTV that "not allowing phones to contact someone, or to arrange homework, that will take some getting used to. They all get so much homework, so that's been convenient."

French lawmakers voted in 2018 to ban the use of phones in primary and middle schools, ruling that children under 15 have to keep their mobile phones out of sight while on school premises.

A survey conducted in the UK by price comparison site uSwitch last year suggested that just under half of UK parents thought their child's school should ban mobile phones.

The use of phones in the UK is generally left up to individual schools. One head teacher, from Anglesey in Wales, told the BBC that teachers could find themselves spending too much time challenging children for using phones, which took time away from actually teaching them

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The incidence of myopia in China has increased significantly in recent years. Some pointed out that 20% to 50% of the students in primary school, 35% to 60% of the students in middle school, and 50% to 75% of the students in college are myopic in China in 2018 [3].24 Aug 2022

### **[Myopia in Chinese Adolescents: Its Influencing Factors ... - NCB](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/" \l ":~:text=The%20incidence%20of%20myopia%20in,China%20in%202018%20%5B3%5D.)**

[Comput Math Methods Med.](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/) 2022; 2022: 4700325.

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# **Myopia in Chinese Adolescents: Its Influencing Factors and Correlation with Physical Activities**

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## **Associated Data**

[**Data Availability Statement**](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/)

[Go to:](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/)

## **Abstract**

### **Purpose**

The study is conducted to analyze the risk factors and the protective factors of myopia in Chinese adolescents and its correlation with physical activities and then to provide 2 formulas to predict the probability of becoming myopic and the probability of preventing myopia.

### **Methods**

This is a cross-sectional study in which a questionnaire survey was conducted among 650 students aged 14-17 from 5 schools in Beijing in 2021. The students were divided into two groups: nonmyopia group and myopia group. Statistically significant variables were selected after the univariate analysis for a binary logistic regression analysis.

### **Results**

In the univariate analysis, 18 risk factors of myopia were found and 14 physical-activity-related protective factors were found. In the multivariate analysis, 5 independent factors were found to be positively related to myopia and could be used for calculating the probability of becoming myopic. The 5 factors are gender, staying up late playing smartphones, parental myopia, daily time spent on digital devices, and regular eye examinations. Five physical-activity-related factors were found to be positively related to the prevention of myopia and can be used for the calculation of the probability of preventing myopia. The 5 factors are regular physical activities, attitude towards physical education, daily time spent on in-school physical activities, daily time spent on after-school physical activities, and eye exercises.

### **Conclusions**

The influencing factors of myopia in adolescents mainly include heredity, habits of using eyes, and environment. Physical activities can effectively reduce the probability of becoming myopic in adolescents and promote eye health. Therefore, taking part in physical activities is an effective way to reduce the prevalence of myopia in adolescents.

[Go to:](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/)

## **1. Introduction**

Eye health was defined by the Lancet Global Health Commission as maximized vision, ocular health, and functional ability, thereby contributing to overall health and well-being, social inclusion, and quality of life [[1](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/#B1)]. The International Agency for the Prevention of Blindness (IAPB) stressed in 2030 IN SIGHT that the eye health of children and adolescents was the focus of future work and should be integrated into school health policy resulting in schools the world over routinely offering sight tests and eye health promotion and prevention information should be taught within education settings [[2](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/#B2)].

The incidence of myopia in China has increased significantly in recent years. Some pointed out that 20% to 50% of the students in primary school, 35% to 60% of the students in middle school, and 50% to 75% of the students in college are myopic in China in 2018 [[3](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/#B3)]. As of October 2021, 52.7% of the children and adolescents in China were myopic, and the rate was 2.5% higher than that in 2019 [[4](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/#B4)]. Schools, where children and adolescents carry out daily activities, are the main places for the improvement of their physical and mental health. The Ministry of Education attaches great importance to the prevention and control of myopia in young students and has formulated a specific work plan for it in 2018. Multiple measures and much effort have been taken to curb the prevalence of myopia.

Previous studies show that gender, age, region of habitation, family history of myopia, daily reading time, breaks while studying, daily time spent on digital devices, and learning piano are independent risk factors of myopia in primary school students in China [[5](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/#B5)]. The pathogenesis of myopia remains unclear so far, which may be related to genetic, environmental, and other factors. Some argued that the influence of environmental factors, such as bad habits of using eyes and visual fatigue, was greater than that of genetic factors [[6](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/#B6), [7](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/#B7)]. In summary, the eye health of children and adolescents is closely related to the environment, heredity, and intense use of the eyes.

It is regarded as an important part of student management, education, and teaching in China's School Management Standards for Compulsory Education that schools should help students to develop strong constitutions and reduce the prevalence of myopia among students. Mingmu Gong, a kind of Chinese eyesight improvement exercise, is said to have a significant effect on the recovery of students' eyesight, which helps to relax the eye muscles and accelerate the eye blood flow and further promote the recovery of eye vision [[8](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/#B8)]. Smartphone users are more likely to be myopic, showing a moderate positive correlation between playing smartphones and myopia. Outdoor activities reduce the probability of myopia, showing a strongly negative correlation between outdoor activities and myopia [[9](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/#B9)]. Compared with nonmyopic children, myopic children spend more time watching screens and shorter time on outdoor activities [[10](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/#B10)]. Outdoor activities help to prevent adolescents from being sedentary and improve their eyesight. Physical education should be integrated with the health service system to promote eye health education.

Based on an in-depth literature review, this study analyzed the influencing factors of myopia in adolescents and predicted the probability of becoming myopic through the analysis of the risk factors of myopia. Physical activities were important factors affecting eye health, and in this study, they were analyzed and used to predict the probability of preventing myopia.

[Go to:](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/)

## **2. Research Objects and Methods**

### **2.1. Participants**

A total of 650 questionnaires were distributed to 650 middle school students in Beijing using stratified sampling, and 610 of them were collected. After excluding 31 invalid questionnaires, there were 579 (89%) valid questionnaires left.

### **2.2. Research Variables**

Based on previous studies, this study summarized the influencing factors of myopia in adolescents and the physical-activity-related factors, according to which the questionnaire was designed. 17 binary variables were investigated, such as gender, only child, playing video games, parental myopia, reading posture, writing posture, staying up late playing smartphones, and regular physical exercises. 21 continuous variables were investigated, such as diopter, daily time spent on digital devices, daily sleep duration, distance to the TV screen, illumination while studying, drinking milk, bedtime, get-up time, afternoon nap duration, breaks while studying, reading extracurricular books, daily time spent in reading in extremely weak or strong light, picky about food, eating whole grains and vegetables, frequency of visual acuity tests, regular eye examinations, attitude towards physical education, daily time spent on in-school physical activities, after-school physical activities, and eye exercises.

### **2.3. Statistical Methods**

The data were statistically analyzed by SPSS 26.0. The continuous variables were first tested for normality, and those that do not conform to the normal distribution were analyzed by nonparametric tests. Binary logistic regression was performed for the multivariate analysis, and GraphPad 9.0 was used to draw figures. All participants agreed to participate in the study.

### **2.4. Ethical Approval**

This research was approved by the independent ethics committee of the Institute of Clinical Pharmacology, Central South University (registered number: ctxy-140003). All methods were carried out in accordance with relevant guidelines and regulations. This study was carried out in compliance with the ARRIVE guidelines. Informed consent was obtained from caregivers, and all information was kept strictly confidential.

[Go to:](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/)

## **3. Results and Analysis**

### **3.1. Univariate Analysis**

The chi-square test and the nonparametric two-sample test were performed for the univariate analysis of 24 independent variables. The results are as follows (see [Table 1](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/table/tab1/)).

### **Table 1**

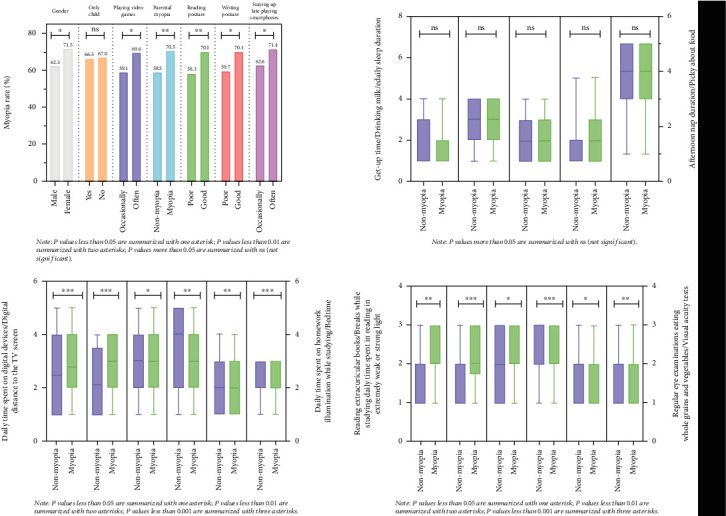
Analysis of influencing factors of myopia.

| **Parameter** | | **Groups** | | **Myopia rate** | **X 2/Z** | **P** |
| --- | --- | --- | --- | --- | --- | --- |
| **Nonmyopia group** | **Myopia group** |
| Gender | Male | 115 | 190 | 62.3% | 5.543 | 0.019 |
| Female | 78 | 196 | 71.5% |
| Only child | No | 94 | 191 | 67.0% | 0.031 | 0.860 |
| Yes | 99 | 195 | 66.3% |
| Playing video games | Occasionally | 67 | 97 | 59.1% | 5.823 | 0.016 |
| Often | 126 | 289 | 69.6% |
| Parental myopia | No | 76 | 107 | 58.5% | 8.090 | 0.004 |
| Yes | 117 | 279 | 70.5% |
| Reading posture | Poor | 123 | 288 | 70.1% | 7.396 | 0.007 |
| Good | 70 | 98 | 58.3% |
| Writing posture | Poor | 116 | 272 | 70.1% | 6.250 | 0.012 |
| Good | 77 | 114 | 59.7% |
| Staying up late playing smartphones | Occasionally | 116 | 194 | 62.6% | 5.013 | 0.025 |
| Often | 77 | 192 | 71.4% |
| Diopter # | | 2 (1~4) | 3 (2~4) |  | -4.579 | <0.001 |
| <2.0 | | 75 | 40 | 10.40% |  |  |
| 2.0-4.0 | | 27 | 105 | 27.20% |  |  |
| 4.0-6.0 | | 35 | 105 | 27.20% |  |  |
| 6.0-8.0 | | 38 | 94 | 24.40% |  |  |
| >8.0 | | 18 | 42 | 10.90% |  |  |
| Daily time spent on digital devices # | | 2 (1~3.5) | 3 (2~4) |  | -4.369 | <0.001 |
| <1 h | | 73 | 39 | 10.10% |  |  |
| 1-2 h | | 29 | 113 | 29.30% |  |  |
| 3-4 h | | 43 | 123 | 31.90% |  |  |
| >4 h | | 48 | 111 | 28.80% |  |  |
| Daily sleep duration # | | 2 (2~3) | 2 (2~2.25) |  | -1.366 | 0.172 |
| <6 h | | 29 | 75 | 19.40% |  |  |
| 6-8 h | | 109 | 215 | 55.70% |  |  |
| >8 h | | 55 | 96 | 24.90% |  |  |
| Distance to TV screen # | | 3 (2~4) | 3 (2~4) |  | -2.238 | 0.025 |
| <1 m | | 28 | 89 | 23.10% |  |  |
| 2-3 m | | 35 | 72 | 18.70% |  |  |
| 3-4 m | | 48 | 84 | 21.80% |  |  |
| 4-5 m | | 40 | 73 | 18.90% |  |  |
| >5 m | | 42 | 68 | 17.60% |  |  |
| Illumination while studying # | | 4 (2~5) | 3 (2~4) |  | -2.97 | 0.003 |
| Reading lamp (white light) | | 29 | 92 | 23.80% |  |  |
| Reading lamp (yellow light) | | 36 | 64 | 16.60% |  |  |
| Pendant lamp (white light) | | 29 | 83 | 21.50% |  |  |
| Pendant lamp (white light) | | 45 | 73 | 18.90% |  |  |
| Natural light (sunlight) | | 54 | 74 | 19.20% |  |  |
| Drinking milk # | | 3 (2~4) | 3 (2~4) |  | -1.188 | 0.235 |
| Never | | 5 | 13 | 3.40% |  |  |
| Occasionally | | 61 | 118 | 30.60% |  |  |
| Often | | 57 | 148 | 38.30% |  |  |
| Every day | | 70 | 107 | 27.70% |  |  |
| Bedtime # | | 2 (1~3) | 1 (1~2) |  | -2.857 | 0.004 |
| After 24:00 | | 91 | 222 | 57.50% |  |  |
| 23:00-24:00 | | 50 | 105 | 27.20% |  |  |
| 22:00-23:00 | | 36 | 33 | 8.50% |  |  |
| 21:00-22:00 | | 16 | 26 | 6.70% |  |  |
| Get-up time # | | 2 (1~3) | 2 (1~3) |  | -0.783 | 0.434 |
| Before 5:00 | | 57 | 116 | 30.10% |  |  |
| 5:00-6:00 | | 51 | 115 | 29.80% |  |  |
| 6:00-7:00 | | 67 | 129 | 33.40% |  |  |
| After 7:00 | | 18 | 26 | 6.70% |  |  |
| Afternoon nap duration # | | 2 (1~2) | 2 (1~3) |  | -0.693 | 0.488 |
| No | | 84 | 178 | 46.10% |  |  |
| <20 minutes | | 72 | 101 | 26.20% |  |  |
| 20-40 minutes | | 29 | 72 | 18.70% |  |  |
| >40 minutes | | 6 | 28 | 7.30% |  |  |
| Daily time spent on homework # | | 2 (2~3) | 3 (2~3) |  | -4.201 | <0.001 |
| <40 minutes | | 43 | 39 | 10.10% |  |  |
| 40-80 minutes | | 74 | 135 | 35.00% |  |  |
| >80 minutes | | 76 | 212 | 54.90% |  |  |
| Breaks while studying # | | 2 (1~2) | 2 (2~3) |  | -3.451 | 0.001 |
| Often | | 60 | 76 | 19.70% |  |  |
| Rarely | | 89 | 180 | 46.60% |  |  |
| Never | | 44 | 130 | 33.70% |  |  |
| Reading extracurricular books # | | 2 (1~2) | 2 (1.75~3) |  | -3.547 | <0.001 |
| Dislike | | 67 | 96 | 24.90% |  |  |
| Like | | 93 | 173 | 44.80% |  |  |
| Very like | | 33 | 117 | 30.30% |  |  |
| Daily time spent in reading in extremely weak or strong light # | | 2 (1~3) | 2 (2~3) |  | -2.528 | 0.011 |
| <20 minutes | | 49 | 66 | 17.10% |  |  |
| 20-40 minutes | | 81 | 161 | 41.70% |  |  |
| 40-80 minutes | | 63 | 159 | 41.20% |  |  |
| Picky about food # | | 4 (3~5) | 4 (3~5) |  | -0.585 | 0.559 |
| Extremely | | 4 | 10 | 2.60% |  |  |
| Quite | | 10 | 24 | 6.20% |  |  |
| Moderate | | 45 | 84 | 21.80% |  |  |
| Slightly | | 49 | 111 | 28.80% |  |  |
| Not | | 85 | 157 | 40.70% |  |  |
| Eating whole grains and vegetables # | | 2 (2~3) | 3 (2~3) |  | -4.243 | <0.001 |
| Never | | 84 | 230 | 59.60% |  |  |
| Rarely | | 68 | 120 | 31.10% |  |  |
| Often | | 41 | 36 | 9.30% |  |  |
| Visual acuity tests # | | 1 (1~2) | 1 (1~2) |  | -2.011 | 0.044 |
| Rarely | | 121 | 212 | 54.90% |  |  |
| Once every 6 months | | 45 | 95 | 24.60% |  |  |
| Once every 3 months | | 27 | 79 | 20.50% |  |  |
| Regular eye examinations # | | 2 (1~2) | 2 (1~2) |  | -2.800 | 0.005 |
| Never | | 91 | 132 | 34.20% |  |  |
| Rarely | | 80 | 199 | 51.60% |  |  |
| Annually | | 22 | 55 | 14.20% |  |  |

[Open in a separate window](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/table/tab1/?report=objectonly)

∗Factors ending with # are not normally distributed according to the results of the SW normality test.

The results in [Table 1](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/table/tab1/) show factors such as gender, playing video games, parental myopia, reading posture, writing posture, staying up late playing smartphones, diopter, daily time spent on digital devices, daily sleep duration, distance to the TV screen, illumination while studying, daily time spent on homework, breaks while studying, reading extracurricular books, daily time spent in reading in extremely weak or strong light, eating whole grains and vegetables, visual acuity tests, and regular eye examinations were found significant (P < 0.05). These factors were kept for the multivariate analysis. Factors such as only child, daily sleep duration, drinking milk, get-up time, afternoon nap duration, and picky about food were found not significant, which means they are not the influencing factors of myopia in adolescents. The details are shown in [Figure 1](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/figure/fig1/).

[[](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/figure/fig1/)](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/figure/fig1/" \t "figure)

[Figure 1](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/figure/fig1/)

Univariate analysis of the influencing factors of myopia.

### **3.2. Univariate Analysis of Physical-Activity-Related Factors**

The chi-square test and the nonparametric two-sample test were performed for the univariate analysis of 13 independent variables. The results are as follows (see [Table 2](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/table/tab2/)).

### **Table 2**

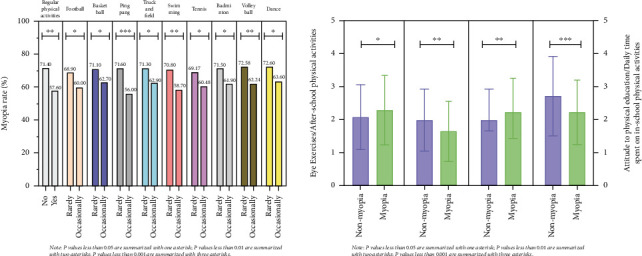
Analysis of the correlation between physical activity and myopia.

| **Parameter** | | **Groups** | | **Myopia rate** | **X 2/Z** | **P** |
| --- | --- | --- | --- | --- | --- | --- |
| **Nonmyopia group** | **Myopia group** |
| Regular physical activities | No | 109 | 272 | 71.40% | 11.190 | 0.001 |
| Yes | 84 | 114 | 57.60% |
| Football | Rarely | 135 | 299 | 68.90% | 3.869 | 0.049 |
| Occasionally | 58 | 87 | 60.00% |
| Basketball | Rarely | 79 | 194 | 71.10% | 4.491 | 0.034 |
| Occasionally | 114 | 192 | 62.70% |
| Ping pang | Rarely | 112 | 283 | 71.60% | 13.866 | <0.001 |
| Occasionally | 81 | 103 | 56.00% |
| Track and field | Rarely | 75 | 186 | 71.30% | 4.520 | 0.033 |
| Occasionally | 118 | 200 | 62.90% |
| Swimming | Rarely | 112 | 271 | 70.80% | 8.519 | 0.004 |
| Occasionally | 81 | 115 | 58.70% |
| Tennis | Rarely | 127 | 285 | 69.17% | 4.044 | 0.044 |
| Occasionally | 66 | 101 | 60.48% |
| Badminton | Rarely | 82 | 206 | 71.50% | 6.093 | 0.014 |
| Occasionally | 111 | 180 | 61.90% |
| Volleyball | Rarely | 68 | 180 | 72.58% | 6.828 | 0.009 |
| Occasionally | 125 | 206 | 62.24% |
| Dance | Rarely | 54 | 143 | 72.60% | 4.713 | 0.030 |
| Occasionally | 139 | 243 | 63.60% |
| Attitude to physical education # | | 4 (3~4) | 3 (3~4) |  | -3.284 | 0.001 |
| Negative | | 96 | 134 | 34.70% |  |  |
| Indifferent | | 27 | 64 | 16.60% |  |  |
| Positive | | 58 | 157 | 40.70% |  |  |
| Very positive | | 12 | 31 | 8.00% |  |  |
| Daily time spent on in-school physical activities # | | 2 (1~3.5) | 3 (2~4) |  | -5.074 | <0.001 |
| <20 minutes | | 48 | 111 | 28.80% |  |  |
| 20-40 minutes | | 29 | 113 | 29.30% |  |  |
| 40-60 minutes | | 43 | 123 | 31.90% |  |  |
| >60 minutes | | 73 | 39 | 10.10% |  |  |
| After-school physical activities # | | 3 (2~4) | 3 (2~4) |  | -2.209 | 0.027 |
| Rarely | | 72 | 116 | 30.10% |  |  |
| Occasionally | | 46 | 92 | 23.80% |  |  |
| Sometimes | | 61 | 127 | 32.90% |  |  |
| Often | | 14 | 51 | 13.20% |  |  |
| Eye exercises # | | 2 (1~3) | 1 (1~2) |  | -3.453 | 0.001 |
| Never | | 84 | 217 | 56.20% |  |  |
| Rarely | | 51 | 107 | 27.70% |  |  |
| Occasionally | | 42 | 36 | 9.30% |  |  |
| Often | | 16 | 26 | 6.70% |  |  |

[Open in a separate window](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/table/tab2/?report=objectonly)

∗Factors ending with # are not normally distributed according to the results of the SW normality test.

The results in [Table 2](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/table/tab2/) show that the myopia rate of adolescents who often took part in physical activities is significantly lower than those who occasionally took physical exercise (P < 0.05). The myopia rate of adolescents who often participated in football, basketball, table tennis, track and field, swimming, tennis, badminton, volleyball, dance, and other sports is low (P < 0.05). Continuous variables such as attitude towards physical education, daily time spent on in-school physical activities, after-school physical activities, and eye exercises were found significant, and they were kept for the multivariate analysis. The details are shown in [Figure 2](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/figure/fig2/).

[[](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/figure/fig2/)](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/figure/fig2/" \t "figure)

[Figure 2](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/figure/fig2/)

Analysis of the correlation between physical activities and myopia.

### **3.3. Multivariate Analysis of Influencing Factors of Myopia**

18 significant factors were kept for the multivariate analysis using binary logistic regression, and the factors are gender, playing video games, staying up late playing smartphones, parental myopia, reading posture, writing posture, diopter, daily time spent on digital devices, distance to the TV screen, illumination while studying, bedtime, daily time spent on homework, breaks while studying, reading extracurricular books, daily time spent in reading in extremely weak or strong light, visual acuity tests, regular eye examinations, and eat whole grains and vegetables. The results are as follows in [Table 3](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/table/tab3/).

### **Table 3**

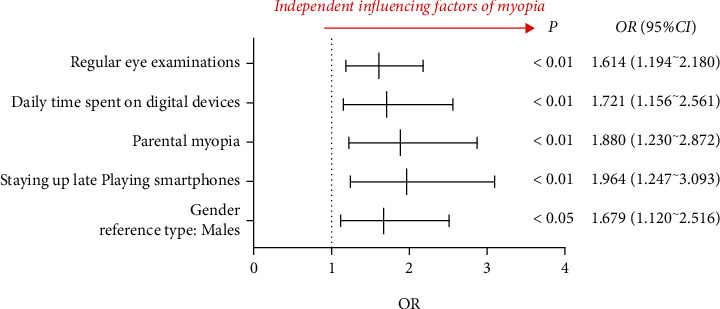
Binary logistic analysis of influencing factors of myopia.

| **Parameter** | **B** | **S.E.** | **Wald** | **DF** | **P** | **OR** | **OR 95% CI** | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Minimum** | **Maximum** |
| Gender | 0.518 | 0.206 | 6.302 | 1 | 0.012 | 1.679 | 1.120 | 2.516 |
| Playing video games | 0.006 | 0.761 | 0.000 | 1 | 0.993 | 1.006 | 0.226 | 4.474 |
| Staying up late playing smartphones | 0.675 | 0.232 | 8.488 | 1 | 0.004 | 1.964 | 1.247 | 3.093 |
| Parental myopia | 0.631 | 0.216 | 8.507 | 1 | 0.004 | 1.880 | 1.230 | 2.872 |
| Reading posture | -0.590 | 0.763 | 0.598 | 1 | 0.439 | 0.555 | 0.124 | 2.472 |
| Writing posture | -0.365 | 0.21 | 3.034 | 1 | 0.082 | 0.694 | 0.460 | 1.047 |
| Diopter | 0.136 | 0.166 | 0.676 | 1 | 0.411 | 1.146 | 0.828 | 1.587 |
| Daily time spent on digital devices | 0.543 | 0.203 | 7.164 | 1 | 0.007 | 1.721 | 1.156 | 2.561 |
| Distance to TV screen | -0.072 | 0.075 | 0.905 | 1 | 0.341 | 0.931 | 0.803 | 1.079 |
| Illumination while studying | -0.116 | 0.080 | 2.100 | 1 | 0.147 | 0.890 | 0.760 | 1.042 |
| Bedtime | -0.167 | 0.115 | 2.095 | 1 | 0.148 | 0.847 | 0.676 | 1.061 |
| Daily time spent on homework | 0.130 | 0.307 | 0.179 | 1 | 0.673 | 1.139 | 0.623 | 2.080 |
| Breaks while studying | 0.066 | 0.212 | 0.098 | 1 | 0.754 | 1.069 | 0.706 | 1.618 |
| Reading extracurricular books | 0.081 | 0.208 | 0.153 | 1 | 0.696 | 1.085 | 0.721 | 1.631 |
| Daily time spent in reading in extremely weak or strong light | 0.221 | 0.147 | 2.273 | 1 | 0.132 | 1.247 | 0.936 | 1.663 |
| Visual acuity tests | 0.168 | 0.134 | 1.581 | 1 | 0.209 | 1.183 | 0.910 | 1.537 |
| Regular eye examinations | 0.478 | 0.153 | 9.723 | 1 | 0.002 | 1.614 | 1.194 | 2.180 |
| Eating whole grains and vegetables | -0.390 | 0.310 | 1.581 | 1 | 0.209 | 0.677 | 0.369 | 1.243 |
| Constants | -2.393 | 1.534 | 2.433 | 1 | 0.119 | 0.091 |  |  |

[Open in a separate window](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/table/tab3/?report=objectonly)

From the above analysis, it can be clearly concluded that gender is an independent factor affecting the incidence of myopia (P < 0.05), and the incidence of myopia in females is 1.679 times higher than that in males. Staying up late playing smartphones is an independent factor of myopia (P < 0.01), and the incidence of myopia in those spending a long time playing smartphones is 1.964 times higher than in those spending a short time staying up late playing smartphones. Parental myopia is an independent factor affecting the incidence of myopia (P < 0.01), and the incidence of myopia in those who have myopic parents is 1.880 times higher than in those who do not. Daily time spent on digital devices is an independent factor of myopia (P < 0.01), and the incidence of myopia in those spending a long time on digital devices is 1.721 times higher than that in those spending a short time on digital devices. Regular eye examinations is an independent factor affecting the incidence of myopia (P < 0.01), and the incidence of myopia in those who never (or rarely) have their eyes examined is 1.614 times higher than that in those who have regular eye examinations annually. The rest factors are not independent influencing factors of myopia (P > 0.05). From the above analysis, the forest plot of the five independent influencing factors of myopia was given.

Based on the above five factors in [Figure 3](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/figure/fig3/) that significantly affect the incidence of myopia, a formula for predicting the probability of becoming myopic is given.

[[](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/figure/fig3/)](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/figure/fig3/" \t "figure)

[Figure 3](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/figure/fig3/)

Forest plot of the five independent influencing factors of myopia.

Z = −3.953 + 0.518∗1 (if gender = female) + 0∗1 (if gender = male) + 0.675∗1 (if staying up late playing smartphones = true) + 0∗1 (if staying up late playing smartphones = false) + 0.631∗1 (if parental myopia = true) + 0∗1 (if parental myopia = false) + 0.543∗3 (daily time spent on digital devices > 4 h) + 0.478∗2 (regular eye examinations = false).

Pmyopia=11+e−Z.

(1)

The following is an example that shows how to predict the probability of becoming myopic of a female student who often stays up late playing smartphones, has myopic parents, spends more than 4 hours on digital devices every day, and rarely has her eyes examined.

Z=−3.953+0.518∗1+0.675∗1+0.631∗1+0.543∗4+0.478∗2=0.999,Pmyopia=11+e−Z=11+e0.999=73%.

(2)

The probability of becoming myopic of the student is 73% (>50%), which means the student will be myopic.

### **3.4. Multivariate Analysis of the Correlation between Physical Activities and Myopia**

In the univariate analysis, 5 significant factors were kept for multivariate analysis using binary logistic regression, and the factors are regular physical activities, daily time spent on in-school physical activities, after-school physical activities, eye exercises, and attitude towards physical education. The results are as follows in [Table 4](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/table/tab4/).

### **Table 4**

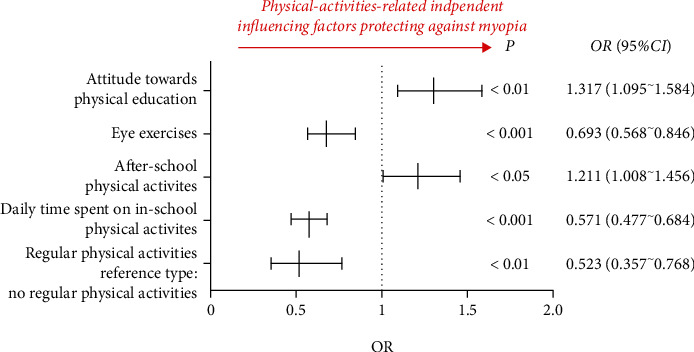
Binary logistic analysis of the correlation between physical activities and myopia.

| **Parameter** | **B** | **S.E.** | **Wald** | **DF** | **P** | **OR** | **OR 95% CI** | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Minimum** | **Maximum** |
| Regular physical activities | -0.648 | 0.196 | 10.965 | 1 | 0.001 | 0.523 | 0.357 | 0.768 |
| Daily time spent on in-school physical activities | -0.560 | 0.092 | 37.376 | 1 | <0.001 | 0.571 | 0.477 | 0.684 |
| After-school physical activities | 0.192 | 0.094 | 4.177 | 1 | 0.041 | 1.211 | 1.008 | 1.456 |
| Eye exercises | -0.366 | 0.102 | 13.002 | 1 | 0.000 | 0.693 | 0.568 | 0.846 |
| Attitude towards physical education | 0.276 | 0.094 | 8.570 | 1 | 0.003 | 1.317 | 1.095 | 1.584 |
| Constants | 1.986 | 0.453 | 19.26 | 1 | <0.001 | 7.287 |  |  |

[Open in a separate window](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/table/tab4/?report=objectonly)

From the above analysis, it can be clearly concluded that regular physical activities is an independent factor reducing the incidence of myopia (P < 0.01), and the incidence of myopia in those who had regular physical activities was 0.523 times lower. Daily time spent on in-school physical activities (P < 0.001), after-school physical activities (P < 0.05), eye exercises (P < 0.01), and attitude towards physical education (P < 0.01) were all independent factors reducing the occurrence of myopia. According to the above analysis, the forest plot of the five independent influencing factors against myopia was given.

Based on the 5 factors in [Figure 4](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/figure/fig4/) that significantly prevent myopia, a formula for predicting preventing myopia prevalence is given.

[[](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/figure/fig4/)](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/figure/fig4/" \t "figure)

[Figure 4](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/figure/fig4/)

Forest plot of the five independent influencing factors protecting against myopia.

Z = 1.986 − 0.648∗1 (if regular physical activities = true) − 0.560∗3 (if daily time spent on in‐school physical activities = 40‐60 minutes) + 0.192∗2 (if after‐schoolphysical activities = occasionally) − 0.366∗3 (if eye exercises = often) + 0.276∗4 (if  attitude  to  physical  education = very like).

Pnonmyopia=11+e−Z.

(3)

The following is an example that shows how to predict the probability of preventing myopia of a student who takes part in physical activities for 40-60 minutes every day, occasionally takes part in after-school physical activities, often do eye exercises, and like PE lessons very much.

Z=1.986−0.648∗1−0.560∗3+0.192∗2−0.366∗3+0.276∗4=0.51,Pnonmyopia=11+e−Z=11+e−0.552=51%.

(4)

The probability of the student not being myopic is 51%, which means the student will not be myopic.

[Go to:](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/)

## **4. Discussion**

The univariate analysis showed that factors like playing video games, parental myopia, reading posture, writing posture, distance to the TV screen, daily time spent on homework, breaks while studying, reading extracurricular books, daily time spent in reading in extremely weak or strong light, eating whole grains and vegetables, visual acuity tests, and regular eye examinations are influencing factor for myopia, which is consistent with Luo's study [[11](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/#B11)]. Students who play digital devices for a long time every day might have eyestrain even keratitis [[12](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/#B12)]. The incidence of myopia in girls was higher than that in boys, which is consistent with the results of Wen's study [[5](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/#B5)]. The difference may be due to different environments. Girls like to be quiet and study harder, while boys prefer outdoor activities. Parental myopia, long daily reading time, and less outdoor activity time are the risk factors associated with the increased incidence of myopia [[13](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/#B13)].

With the popularity of electronic products, most adolescents are equipped with learning and game devices. They often spend 3-4 hours reading, writing, and doing homework without rest, and sometimes they even stay up until the wee hours of the morning, which increases the burden on their eyes. The muscles inside and outside the eyes get tense and cannot get a good rest, which might lead to eye muscle spasms. The multivariate analysis of the significant factors was conducted after the univariate analysis of myopia, and the significant factors obtained by multivariate analysis were regarded as the independent influencing factors of myopia. Through binary logistic regression analysis, it was found that gender, parental myopia, staying up late playing smartphones, daily time spent on digital devices, and regular eye examinations were the independent influencing factors of myopia. According to these independent factors affecting myopia, this study attempted to give a formula for predicting the probability of becoming myopic.

The results of the univariate analysis of the correlation between physical activities and myopia showed that the incidence of myopia was lower in those that took part in regular physical activities and actively participated in sports (basketball, volleyball, and football). Continuous variables such as daily time spent on in-school physical activities, after-school physical activities, eye exercises, and attitude towards physical education are also influencing factors of myopia. Outdoor activities and physical activities are beneficial to reduce the incidence of myopia. For adolescents, sports such as basketball, volleyball, and badminton can effectively reduce the risk of becoming myopic [[14](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/#B14)]. Factors such as more outdoor activities, exposure to natural light, and outdoor environment are protective for the eyes of adolescents [[15](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/#B15)–[18](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9433230/#B18)]. Through binary logistic regression analysis, it is found that regular physical activities, daily time spent on in-school physical activities, after-school physical activities, eye exercises, and attitude towards physical education are the main influencing factors in the prevention of myopia. Based on these independent factors, the prediction formula for preventing myopia is given and the probability of nonmyopia can be calculated according to the specific conditions of the students.

Potential limitations of our study should be mentioned. First of all, it is difficult to investigate the change of myopia with time by a cross-sectional study, and a multilevel linear model should be adopted to obtain a causal explanation in the future. Secondly, compared with previous review studies, this study may only be a potential myopia control strategy, and in future surveys, the time of physical activities and its impact on myopia need to be better defined and quantified.

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## **5. Conclusions**

(1) The results of the univariate analysis showed the influencing factors of myopia in adolescents and the factors related to physical activities that affect the prevalence of myopia. (2) The results of the multivariate analysis showed the independent influencing factors of myopia in adolescents and the independent influencing factors related to physical activities that affect the prevalence of myopia. (3) The significant factors in multivariate analysis were used to provide 2 formulas to predict the probability of becoming myopic and the probability of preventing myopia.

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## **Data Availability**

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

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## **Conflicts of Interest**

No financial or nonfinancial benefits have been received or will be received from any party related directly or indirectly to the subject of this article.

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## **Authors' Contributions**

YY was responsible for conceptualization, data curation, formal analysis, investigation, methodology, project administration, supervision, validation, visualization, writing—original draft, and writing—review and editing; CQ was responsible for conceptualization, formal analysis, methodology, project administration, resources, supervision, and writing—review and editing; YFQ was responsible for investigation, methodology, supervision, and writing—review and editing. Cheng Qiu and Yin Yao contributed equally to this work.

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