

The Analysis and Assessment of Dangerous Factors in the Visual Lifestyle of Children from the Perspective of Myopia Prevention

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Abstract

Objectives: The myopic population is continually increasing worldwide. The purpose of this paper was to examine the risk factors for myopic occurrence. Moreover, from a public health perspective, this paper also proposed a framework and description of measures for the prevention of myopia. **Methods:** This article is a literature review that analyses vital factors affecting the development of myopia. It was conducted using “MEDLINE, CINAHL Plus with Full Text, academic search complete” on the EBSCO database for the period of 1990 to June 2014. Subsequently, we used Pub Med and Google Scholar to search for literature in relation to vision and lifestyle patterns and continued with the work of consolidating the gathered literature.

Results: In this study, vital factors, including viewing distance, varying influences unique to an individual, family, education, and the social scene of the nation, were found to affect the occurrence of myopia. Other than proposing a framework of multiple factors that influence vision-related lifestyle, this study adopts a preventive and public health point of view to investigate methods currently being used to assess children's visual health and vision-related lifestyle in order to organize and summarize scenarios related to visual tasks, and to assess visual aid resources in children.

Keywords: lifestyle; myopia; public health; risk factor; vision

Introduction

Health, including healthy eyesight, is an important and priceless asset. For children, the most of learning relies on the function of vision. At present, 285 million people worldwide are diagnosed with visual impairment. Globally, 80% of all visual impairment is preventable or curable. The condition of refractive errors accounts for the majority of visual impairment cases, and children represent the largest myopic group (World Health Organization, 2014). A nearsighted person can clearly see near objects but not faraway objects. Symptoms of myopia include blurred distance vision, eye rubbing, and squinting (Saw, Katz, Schein, Chew, & Chan, 1996). Myopia has become a global public health issue. The prevalence of myopia varies due to national, regional, and ethnic differences. The rates of myopia are especially high amongst urban dwellers and Chinese descent (Wen et al., 2013; Xiang et al., 2013).

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In Taiwan, the prevalence of myopia for persons ages 12–19, 20–39, 40–64, and ≥ 65 years was 70.3%, 65.4%, 30.4%, and 5.6%, respectively (Guo, Lin, Lin, & Cheng, 2012).

According to a census of people over age 40 by the National Eye Institute in the United States, the myopia rate in the year 2010 was 23.9% (Prevent Blindness America, 2012). Compared with the total of 30,357,202 myopic adults over age 40 in the year 2000, the total of 34,119,279 myopic adults over age 40 in the year 2010 was a huge increase (National Eye Institute, n. d.). Using meta-analysis to analyse the European myopic population in different historical periods, researchers found the trend of an increasing myopic population in more-recent generations. Some 22% of people born between 1930 and 1939 are myopic; 25.4% of people born between 1940 and 1949 are myopic; 33.0% of people born between 1950 and 1959 are myopic (Williams & Hammond, 2014). The phenomenon of prevalent myopia has gradually spread to other countries.

Taking a preventive perspective from community health nursing, the paper's authors gathered relevant factors that cause children's myopia and proposed attaching great importance to the role of children's lifestyle in the development of myopia. In addition, this paper organized assessment and measurement methods in order to provide a base for myopia prevention and studies of children's vision care in the future.

Methods

This study gathered and reviewed literature about risk factors in relation to the myopia prevention. We searched for "MEDLINE, CINAHL Plus with Full Text, academic search complete" on the EBSCO database. Keywords were "eye or myopic or myopia", "measure or assess" and "AB children". The searches were conducted for the period of January 1990 to June 2014. Further, words and phrases with no direct correlation to the prevention of myopia were excluded. For example, abstract naming surgery, laser, gene, atropine, injuries, blindness, sleep, and alcohol were excluded. Subsequently, we used PubMed and Google Scholar to search for literature pertaining to vision and lifestyle patterns and continued with the work of consolidating the gathered literature.

Results

1. Dangerous factors

The eye-to-object distance has an important influence on children. Near-work tasks are particularly dangerous to vision (Ciuffreda & Vasudevan, 2008; Ong & Ciuffreda, 1995). An investigation of 1,108 kindergarten children ages 5–7 during the years 2009–2010 in Taiwan found a strong correlation between the occurrence of myopia and the time children spent on near-work tasks; children were spending an average of 3.6 hours on near-work tasks each day (Peng, 2011). Children in Asian countries were also found to be spending increasing amounts of time on near work as they grew older (Guo et al., 2013; Liu & Chen, 2006).

All near-work activities, which included reading/studying, computer use, near work with hobbies and playing Game Boy, took up one-fourth of students' after-school time (Rah, Walline, Mitchell, & Zadnik, 2006). The top near-work activity of children's daily after-school routine was watching television (Peng, 2011). Also, according to a 2011–2012 survey in the Greater Beijing area, the hours that students spent playing with electronic gadgets in the years 2011 and 2012 showed a triple increase in eye-use time (Guo et al., 2013). An American study of 212 students ages 5–18 in grades 1–12 found that students spent an average of 3.3 hours on computers and related products on Saturdays (Burke & Peper, 2002).

In contrast to near-work activities, outdoor scenarios involving eyes focused on a distant object were also discussed in a number of important studies in recent years. Conducting a study on students in grades 4–8, researchers found that the average distance between children's eyes and a focused object was 438.5 cm in outdoor sports participation (Rah et al., 2006). Researchers found a correlation between decreasing hours of outdoor activities and incidents of myopia (Guggenheim et al., 2012; Guo et al., 2014).

After adjusting factors including the distance between an object and human eyes, parental myopia, and ethnicities, the study found that the time spent engaged in outdoor activities had a stronger correlation with the development of myopia than did the type of activity (Rose et al., 2008). Conducting a daily light exposure study of 101 children ages 10–15, Australian researchers found a significant difference in the amount of time spent exposed to light (>1000 lx) each day between myopic children and emmetropic children (Read, Collins, & Vincent, 2014).

Therefore, according to the literature listed in the foregoing paragraphs, life and activity scenarios, eye-to-object distance, and duration of eye use are all important factors in the prevention of myopia. In particular, attention should be paid to indoor near-work tasks and outdoor distant objects, which are respectively dangerous and beneficial to eye health. On the other hand, our literature review revealed that other risk factors affecting the occurrence of myopia in children fall within the four categories of the individual, family, education, nation and society.

1.1 Personal factors

Age can affect the risk of myopia development (You et al., 2012). After conducting a three-month experiment involving kittens monocularly deprived of vision, Hubel and Wiesel found that the effect on the kittens' visual deprivation did not affect them as adult cats (Daw, 2009).

Gender factor: Examining the patterns of myopigenic activity such as a large amount of time spent on near work and a small amount of time spent outdoors in children growing up in Sydney, Australia, researchers found that girls engaged in more myopigenic activity than boys did (French, Morgan, Mitchell, & Rose, 2013). As revealed by a follow-up investigation of 543 myopic children ages 7–9 in Singapore, children's gender was related to children's ocular axial length (Saw et al., 2005). According to a 2009–2010 survey of 1,108 Taiwanese kindergarten children ages 5–7, gender did not cause statistical differences, yet more girls had myopia (Peng, 2011).

1.2 Familial factors

Parental myopia: Some research revealed a higher rate of myopia among children with myopic parents (Peng, 2011). A follow-up investigation of 543 children ages 7–9 in Singapore revealed that parents' myopic history was related to the statistics of children's ocular axial length (Saw et al., 2005). However, parents' myopic history only affected children ages 5–6 and did not affect children ages 12–17 as far as showing a statistical difference (French, Morgan, Mitchell, & Rose, 2013).

In addition, the prevalence of myopia varies across populations of different ethnicities. Researchers who examined patterns of myopigenic activity in Sydney, Australia, found that children of East Asian ethnicity had more lifestyle patterns related to the incidence of myopia in children when compared with descendants of white people. Such lifestyle patterns include high levels of near work and low levels of outdoor activities (French et al., 2013). According to Australian researchers' investigation of Sydney junior high school students aged 12.7 years on average, the rate of myopia was higher among Asian students (Ip et al., 2008).

Other than parental myopia and ethnicity-related genetic factors, factors such as parental behaviour guidance or emulation and the environment where children grow up all need further investigation for clarification. Relevant literature also support and acknowledge the great influence that parents and siblings have on children in a family (Furman & Buhrmester, 1985). According to a Singaporean study, it was clearly evident that familial siblings contribute to the changes in refractive errors and vitreous chamber depths (Guggenheim, Pong-Wong, Haley, Gazzard, & Saw, 2007).

1.3 Educational Factors:

School factors: Adopting meta-analysis to analyze the European myopic population in different generations, British researchers detected a significantly strong correlation between educational attainment and prevalence of myopia. Some 16% of primary school graduates were diagnosed with myopia, and 35% of people with a higher-education degree were diagnosed with myopia (Williams & Hammond, 2014).

Also, researchers found a significant difference in refractive status among students in grades 3–5 at different schools(Williams & Hammond, 2014).Also, researchers found a significant difference in refractive status among students in grades 3–5 at different schools(Shih, Lin, Ko, & Hung, 1989). A survey of 12.7-year-old junior high school students in Sydney, Australia, revealed a larger number of myopic students in public schools than in private schools(Ip et al., 2008).According to a large-scale survey in the Greater Beijing area, myopia-related factors included school types and reading in dim light(You et al., 2012).

Study-related factors: The “being forced to study” factor could meaningfully predict the degree of Taiwan children’s myopia(Liu & Chen, 2006).A large-scale survey in the Greater Beijing area suggested that myopia-related factors include daily long-hour and continuous study without rest over a long period of time(You et al., 2012).

According to a 2011–2012 survey of 643 grade 2 and grade 5 students in the Greater Beijing area, children’s ocular axial length was apparently related to longer hours of school study (Guo et al., 2013).Academic performance: The academic performance of grade 7 students without vision problems and students with vision impairment exhibited a significant difference. The numerical mark of students’ academic performance was 67.1 for students with normal vision and 73.8 for students with poor vision (Yang & Shyoug, 2000). In addition, a study comparing the academic performance of American grade 8 students in the myopia group and the emmetropia group found that students in the myopia group did better than students in the emmetropia group on the Iowa Tests of Basic Skills with respect to the reading score and the overall language score (Mutti, Mitchell, Moeschberger, Jones, & Zadnik, 2002).

Therefore, the correlation between myopia and education factors is undeniable. Schools are still the most important establishments to lead in myopia prevention. Given that the education climate might vary from nation to nation, work toward myopia prevention should consider the culture of education in different areas.

1.4 Society and nation-related factors

The Asian population’s competitive society in recent years has been affected by myopia-related factors(Seet et al., 2001).According to a 2003–2005 study of 2,367 grade 7 students all residing in Sydney, Australia, the myopia rate was 6.9% in the outer suburban region and 17.8% in the inner-city region, indicating that urban and rural differences also affected the myopia rate even in the same city(Ip, Rose, Morgan, Burlutsky, & Mitchell, 2008).After variables including near-work distance and outdoor activities were adjusted, a study found that apartment dwelling was related to myopia(Ip et al., 2008).

Subsequent to a no-schooling policy in China during the Cultural Revolution Decade (1966–1976), educational supervision resumed after 1976. Statistically, the number of myopic adults born between 1950 and 1955 was less than the number of myopic people born between 1940 and 1945(Wang, Xu, & Jonas, 2013).Therefore, national, social, and cultural factors must be taken into account. Using appropriate methods to carefully assess local myopia-related factors could help to design suitable plans pertaining to the prevention of myopia.

Summary: Regardless of a near or far eye-to-object distance being involved, outdoor activities are a direct and important factor in the development of myopia. In terms of the prevention of myopia, an individual is still subject to the influence of the individual himself, the family, education, the society, and the nation. Parents, teachers, society’s culture, and national policies might also affect children’s behaviour. Values which parents hold true when giving instructions are also subject to the influence of social culture and public opinions. All of these factors might affect children’s lifestyle and are highly related to the lifestyle of people in different countries.

2. The Concept of visual Lifestyle

Focusing on children’s visual life experiences, this study proposed the concept of visual lifestyle. As mentioned in the Medical Subject Headings (MeSH) terms, lifestyle refers to a typical way of life or manner of living characteristic of an individual or group (National Center for Biotechnology Information, n.d.).

A healthy lifestyle usually contributes to better health. However, lifestyle might be shaped in a person's childhood and become impossible to improve.

Researchers who investigated behaviour of problematic children through qualitative research learned that lifestyle is an important issue (Turnbull & Ruef, 1997). Some researchers also mentioned the influence of life problems on lifestyle (Jensen, 2007). Researchers mentioned that the five dimensions of lifestyle research are activity and behaviour, value and attitude, individual and group, group interaction, and coordinating identification and selection (Veal, 1993). It can be inferred that a person's lifestyle is interweaved with daily regular activities. Children's lifestyle depends more on patterns of family interactions, education style, and patterns of interaction with other groups particular to the society's culture.

As children's lifestyle changes along with changes and trends brought about by the passage of time, visual lifestyle does too. Although factors resulting from personal traits are difficult to focus on and to change in prevention work, the eye-to-object distance and duration of children's eye use are subject to the influence of parents, child-care providers, family upbringing, and particularly years of crucial development in vision. After children start their schooling, they might be subject to the influence of school and education factors while at the same time the education system itself is subject to national policies and social culture. Depending on the particular society, the visual lifestyle of children in the preschool stage might be under the influence of family education and preschool education. From the elementary school stage to the senior high school stage, children under the influence of family factors might gradually shift to being under the influence of education factors along with social and cultural impact.

In Asian countries, for example, grades 1 and 2 are an important phase during which students learn to write Chinese characters. The course of children's activities and behaviour, parental expectations of children's good academic performance, school assignments, as well as the school education system are all dimensions evaluated by a local community. Therefore, the assessment of visual lifestyle could be used as a framework for myopia prevention and assessments as well as for relevant programs and monitoring of health risks in the future (Figure 1).

Researchers proposed the idea of "levels of prevention" from the perspective of public health (Clark, 1954; Leavell & Clark, 1965). Understanding possible causes of myopia in the local community is the only way to avoid a Type III error suggested by Howard Raiffa and subsequent decision-making mistakes (Dunn, 2001; Hammond, Keeney, & Raiffa, 1998). Assessing and monitoring children's visual lifestyle is the first step in primary myopia prevention. Important elements of assessing local children's visual lifestyle include dimensions of scenarios, duration of eye use, and the way in which vision is used. Additionally, there are assessments of visual aid resources.

2.1 Scenarios that involve the use of vision: Assessing the type of visual life scenario involves depicting the location and type of indoor and outdoor scenarios based on local children's visual experience. For example, doing practice tests in a school classroom designates the school as the scenario setting, the classroom as the particular setting of an indoor activity, and doing practice tests as the scenario type. Another example is that riding a bike in a park makes the park the scenario setting for that outdoor activity and makes riding a bike the scenario type.

2.2 Duration of eye use: the duration of eye use in individual scenarios is calculated in minutes and hours. The duration is calculated by recording the time of activity between start and end. Daytime and night-time are separated based on the time of sunrise and sunset. Activities on weekdays and weekends are recorded according to the life cycle of a week. Taking the performance of practice tests in a school classroom at 10:00~10:50 a.m. on Tuesday, May 13, 2014, as an example, Tuesday is a normal weekday, 10:00~10:50 a.m. is a time period, and the activity lasts for 50 minutes.

2.3 The manner of eye use: This involves measuring the eye-to-object distance, angle, eye blink, and eye movement. 2.3.1 The eye-to-object distance is an important factor for calculating the risk of developing myopia. Common distance-measurement tools include a cloth tape measure, a steel tape measure, an angle-measuring instrument, an image-based measurement system, and a laser distance measuring machine. The unit for measuring the eye-to-object distance is centimetre and metre, and the unit for measuring the eye-to-object angle is degree. For example, the centimetre is used to measure the distance between the book and the eyes of the book's reader.

Another example is that degree is used to measure the angle formed by the computer monitor and the video-watching computer user.

2.3.2 Measuring eye blink: Blink rate, calculated based on the number of eye blinks per minute, can be used for the measurement of fatigue (Lambooj, Fortuin, Heynderickx, & IJsselsteijn, 2009). However, researchers also cautioned that many factors might affect the blink rate (Stern, Boyer, & Schroeder, 1994). For example, the blink rate might be subject to the influence of different tasks, and the influence of conversation, rest and reading might form a descending order (Bentivoglio et al., 1997). In terms of the influence of computer use on the eye blink rate, contemporary researchers have begun to notice how electronic gadgets affect children. In particular, some studies have looked into the impact of computers and mobile phones on adult users' eye conditions such as computer vision syndrome or dry eye syndrome (Rosenfield, 2011; Thomson, 1998).

2.3.3 Measures of eye movements usually track eye-movement trajectories. Researchers used an eye-tracking system to track the eye movement of healthy children ages 2–9, which followed an object's movement from the upper-right corner to the bottom left corner of a computer monitor. After measuring the saccadic reaction time and the reaction time to fixation on the cartoon and gaze fixation area, the Intraclass Correlation Coefficient was used to find that the test-retest reliability was 0.51–0.84 (Pel, Manders, & van der Steen, 2010).

2.4 Visual auxiliary resources: Intrinsic aspects are those such as nutritional intake. Extrinsic aspects are such things as eye glasses, cycloplegic drugs, and auxiliary desk lamps. Some examples include the intensity of illumination when one is doing homework at home, the use of a desk lamp or not, the existence of glare or not, and the light reflection rate of a book or table. A Singaporean study on the comparison between the outdoor time recorded on a diary and a portable light meter revealed that the correlation between the light meter and diary writing was poor to fair (Dharani et al., 2012).

2.5 Visual acuity (VA) is one of the most important ophthalmological parameters in clinical studies. Other than screening and diagnosing myopia, the VA test can also reveal dynamic changes in the emmetropization process that children experience. Comparing 2,103 myopic and non-myopic children ages 5–6 and 12–17 in Sydney, Australia, revealed that a lower degree of hyperopia can forecast the occurrence of myopia in the future (French et al., 2013). The most effective myopia-related eye test is the refraction test, which can be classified into subjective and objective methods of refraction. Researchers believed that good refractive examinations should include both subjective and objective examinations (Wang, 2004, p. 97).

Discussion

The mechanism of causes of children's myopia is quite complex. Clinical observation has found that the progress of high myopia is an irreversible process (Verhoeven et al., 2014). For that reason, initial prevention would be the key to eliminating myopia.

Adopting the concept of epidemiology to identify factors related both to the risk of developing myopia and to protecting against it, this paper put forward a framework for children's visual lifestyle as well as organized and systemized scenarios, duration of eye use, and ways in which vision is used in daily life from a public health and initial prevention perspective. In addition, this paper addressed measurements of auxiliary resources to work on myopia prevention. The authors expect that future researchers can now focus on the lifestyle and social culture of local community groups as well as employ the concept of visual lifestyle in the initial work of preventing myopia in children.

This paper was based on a literature review. Even though the authors included many articles and expanded the years covered for their literature review, there still might appear to be a selection bias. In addition, articles from the electronic database were mainly in English. Although Chinese papers were included, we still were short on articles in other languages.

Most people agree that children are the future masters of a nation. The health of children is the foundation of a nation's health. Children's visual health is more likely to affect a country's future competitiveness. Children have the right to normal development. People should protect children's vision and ensure its healthy development.

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References

- Bentivoglio, A. R., Bressman, S. B., Cassetta, E., Carretta, D., Tonali, P., & Albanese, A. (1997). Analysis of blink rate patterns in normal subjects. *Movement Disorders*, 12(6), 1028-1034. [Online] Available: <http://www.albanese.biz/pdf/03139.pdf>
- Burke, A., & Peper, E. (2002). Cumulative trauma disorder risk for children using computer products: results of a pilot investigation with a student convenience sample. *Public Health Reports*, 117(4), 350. [Online] Available: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1497444/pdf/12477916.pdf>
- Ciuffreda, K. J., & Vasudevan, B. (2008). Nearwork-induced transient myopia (NITM) and permanent myopia--is there a link? *Ophthalmic Physiol Opt*, 28(2), 103-114. doi:10.1111/j.1475-1313.2008.00550.x
- Clark, E. G. (1954). Natural history of syphilis and levels of prevention. *British Journal of Venereal Diseases*, 30(4), 191. [Online] Available: <http://sti.bmj.com/content/30/4/191.full.pdf>
- Daw, N. W. (2009). The foundations of development and deprivation in the visual system. *J Physiol*, 587(Pt 12), 2769-2773. doi:10.1113/jphysiol.2009.170001
- Dharani, R., Lee, C. F., Theng, Z. X., Drury, V. B., Ngo, C., Sandar, M., . . . Saw, S. M. (2012). Comparison of measurements of time outdoors and light levels as risk factors for myopia in young Singapore children. *Eye (Lond)*, 26(7), 911-918. doi:10.1038/eye.2012.49
- Dunn, W. N. (2001). Using the method of context validation to mitigate Type III errors in environmental policy analysis. *Knowledge, power and participation in environmental policy analysis*, 417-436.
- French, A. N., Morgan, I. G., Mitchell, P., & Rose, K. A. (2013). Patterns of myopigenic activities with age, gender and ethnicity in Sydney schoolchildren. *Ophthalmic Physiol Opt*, 33(3), 318-328. doi:10.1111/opo.12045
- French, A. N., Morgan, I. G., Mitchell, P., & Rose, K. A. (2013). Risk Factors for Incident Myopia in Australian Schoolchildren: The Sydney Adolescent Vascular and Eye Study. *Ophthalmology*, 120(10), 2100-2108. doi:10.1016/j.ophtha.2013.02.035
- Furman, W., & Buhrmester, D. (1985). Children's perceptions of the qualities of sibling relationships. *Child development*, 448-461.
- Guggenheim, J. A., Northstone, K., McMahon, G., Ness, A. R., Deere, K., Mattocks, C., . . . Williams, C. (2012). Time outdoors and physical activity as predictors of incident myopia in childhood: a prospective cohort study. *Invest Ophthalmol Vis Sci*, 53(6), 2856-2865. doi:10.1167/iovs.11-9091
- Guggenheim, J. A., Pong-Wong, R., Haley, C. S., Gazzard, G., & Saw, S. M. (2007). Correlations in refractive errors between siblings in the Singapore Cohort Study of Risk factors for Myopia. *Br J Ophthalmol*, 91(6), 781-784. doi:10.1136/bjo.2006.107441
- Guo, Y., Liu, L., Xu, L., Lu, Y., Tang, P., & Feng, Y. (2014). Outdoor activity and myopia among 681 primary students in urban and rural regions of Beijing. *Zhonghua Yi Xue Za Zhi*, 94(3), 191-194.
- Guo, Y., Liu, L. J., Xu, L., Tang, P., Lv, Y. Y., Feng, Y., . . . Jonas, J. B. (2013). Myopic shift and outdoor activity among primary school children: one-year follow-up study in Beijing. *PLoS One*, 8(9), e75260-e75260. doi:10.1371/journal.pone.0075260
- Guo, Y. H., Lin, H. Y., Lin, L. L. K., & Cheng, C. Y. (2012). Self-reported myopia in Taiwan: 2005 Taiwan National Health Interview Survey. *Eye (London, England)*, 26(5), 684-689. doi:10.1038/eye.2012.9
- Hammond, J. S., Keeney, R. L., & Raiffa, H. (1998). The hidden traps in decision making. *Harv Bus Rev*, 76(5), 47-48, 50, 52 passim.
- Ip, J. M., Rose, K. A., Morgan, I. G., Burlutsky, G., & Mitchell, P. (2008). Myopia and the urban environment: findings in a sample of 12-year-old Australian school children. *Investigative Ophthalmology & Visual Science*, 49(9), 3858-3863. doi: 10.1167/iovs.07-1451.

- Ip, J. M., Saw, S.M., Rose, K. A., Morgan, I. G., Kifley, A., Wang, J. J., & Mitchell, P. (2008). Role of Near Work in Myopia: Findings in a Sample of Australian School Children. *Investigative Ophthalmology & Visual Science*, 49(7), 2903-2910. doi:10.1167/iovs.07-0804
- Jensen, M. (2007). Defining lifestyle. *Environmental Sciences*, 4(2), 63-73. doi:10.1080/15693430701472747
- Lambooj, M., Fortuin, M., Heynderickx, I., & IJsselsteijn, W. (2009). Visual discomfort and visual fatigue of stereoscopic displays: a review. *Journal of Imaging Science and Technology*, 53(3), 30201-30201. [Online] Available: <http://www.cs.sfu.ca/CourseCentral/820/li/material/source/papers/Visual-discomfort-09.pdf>
- Leavell, H. R., & Clark, E. G. (1965). *Preventive medicine for the Doctor in his community: An epidemiologic approach*. Blakiston Division, McGraw-Hill.
- Liu, W.J., & Chen, C.Y. (2006). Evaluation of the Correlation among the Learning Stress, Habitual Use of Eyes and Myopia of the Elementary School Students. *Chinese Journal of School Health*(48), 39-61.
- Mutti, D. O., Mitchell, G. L., Moeschberger, M. L., Jones, L. A., & Zadnik, K. (2002). Parental Myopia, Near Work, School Achievement, and Children's Refractive Error. *Investigative Ophthalmology & Visual Science*, 43(12), 3633-3640. [Online] Available: <http://iovs.arvojournals.org/article.aspx?articleid=2162292>
- National Center for Biotechnology Information.(n.d.). Mesh. [Online] Available: <http://www.ncbi.nlm.nih.gov/mesh>
- National Eye Institute. (n. d.). Statistics and Data: Myopia.[Online] Available: <https://www.nei.nih.gov/eyedata/myopia.asp> (Accessed in February, 20 2016)
- Ong, E., & Ciuffreda, K. J. (1995). Nearwork-induced transient myopia: a critical review. *Doc Ophthalmol*, 91(1), 57-85.
- Pel, J. J., Manders, J. C., & van der Steen, J. (2010). Assessment of visual orienting behaviour in young children using remote eye tracking: methodology and reliability. *Journal of Neurosci Methods*, 189(2), 252-256. doi:10.1016/j.jneumeth.2010.04.005
- Peng, H.Y. (2011). *A Study on myopia of preschool children and its related factors in Taiwan*. (Doctoral dissertation), National Taiwan Normal University Taipei. [Online] Available: <http://ndltd.ncl.edu.tw/cgi-bin/gs32/gsweb.cgi?o=dncldr&s=id%3D%22099NTNU5571030%22.&searchmode=basic> (Accessed in February, 20 2016)
- Prevent Blindness America. (2012). Vision Problems in the U.S. [Online] Available: <http://visionproblemsus.org/> (Accessed in February, 20 2016)
- Rah, M. J., Walline, J. J., Mitchell, G. L., & Zadnik, K. (2006). Comparison of the experience sampling method and questionnaires to assess visual activities in pre-teen and adolescent children. *Ophthalmic & Physiological Optics*, 26(5), 483-489. doi:10.1111/j.1475-1313.2006.00372.x
- Read, S. A., Collins, M. J., & Vincent, S. J. (2014). Light exposure and physical activity in myopic and emmetropic children. *Optometry and vision science*, 91(3), 330-341. doi:10.1097/OPX.0000000000000160
- Rose, K. A., Morgan, I. G., Ip, J., Kifley, A., Huynh, S., Smith, W., & Mitchell, P. (2008). Outdoor activity reduces the prevalence of myopia in children. *Ophthalmology*, 115(8), 1279-1285. doi:10.1016/j.optha.2007.12.019
- Rosenfield, M. (2011). Computer vision syndrome: a review of ocular causes and potential treatments. *Ophthalmic and Physiological Optics*, 31(5), 502-515. doi: 10.1111/j.1475-1313.2011.00834.x
- Saw, S.M., Katz, J., Schein, O. D., Chew, S.-J., & Chan, T.-K. (1996). Epidemiology of myopia. *Epidemiologic reviews*, 18(2), 175-187. [Online] Available: <http://epirev.oxfordjournals.org/content/18/2/175.full.pdf>
- Saw, S. M., Chua, W. H., Gazzard, G., Koh, D., Tan, D. T. H., & Stone, R. A. (2005). Eye growth changes in myopic children in Singapore. *The British Journal Of Ophthalmology*, 89(11), 1489-1494. [Online] Available: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1723957/pdf/v085p00521.pdf>
- Seet, B., Wong, T. Y., Tan, D. T., Saw, S. M., Balakrishnan, V., Lee, L. K., & Lim, A. S. (2001). Myopia in Singapore: taking a public health approach. *Br J Ophthalmol*, 85(5), 521-526. [Online] Available: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1723957/pdf/v085p00521.pdf>
- Shih, Y.-F., Lin, L. L. K., Ko, L.-S., & Hung, P.-T. (1989). The Effect of Distance Gazing and Eye Ball Exercise on Prevention of Myopia Progression 28(1), 49-52.
- Stern, J. A., Boyer, D., & Schroeder, D. (1994). Blink rate: a possible measure of fatigue. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 36(2), 285-297. doi:10.1177/001872089403600209
- Thomson, W. D. (1998). Eye problems and visual display terminals—the facts and the fallacies. *Ophthalmic and Physiological Optics*, 18(2), 111-119.

- Turnbull, A. P., & Ruef, M. (1997). Family perspectives on inclusive lifestyle issues for people with problem behavior. *Exceptional Children*, 63, 211-228. [Online] Available: http://www.beachcenter.org/Research/FullArticles/PDF/PBS1A_Family_perspectives_on_inclusive8_07.pdf
- Veal, A. J. (1993). The concept of lifestyle: a review. *Leisure Studies*, 12(4), 233-252. doi:10.1080/02614369300390231
- Verhoeven, V. J., Wong, K. T., Buitendijk, G. H., Hofman, A., Vingerling, J. R., & Klaver, C. C. (2014). Visual Consequences of Refractive Errors in the General Population. *Ophthalmology*. doi:10.1016/j.ophtha.2014.07.030
- Wang, M. T. (2004). *Optometric instrumentation and methods*. Taipei City: Yi Hsien.
- Wang, Y. X., Xu, L., & Jonas, J. B. (2013). The effect of the Chinese Cultural Revolution and Great Leap Forward on the prevalence of myopia. *European Journal of Epidemiology*, 28(12), 1001-1004. doi:10.1007/s10654-013-9858-z
- Wen, G., Tarczy-Hornoch, K., McKean-Cowdin, R., Cotter, S. A., Borchert, M., Lin, J., . . . Varma, R. (2013). Prevalence of myopia, hyperopia, and astigmatism in non-Hispanic white and Asian children: multi-ethnic pediatric eye disease study. *Ophthalmology*, 120(10), 2109-2116. doi:10.1016/j.ophtha.2013.06.039
- Williams, K. M., & Hammond, C. J. (2014). Prevalence of myopia and association with education in Europe. *The Lancet*, 383, S109. [Online] Available: <http://linkinghub.elsevier.com/retrieve/pii/S014067361460372X> (February 25, 2014)
- World Health Organization. (2014). Visual impairment and blindness. [Online] Available: <http://www.who.int/mediacentre/factsheets/fs282/en/> (Accessed in February 25, 2014)
- Xiang, F., He, M., Zeng, Y., Mai, J., Rose, K. A., & Morgan, I. G. (2013). Increases in the prevalence of reduced visual acuity and myopia in Chinese children in Guangzhou over the past 20 years. *Eye (London, England)*, 27(12), 1353-1358. doi:10.1038/eye.2013.194
- Yang, R.J., & Shyong, K.L. (2000). Factors Influencing Vision Defects: A Preliminary Study of Seventh Graders in a Junior High School in Taipei. *The Journal of Health Science*, 2(2), 123-136. [Online] Available: <http://dyna.hcc.edu.tw/campus/data/web/270/files/201307021500441.pdf>
- You, Q. S., Wu, L. J., Duan, J. L., Luo, Y. X., Liu, L. J., Li, X., . . . Guo, X. H. (2012). Factors associated with myopia in school children in China: the Beijing childhood eye study. *Plos One*, 7(12), e52668. doi: 10.1371/journal.pone.0052668

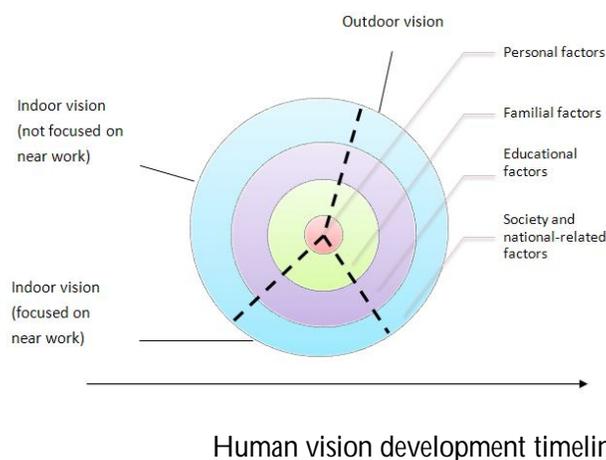


Figure 1: Framework of visual lifestyle for myopia prevention. Vision development is a dynamic process. The process will continue to change when children are growing up. For myopia prevention, it depended on the ratio of indoor and outdoor time daily. The factors of personal, familial, society and national-related could affect the ratio.