The Open Ophthalmology Journal

Content list available at: https://openophthalmologyjournal.com

RESEARCH ARTICLE

Determinants of Refractive Errors on School-going Children Attending Ophthalmic Clinic of AlMoosa Hospital in Saudi Arabia

Ayoob Lone[1,*], Fahad Abdullah Saeed AlWadani[2] and Abdulrahman Alnaim[3]

[1]*Department of Clinical Neurosciences, College of Medicine, King Faisal University, Alhasa, P.O. Box 31982, Saudi Arabia*
[2]*Department of Ophthalmology, College of Medicine, King Faisal University, Alhasa, Saudi Arabia*
[3]*Department of Pediatrics, College of Medicine, King Faisal University, Alhasa, Saudi Arabia*

Abstract:

Objective:

The risk factors for vision problems in youngsters are relatively unknown in Saudi Arabia. The purpose of this study was to examine the determinants of refractive errors among school-going children attending the ophthalmic clinic of AlMoosa Hospital in Saudi Arabia.

Methodology:

A sample of 161 school-going children were recruited voluntarily to complete a set of measures examining the determinants of refractive errors. The binary logistic regression model was applied to determine the relationship between independent and dependent variables.

Results:

Refractive errors were common among Saudi school-going children, with myopia being the most common type of refractive error. About 96 (59.6%) samples had myopia, 28 (17.4%) children had hyperopia and 27 (16.8%) children did not have any refractive error. Genetic traits and machine dependence were found to be significant predictors of refractive error.

Conclusion:

The preschool eye test and routine vision investigation should be performed on children to detect refractive errors early.

Keywords: Refractive error, Myopia, Genetic traits, Machine dependence, Ophthalmic clinic, Visual impairment.

Article History	Received: February 16, 2023	Revised: July 12, 2023	Accepted: July 19, 2023

1. INTRODUCTION

Refractive error is the major cause of visual impairment, and it has also been one of the main responsibilities of global leaders to prevent blindness [1, 2]. The World Health Organization estimates that at least 2.2 billion people worldwide suffer from visual impairment and approximately 19 million children below 15 years of age were visually impaired. Approximately 43% of this population is visually impaired due to refractive errors, which are the leading cause of visual inability in youngsters [3]. In refractive error, the eye fails to focus parallel beams of light on the retina due to an imbalance in the eye's axial length and refractive power [4]. Refractive error includes hyperopia, myopia, and astigmatism [5]. In Saudi Arabia, the prevalence of refractive error among school-aged children is alarming and ranges from 10.7% to 23% [6 - 8].

The most common cause of vision impairment in children aged 5 to 15 is untreated refractive errors [9]. Visual impairment caused by uncorrected refractive errors in children can have serious repercussions, including low academic achievements and work possibilities. Additionally, this may lead to lower economic growth and reduced life quality for people, families, and societies [10]. Globally, 153 million people are visually impaired as a result of uncorrected refractive defects. This number includes 12.8 million children aged 5 to 15, resulting in a worldwide prevalence of 1%.

The prevalence of refractive errors is influenced by genetic and environmental factors. Previous researchers have suggested that genetic factor is significantly associated with refractive error [11 - 14], which contributes to the high

* Address correspondence to this author at the Department of Clinical Neurosciences, College of Medicine, King Faisal University, Alhasa, P.O. Box 31982, Saudi Arabia; Tel: +966553039056; E-mail: mlone@kfu.edu.sa

prevalence of visual impairment. Other factors that contribute to refractive error in school-age children include food, lifestyle, visual exposure, and urbanization [15]. Children's eating habits influence the development of refractive error. Studies have shown that myopes consume much less fresh vegetables, fruits, whole grains, and other foods in their regular diet [16]. Other findings reported that myopic children consumed less food high in protein, fat, vitamins, and minerals and more food high in carbohydrates, starches, or sugars [17]. To stop the onset of refractive error or any other health issues in children, a nutritious diet must be established. Another factor that may contribute to the progression of myopia in school-aged children is a hectic academic schedule. Traumatic educational schedules such as homework (worksheet and assignments) in initial years of schooling and tuition classes in primary schools were found to be positively and significantly related to myopia [18]. Hours of sleep are also associated with myopia and its progression becomes a risk factor for myopia in children [19].

Regarding visual experience, previous research suggested that positive attitudes, practices, and self-confidence could help people overcome their fear of spectacles. Literature has revealed that young kids are spending more time watching television, and playing video games and computer games resulting in visual impairments [20]. These children suffer from a wide range of ocular symptoms, including eyestrain, tiredness, irritation, redness, blurred vision, and double vision.

As previously stated, the prevalence of refractive error is increasing dramatically in Saudi Arabia, which requires immediate action; however, school-aged children have received the least attention. To our knowledge, there are few researches on the prevalence of refractive error among children in Saudi Arabia, and no research has been conducted specifically on the determinant factors of refractive error among school-aged children. As a result, this study aimed to investigate the determinants of refractive error in order to alleviate this invisible problem.

2. MATERIALS AND METHODS

2.1. Study Design

This institutional based cross sectional study was carried out at the ophthalmic clinic of AlMoosa hospital AlHassa, Saudi Arabia. This hospital is well-known for giving eye care to the residents living within its catchment area. The present study was carried out from November 2022 to January 2023. Children with both corrected and uncorrected refractive errors who visited the clinic during the data collection time were included in the study. This study was conducted in accordance with the Helsinki Declaration and after the ethical approval from the Deanship of Scientific Research, King Faisal University, Alhasa Saudi Arabia (KFU-REC-2022-JAN-ETHICS512). Informal verbal consent was taken from all the parents or guardians prior to participation in the study and their confidentiality was ensured.

2.2. Study Sample

The sample size of this study was estimated according to sample size calculations for cross-sectional studies. According to the previously published studies, the prevalence of refractive error was 13.7% among school-going children in a local study [6]. After obtaining informal consent, 185 volunteer school going children were recruited to participate in this research and 161 children (Males = 87; Females = 74) aged between 4 and 12 years (M = 8.89; SD = 2.74) finally completed the survey. The other 24 study participants were excluded because of missing answers to the study items.

2.3. Measures

The questionnaire measuring the determinants of refractive errors was adapted from a previous study [21]. The questionnaire was initially written in English, and then translated into Arabic language. A panel of expert researchers evaluated the scale's content and face validity. The face validity of the Arabic version was examined by an Arabic speaker research expert. Prior to data collection, a pilot study was carried out on fifteen randomly selected children. Based on the pilot study, participants understood and answered all of the questionnaire items.

The questionnaire was containing 2 parts, the first part of the questionnaire consists of demographic information and the second part includes questions related to determinants of refractive error. A team of 5 members including two nurses, one optometrist, one ophthalmologist and a medical student were involved in data collection after receiving proper training by the principal investigator.

Demographic data including age, gender and other information related to visual impairment such as visual problem, duration of weaning eyeglass, history and type of refractive error, *etc*. was collected by the nurse through personal interviews.

Regarding questions of determinants to refractive error, the questionnaire consisted of 19 items covering five dimensions, namely, eating habits genetic traits, lifestyle, personal achievements and machine dependence. Responses are obtained on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Jayaraman K, *et al*. [21], obtained a reliability coefficient of all the dimensions ranging from 0.62 to 0.79. For the present study, the Cronbach's alpha was between 0.67 to 0.77.

The refractive error was measured by the ophthalmic nurse using spherical power (right or left) and cylinder power (right or left). A refractometer was used to examine the non-cycloplegic autorefraction of both eyes. After that cycloplegy 1% was used three times in 10 minutes' interval, after 30 minutes from the last drop a retinoscopy was used to evaluate the refractive error. The spherical equivalent (SE) of the refractive error was calculated as SE = (spherical power) + (cylinder power)/2. A professional eye care doctor performed and recorded all of the eye measurements.

2.4. Statistical Analysis

After checking for the quality and consistency of the data, the data was coded and put into EPI data version 3.1 and after that, it was exported to SPSS (version, 25) for analysis. At first, frequency distribution and descriptive statistics with mean and

standard deviation were computed. Binary logistic regression analyses in enter method were utilized to examine the role of independent variables on refractive error. A *P* value of < 0.05 was considered statistically significant.

3. RESULTS

3.1. Initial Analysis

Participants of the present study (Table **1**) were 161 children (87 males and 74 females) living in Hofuf city of Alhasa Region of Saudi Arabia. The age of these participants ranged from 3 to 12 years (*Mean* = 8.89; *SD* = 2.74). About 96 (59.6%) samples with myopia, 28 (17.4%) children with hyperopia and 27 (16.8%) children without any refractive error. It is surprising that the prevalence of refractive errors was high among the school-going Saudi children. Male participants (52.38%) complained of more refractive errors in comparison to their counterpart female participants (47.61%).

Table **2** presents mean scores and *SDs* of determinant variable including eating habits, genetic traits, lifestyle, personal achievement and machine dependence that affects the vision of the 161 school-going children. The result showed that children have disagreed about unhealthy eating habits (*M* = 2.15). Regarding the genetic trait (*M* = 3.24) of the children, the mean score indicates that more than 50% children's parents had a refractive error. In addition, the children disagreed that they had poor lifestyles (*M* = 2.62). Moreover, the mean score of personal achievement (*M* = 3.36) showed that children had good personal achievements in their academic records. Lastly, the machine dependency mean score (*M* = 3.75) indicates that children consume more time using electronic gadgets results in high machine dependency.

3.2. Binary Logistic Regression

In the present study, it was hypothesized that independent variables including eating habits, genetic traits, lifestyle, personal achievement, and machine dependence had a direct impact on refractive errors. Binary logistic regression analyses were utilized to examine the role of independent variables in these relationships. Refractive error yes/no was considered the dichotomous outcome variable. Results of logistic regression analysis (Table **3**) revealed all variables influenced refractive error with Nagelkerke's $R2$ of .61, $p < .05$, and the total probability of correct classification was 0.78. Results show that genetic traits and machine dependence were found to be statistically significant. The positive relationship of genetic traits with refractive error indicated that heritable factors play a significant role in the development of refractive errors. Moreover, machine dependence was also found positively and significantly related to refractive error. This shows that with the increasing use of smartphones, tablets and computers refractive errors increase significantly.

Table 1. Demographic and personal characteristics of participants.

Characteristics	*N*	*%*
Gender	-	-
Male	87	54.00
Female	74	46.00
Age	-	-
<5 years	20	12.40
6 – 9 years	106	65.80
>10 years	35	21.70
Refractive Error	-	-
Yes	126	78.30
No	35	21.70
Type of Refractive Error	-	-
No refractive error	35	21.73
Myopia	96	59.63
Hyperopia	20	12.42
Astigmatism	10	6.22
Refractive Error by Gender	-	-
Male	66	52.38
Female	60	47.62
Refractive Error by Age	-	-
<5 years	18	14.28
6 – 9 years	85	67.46
>10 years	23	18.25
Onset of Wearing Spectacles (in years)	-	-
<5 years	64	39.8
6 – 7 years	48	29.8
8 – 9 years	28	17.4
10 – 11 years	19	11.8
>12 years	2	1.2

Table 2. Means and standard deviations of independent variables.

Variables	M	SD
Eating habits	2.15	.66
Genetic trait	3.24	1.16
Lifestyle	2.62	.77
Personal achievement	3.36	1.03
Machine dependence	3.75	.62

Table 3. Result of binary logistic regression analysis predicting refractive errors from independent variables.

Variables	Exp(β)	Wald	P value	Decision
Eating habits	2.21	2.61	.10	Not Supported
Genetic trait	2.29	8.15	**.00**	Supported
Lifestyle	.69	1.18	.27	Not Supported
Personal achievement	.69	1.38	.24	Not Supported
Machine dependency	.01	30.96	**.00**	Supported
Nagelkerke R Square	-	-	.61	-
Classification Results	-	-	78.30%	-

Note: **p* < .05. ***p* < .01.

4. DISCUSSION

Refractive error is a critical problem among youngsters in Saudi Arabia [7, 22, 23], and worldwide [24 - 26] as the majority of children are unconcerned about their poor vision and may believe they have normal vision. Some children have problems observing near objects clearly, which leads to low academic achievement and poor quality of life. To our knowledge, this is the first study to explore the determinant factors predicting refractive errors among school-going children in Saudi Arabia's eastern region. The current study indicated that the prevalence of refractive errors in youngsters is alarming. Among different types of refractive errors, myopia was found to be the most common type of refractive error in these children. These findings are consistent with previous research examining the prevalence of refractive error in school-aged children [6, 27 - 35].

Binary logistic regression analyses were used to examine the role of determinant factors on visual impairment. Among the five independent variables, only two factors such as genetic traits and machine dependence were found as significant predictors of refractive error. The positive relationship between genetic traits and refractive error demonstrated that heritable factors play an important role in the progression of vision problems. Previous heritability studies using twin data revealed that ocular refraction has a high heritability estimate [12, 37, 38]. Furthermore, positive parental history of refractive error was significantly related to refractive error [20, 39]. These findings provide support for heritability as a predisposed factor for the development of refractive error in children [40]. The association of heritability factors to refractive error is the result of shared environments and behaviors, as well as shared genes [41, 42]. Machine dependence was also to be found positively and significantly related to refractive error. This result is consistent with the previous findings that examined the relationships between digital screen time and visual impairment [7, 43, 44]. Due to Covid-19 pandemic, most teaching and learning are being conducted online, which requires lengthy hours of close work, using small display screens and engaging in longer screen viewing time may contribute to screen dependency in children. Another reason for Saudi children's excessive use of electronic devices may be to maintain daily contact with their mother/father or guardian and to contact someone in an emergency or when their parents are away from home. These factors have a significant impact on these children's vision. Research has shown that using electronic devices for more than 2 h per day presents an independent risk factor for myopia, and heavy use of electronic products is one of the important risk factors for ametropia in both boys and girls [29, 45]. According to a review article, watching television and playing computer/video/mobile games for more than 2 hours per day increased the risk of developing myopia in youngsters [46].

5. LIMITATIONS

There were some limitations to the current study. First, data of the present study was obtained from the AlHasa Governorate of Saudi Arabia. Data collected in this setting may thus be unique, and a replication of this study in other regions of the country may produce different outcomes. Second, this study was conducted in a hospital setting, the prevalence of refractive error may have been overestimated because most people go to the hospital for vision problems. Third, the questionnaire method was used in this study, which cannot demonstrate a causal relationship between the determinant factors and refractive error. Therefore, future research could further explore the link between the determinant factors and refractive error. Finally, the sample size of the present study was relatively small and homogeneous which also limits generalization.

CONCLUSION

The present study demonstrated that the prevalence of

refractive errors was high among the school-going Saudi children and myopia is the most frequent kind of refractive error. Genetic traits and machine dependence were found significant predictors of refractive error. Therefore, every child should be properly examined before enrolled in schools, and routine eye examinations should be performed during their stay in the schools in order to detect refractive errors early.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Deanship of Scientific Research, King Faisal University, Saudi Arabia (KFU-REC-2022-JAN-ETHICS512).

HUMAN AND ANIMAL RIGHTS

No animals were used in this research. All procedures performed in studies involving human participants were in accordance with the ethical standards of institutional and/or research committee and with the 1975 Declaration of Helsinki, as revised in 2013.

CONSENT FOR PUBLICATION

Informed consent was obtained from all participants involved in the study.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The source of the data are patients visited to Ophthalmic Clinic at Almoosa Hospital, Alhasa Saudi Arabia. The material used for data collection was the questionnaire measured determinants of refractive errors. The data that support our findings can be found through directly asking the corresponding author [A.L].

FUNDING

This study was supported by the Deanship of Scientific Research, King Faisal University, Alhasa, Saudi Arabia (Grant No. GRANT4134).

CONFLICT OF INTEREST

The authors declare no conflict of interest financial or otherwise.

ACKNOWLEDGEMENTS

Declared none.

REFERENCES

[1] World Health Organization. World report on vision. 2023. Available From: https://apps.who.int/iris/bitstream/handle/10665/328717/9789240008564-chi.pdf

[2] Rayapoullé A, Gronfier C, Forhan A, Heude B, Charles MA, Plancoulaine S. Longitudinal association between sleep features and refractive errors in preschoolers from the EDEN birth-cohort. Sci Rep 2021; 11(1): 9044. [http://dx.doi.org/10.1038/s41598-021-88756-w] [PMID: 33907290]

[3] Pascolini D, Mariotti SP. Global estimates of visual impairment: 2010. Br J Ophthalmol 2012; 96(5): 614-8. [http://dx.doi.org/10.1136/bjophthalmol-2011-300539] [PMID: 22133988]

[4] Grosvenor T. Primary Care Optometry. 5th ed. St. Louis: Elsevier Health Sciences 2007.

[5] Li SM, Kang MT, Wang NL, Abariga SA. Wavefront excimer laser refractive surgery for adults with refractive errors. Cochrane Database Syst Rev 2020; 12(12): CD012687. [PMID: 33336797]

[6] Al Wadaani FA, Amin TT, Ali A, Khan AR. Prevalence and pattern of refractive errors among primary school children in Al Hassa, Saudi Arabia. Glob J Health Sci 2012; 5(1): 125-34. [http://dx.doi.org/10.5539/gjhs.v5n1p125] [PMID: 23283044]

[7] Bardisi WM, Bin Sadiq BM. Vision screening of preschool children in Jeddah, Saudi Arabia. Saudi Med J 2002; 23(4): 445-9. [PMID: 11953773]

[8] Rowaily MAAI, Alanizi BM. Prevalence of uncorrected refractive errors among adolescents at King Abdul-Aziz Medical City, Riyadh. J Clin Exp Ophthalmol 2010; 1(3): 114. [http://dx.doi.org/10.4172/2155-9570.1000114]

[9] Dandona R, Dandona L. Refractive error blindness. Bull World Health Organ 2001; 79(3): 237-43. [PMID: 11285669]

[10] Resnikoff S, Pascolini D, Mariotti SP, Pokharel GP. *Global magnitude of visual impairment caused by uncorrected refractive errors in 2004.* Geneva. Bull World Health Organ 2004.

[11] Hammond CJ, Snieder H, Gilbert CE, Spector TD. Genes and environment in refractive error: The twin eye study. Invest Ophthalmol Vis Sci 2001; 42(6): 1232-6. [PMID: 11328732]

[12] Wojciechowski R, Congdon N, Bowie H, Munoz B, Gilbert D, West SK. Heritability of refractive error and familial aggregation of myopia in an elderly American population. Invest Ophthalmol Vis Sci 2005; 46(5): 1588-92. [http://dx.doi.org/10.1167/iovs.04-0740] [PMID: 15851555]

[13] Peet JA, Cotch MF, Wojciechowski R, Bailey-Wilson JE, Stambolian D. Heritability and familial aggregation of refractive error in the Old Order Amish. Invest Ophthalmol Vis Sci 2007; 48(9): 4002-6. [http://dx.doi.org/10.1167/iovs.06-1388] [PMID: 17724179]

[14] Guggenheim JA, Pong-Wong R, Haley CS, Gazzard G, Saw SM. Correlations in refractive errors between siblings in the Singapore Cohort Study of Risk factors for Myopia. Br J Ophthalmol 2007; 91(6): 781-4. [http://dx.doi.org/10.1136/bjo.2006.107441] [PMID: 17135339]

[15] Jones-Jordan LA, Sinnott LT, Manny RE, *et al.* Early childhood refractive error and parental history of myopia as predictors of myopia. Invest Ophthalmol Vis Sci 2010; 51(1): 115-21. [http://dx.doi.org/10.1167/iovs.08-3210] [PMID: 19737876]

[16] Katz L, Lambert WA. New look at myopia development: Possible links with childhood stress & diet. J Behav Optom 2011; 22(3): 69-73.

[17] Semba RD. Nutritional Blindness (Vitamin A Deficiency Disorders). In: Handbook of Nutrition and Ophthalmology. 2007; pp. 1-119.

[18] Saw SM, Hong RZ, Zhang MZ, *et al.* Near-work activity and myopia in rural and urban schoolchildren in China. J Pediatr Ophthalmol Strabismus 2001; 38(3): 149-55. [http://dx.doi.org/10.3928/0191-3913-20010501-08] [PMID: 11386647]

[19] Loman J, Quinn GE, Kamoun L, *et al.* Darkness and near work. Ophthalmology 2002; 109(5): 1032-8. [http://dx.doi.org/10.1016/S0161-6420(02)01012-6] [PMID: 11986114]

[20] Yingyong P. Risk factors for refractive errors in primary school children (6-12 years old) in Nakhon Pathom Province. J Med Assoc Thai 2010; 93(11): 1288-93. [PMID: 21114208]

[21] Jayaraman K, Iranmanesh M, Liang CC, Inranmanesh M. The determinants of early refractive error on school-going Chinese children: An empirical study in Malaysia. SAGE Open 2016; 6(2): 2158244016644945. [http://dx.doi.org/10.1177/2158244016644945]

[22] Desouky DE, Nighat M, Tariq K. Refractive error among a sample of female primary school children in Taif City, KSA. Int J Public Health Epidemiol 2014; 2(10): 89-97.

[23] General Authority of Statistics. Population Statistics. In: Statistical Year Book. 2015; 51.

[24] Sewunet SA, Aredo KK, Gedefew M. Uncorrected refractive error and associated factors among primary school children in Debre Markos

District, Northwest Ethiopia. BMC Ophthalmol 2014; 14(1): 95. [http://dx.doi.org/10.1186/1471-2415-14-95] [PMID: 25070579]

[25] EL-Bayoumy BM, Saad A, Choudhury AH. Prevalence of refractive error and low vision among school children in Cairo. East Mediterr Health J 2007; 13(3): 575-9. [PMID: 17687830]

[26] Mb P, R M, Ma R. A study on the prevalence of refractive errors among school childern of 7-15 years age group in the field practice areas of a medical college in Bangalore. Int J Med Sci Public Health 2013; 2(3): 641-5. [http://dx.doi.org/10.5455/ijmsph.2013.220420131]

[27] Aldebasi YH. Prevalence of correctable visual impairment in primary school children in Qassim Province, Saudi Arabia. J Optom 2014; 7(3): 168-76. [http://dx.doi.org/10.1016/j.optom.2014.02.001] [PMID: 25000873]

[28] Williams C, Miller LL, Gazzard G, Saw SM. A comparison of measures of reading and intelligence as risk factors for the development of myopia in a UK cohort of children. Br J Ophthalmol 2008; 92(8): 1117-21. [http://dx.doi.org/10.1136/bjo.2007.128256] [PMID: 18567647]

[29] Althnayan YI, Almotairi NM, Alharbi MM, Alamer HB, Alqahtani HB, Alfreihi S. Myopia Progression Among School-Aged Children in the COVID-19 Distance-Learning Era. Clin Ophthalmol 2023; 17: 283-90. [http://dx.doi.org/10.2147/OPTH.S381061] [PMID: 36711259]

[30] Yam JC, Tang SM, Kam KW, *et al.* High prevalence of myopia in children and their parents in Hong Kong Chinese Population: The Hong Kong Children Eye Study. Acta Ophthalmol 2020; 98(5): e639-48. [http://dx.doi.org/10.1111/aos.14350] [PMID: 31981300]

[31] Plotnikov D, Williams C, Atan D, Davies NM, Ghorbani Mojarrad N, Guggenheim JA. Effect of education on myopia: Evidence from the United Kingdom ROSLA 1972 reform. Invest Ophthalmol Vis Sci 2020; 61(11): 7. [http://dx.doi.org/10.1167/iovs.61.11.7] [PMID: 32886096]

[32] Pärssinen O. The increased prevalence of myopia in Finland. Acta Ophthalmol 2012; 90(6): 497-502. [http://dx.doi.org/10.1111/j.1755-3768.2011.02210.x] [PMID: 21902818]

[33] Mukazhanova A, Aldasheva N, Iskakbayeva J, *et al.* Prevalence of refractive errors and risk factors for myopia among schoolchildren of Almaty, Kazakhstan: A cross-sectional study. PLoS One 2022; 17(6): e0269474. [http://dx.doi.org/10.1371/journal.pone.0269474] [PMID: 35657822]

[34] Pradhan N, Sachdeva A, Goel T, Bhola B, Jha D. Prevalence of refractive errors among school children of 6-12-years of age group and reason for not using spectacles even after correction. Int J Res Med Sci 2018; 6(3): 798-801. [http://dx.doi.org/10.18203/2320-6012.ijrms20180444]

[35] Wu LJ, You QS, Duan JL, *et al.* Prevalence and associated factors of myopia in high-school students in Beijing. PLoS One 2015; 10(3): e0120764. [http://dx.doi.org/10.1371/journal.pone.0120764] [PMID: 25803875]

[36] Alghamdi W. Prevalence of refractive errors among children in Saudi Arabia: A systemic review. Open Ophthalmol J 2021; 15(1): 89-95. [http://dx.doi.org/10.2174/1874364102115010089]

[37] Dirani M, Chamberlain M, Shekar SN, *et al.* Heritability of refractive error and ocular biometrics: The Genes in Myopia (GEM) twin study. Invest Ophthalmol Vis Sci 2006; 47(11): 4756-61. [http://dx.doi.org/10.1167/iovs.06-0270] [PMID: 17065484]

[38] Lyhne N, Sjølie AK, Kyvik KO, Green A. The importance of genes and environment for ocular refraction and its determiners: A population based study among 20-45 year old twins. Br J Ophthalmol 2001; 85(12): 1470-6. [http://dx.doi.org/10.1136/bjo.85.12.1470] [PMID: 11734523]

[39] Saad A, El-Bayoumy BM. Environmental risk factors for refractive error among Egyptian schoolchildren. East Mediterr Health J 2007; 13(4): 819-28. [PMID: 17955764]

[40] Alem KD, Gebru EA. A cross-sectional analysis of refractive error prevalence and associated factors among elementary school children in Hawassa, Ethiopia. J Int Med Res 2021; 49(3): 300060521998894. [http://dx.doi.org/10.1177/0300060521998894] [PMID: 33752506]

[41] Fan Q, Verhoeven VJM, Wojciechowski R, *et al.* Meta-analysis of gene–environment-wide association scans accounting for education level identifies additional loci for refractive error. Nat Commun 2016; 7(1): 11008. [http://dx.doi.org/10.1038/ncomms11008] [PMID: 27020472]

[42] Harb EN, Wildsoet CF. Origins of refractive errors: Environmental and genetic factors. Annu Rev Vis Sci 2019; 5(1): 47-72. [http://dx.doi.org/10.1146/annurev-vision-091718-015027] [PMID: 31525141]

[43] Lanca C, Saw S. The association between digital screen time and myopia: A systematic review. Ophthalmic Physiol Opt 2020; 40(2): 216-29. [http://dx.doi.org/10.1111/opo.12657]

[44] Yang GY, Huang LH, Schmid KL, *et al.* Associations between screen exposure in early life and myopia amongst chinese preschoolers. Int J Environ Res Public Health 2020; 17(3): 1056. [http://dx.doi.org/10.3390/ijerph17031056] [PMID: 32046062]

[45] Li L, Xu J, Lu Y, Feng L. Research progress on myopia prevention and control by promoting outdoor activity and physical exercise in children and adolescents. China Sport Sci Technol 2019; 55: 3-13.

[46] Saxena R, Vashist P, Tandon R, *et al.* Incidence and progression of myopia and associated factors in urban school children in Delhi: The North India Myopia Study (NIM Study). PLoS One 2017; 12(12): e0189774. [http://dx.doi.org/10.1371/journal.pone.0189774] [PMID: 29253002]