

Assessment of Genetic High Myopia at Onset and Progression in School-Aged Children with Visual Impairment in Rivers State, Nigeria

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Abstract

The study assessed Genetic High Myopia at Onset and Progression in School-aged Children with Visual Impairment in Rivers State, Nigeria. The design adopted in this study was a survey research design. One research question and one corresponding hypothesis guided the conduct of the study. The sampling technique used was the stratified sampling technique. A self-structured questionnaire was employed as an instrument for data collection. An expert in Special Needs Education and two experts in Measurement and Evaluation validated the instrument. The reliability coefficient was obtained using Cronbach's alpha. Mean rating was used in answering the research question and independent sample t-test analysis was used to test the hypothesis at 0.05 significance level. The Statistical Package for Social Science (SPSS) aided the data analysis. The study revealed that to a high extent, parental refractive error is a risk factor of high genetic myopia at onset and progression amongst school-aged children with visual impairment in Rivers State, Nigeria. The study recommended that the heritability susceptibility theory of high myopia may not be disputed, therefore, parents should take their children for regular optical evaluation especially where one or both parents have refractive error to control the progression of myopia to elevated levels which causes visual impairment.

Keywords: *Genes, High myopia, School-aged children, Visual impairment*

Introduction

The incidence of myopia in the human population can be traced to more than four centuries ago. It has been identified as one of the significant causes of vision loss and a risk for a range of pathological ocular conditions. Myopia is a sub-type of refractive error that features with blurring of long distant objects in all of its types. Park (2012) stated that myopia which causes people to see things that are near but not things that are at a distance is the result of an elongated eyeball which leads to misalignment of light on the retina. Santini (2019) explained that myopia results when the eye's refractive elements, the cornea and the lens together focus at a distance shorter than the eye's physical axial length, resulting in an image placed in front of the retina. Zadnik, Mutti, Friedman, Quale, Jones, Qiu, Kim, Hsu and Moeschberger (1999) pointed out that myopic eyes are associated with excessive axial length, steep corneas, and thin and less crystalline lens. Tomiyama and Richardale (2019) opined that the goal of emmetropisation is for the eye's corneal and lenticular refraction to match the measuring axial length of the eye during growth but in myopia, the process overshoots emmetropisation and results in myopic refractive error.

Myopia may be described according to time of onset, severity, and/or associated comorbidity. Its classification also follows the same in most incidences. Common or juvenile myopia may start at childhood, progress with the child's developing eyes, and remain at a minimal or moderate level of less than -6 diopters (D). It is predominantly observed in school-aged children especially when they start basic school after 6 years of age. Juvenile myopia may be described as an axial elongation above the norm, with other parts of the eye remaining within the normal range. It stabilises at mid-adolescence (15 -17 years) and hardly progresses to higher levels after early 20 years of age. Juvenile myopia is associated with the blurring of long-distance objects only and may be managed with prescriptive spectacles. It is also not a visual disease since the eye is healthy and other ocular structures remain within normal range.

Pathologic or high myopia on the other hand is more severe and associated with excessive elongation of the globe. It may be found to exist with a genetic component, an early onset, and subsequent progression and this is one reason why it may be found early in young pairs of eyes. The defect arises when myopic eyes fail to stabilise at a mild or moderate level but continue to elongate to a high level, keeping the eye susceptible to degenerative changes at the posterior end. Myopia may be high when intervention measures are not taken to slow down the progression. It may progress to elevated levels because children's eyes are adaptive and may develop in the wrong dimensions if lured to do so, thus, exposing premature pairs of eyes to environmental risk factors such as intense near-work, especially with genetic influence and the visual effects that follow may be interpreted as normal and a sure sign for the progression of myopia.

The natural ability of myopia to progress with growing eyes is an indication that its level after an onset may vary with time and this makes ocular changes in children a common occurrence. Lyon (2019) remarked that as a child grows, their eyes also grow and the shape of the eye can change. The progression of myopia is actually when myopia becomes a problem and a source of concern. It is the reason why parents, countries, and even the international community see the case of myopia as one needing urgent intervention because

of the consequences.

It is the nature of inherited traits like high myopia to remain quiet without being noticed for a long time but with the presence of environmental factors such as inappropriate use of a young pair of eyes, elongation of the eye commences to high levels. Therefore, environmental factors serve as triggers responsible for the progression of myopia. Tabery (2014) gave a clear description of this process that molecular geneticists have discovered that genes get turned on or off depending on which environment they are exposed to. Lim, Gong, Ah-Kee, xiao, Zhang and Yu (2014) stated that there was a strong association between parental history of myopia, genesis, and progression of myopia in offspring.

A single copy of the disease from either parent located in a non-sex chromosome may result in autosomal dominance inheritance, thus, a child may inherit the myopia gene from either parent who may have the gene. Also, an activation of an autosomal recessive inheritance from two copies of the diseased gene donated by both parents may trigger an incidence. Again, variants of the gene on the X chromosome may result in an X-linked inheritance where persons without a history of the disorder may begin to display the symptoms. Seet, et al. (2001) stated that myopia has been postulated to arise from an underlying genetic predisposition that makes the eye more susceptible to environmental modifications of its growth. This may indicate that the myopia gene may be exposed to certain environmental triggers responsible for its progression and rising prevalence.

Thus, a child with myopic parents may inherit the physiological condition of a myopic eye associated with the incidence of myopia such as longer eyes which is a major character trait of myopia. It may be caused by a single gene with an increased risk determined by the number of myopic parents. Findings from studies report that prevalence and severity of myopia is associated with children with myopic parents and that parental myopic status is not only an indication of the onset of myopia but also a source of progression in school-aged children.

Coviltir, Burcel, Cherecheanu, Ionescu, Dscalescu, Potop and Burcea (2019) stated that the heritability of myopia is greater in monozygotic twins (95%) compared to dizygotic twin (29%) and the hypothesis of inheritability- susceptibility indicates that myopia appears to be more frequent in children whose both parents are myopic (32.9%) versus (6.3%) in children whose both parents are emmetropic. Young (2004) explained that there is a positive correlation between parental myopia and myopia in their children which is an indication of hereditary factors in myopia susceptibility because children with a family history of myopia had an average of less hyperopia, deeper anterior chambers, and longer vitreous chamber even before becoming myopic, thus, they are more likely to develop myopia either as children or adolescents.

Williams and Hammond (2019) stated that the person is so nearsighted that degenerative changes begin to occur at the back of the eye which leads to low vision that cannot be corrected with glasses or contact lenses. The researchers further stated that myopia progresses until such persons need -5 diopters (D) or more of spherical correction and a person who needs $>-5D$ has a visual acuity that is far worse than the threshold for blindness.

Years ago, the difference between juvenile myopia and high myopia in young

children remained distinct but in the last few decades, the distinction began to thin dangerously. Its sudden rise in prevalence and level of severity in recent times has given myopia its description as a public health problem. Holden, Wilson, Jong, Sankaridurg, Frickie, Smith and Resnikoff (2015) explained that uncorrected distant refractive error is already a global health problem, the main cause of visual impairment and the second highest cause of blindness but this does not include blindness from pathological myopia nor does the estimation of its financial burden take into account blindness due to pathological myopia. That was why Carr and Stell (2017) asserted that it is a leading cause of visual impairment worldwide.

Guo, Du, Lu and Zhang (2015) reported that high myopia is a public health problem internationally imposing an enormous economic and social burden on many countries and China is no exception. Ong (2020) defined pathologic myopia as an eye with a refractive error greater than -6.00 diopters (D), accompanied by characteristic degenerative changes in the sclera, choroid, and retinal pigment epithelium associated with decreased vision. Windsor and Windsor (2017) defined pathological myopia as an extremely high amount of nearsightedness that causes a major alteration of the shape or globe of the eye which may lead to profound vision loss. Robert (2015) described it as the seventh leading cause of blindness in which the macula thins with every increase in axial length or as the eye elongates.

Li and Zhang (2017) described common myopia as a complex trait resulting from the effects of genetic and environmental factors while high myopia may be transmitted as a complex trait or a mendelian trait. They further stated that sometimes, common or physiologic myopia in early childhood may develop as high myopia or pathologic myopia in adults or older individuals and that most individuals with high myopia may not have pathological changes in the retina, especially in young ages. National Research Council of United States Committee on Vision (1989) stated that myopia progression can occur in simple myopia in which the eye is anatomically normal, healthy, and capable of normal corrected visual acuity, and can also occur in pathologic myopia in which the eye ophthalmoscopically or other-wise shows visible pathological signs or both

Kochik (2019) stated that it is now known that no amount of myopia is considered safe, the more the myopia, the greater the risk starting from even the smallest measurable amount. American Academy of Ophthalmology (2018) reiterated that nearsightedness may not seem like a serious eye condition since glasses and contacts can provide effective treatment but high myopia defined as -6D or more may lead to potential blinding complications. Pugazhendhi, Ambati and Hunter (2020) explained that as the prevalence of myopia increases, the age of the disease onset decreases which allows more time for myopia to progress before stabilisation as well as increase the chance of progression into higher myopia. Shar (2019) also opined that myopia progression is associated with the development of sight-threatening conditions and that refractive error as low as -3.00D significantly increases the risks of cataracts, retinal detachment, and myopic macular degeneration.

Myopia may progress if a child is found to be myopic at an early age of 6 or 7 years if the child is found to have very low levels of hyperopia at the same age if he/she is often engaged with educational activities especially with the extended period of more than 45

minutes and a working distance of less than 20 centimeters, if he/she has a family history of myopia with the risk increasing with numbers of myopic parents and if such child has very little or no outdoor time most days in the week. Parssinen, Kauppinen and Viljanen (2014) stated succinctly that factors predicting faster myopic progression were parental myopia and less time spent in sports and outdoor activities in childhood.

The impact of elevated levels of myopia on a person cannot be overlooked. Wolffsohn, Flitcroft, Gifford, Jong, Jones, Klaver, Logan, Naidoo, Resnikoff, Sankaridurg, Smith, Trolier and Wildsoet (2019) remarked that myopia has been the topic of scientific study for more than four hundred years but it is only more recent that it has been recognised as a serious public health issue, owing to its being a significant cause of vision loss and a risk for a range of pathologic ocular conditions. Hyman, Gwaiada and Hussein (2005) reiterated that even low levels of myopia are associated with increased risks of ocular complications such as retinal, glaucoma, and cataract.

Holden, et al. (2015) stated that myopia can no longer be considered a benign refractive error, easily corrected with a pair of spectacles or contact lenses because it has an insidious side which even if adequately corrected can sometimes progress and may lead to sight-threatening complications. Also, current forms of correction (spectacles, contact lenses, and refractive surgery) do not cure the underlying condition but provide an optical solution for clear vision and thus do not offer any protection from the consequences of high myopia.

Morgan, et al. (2016) also explained that early onset leaves more time for progression at higher rates and provides a simple explanation of how the epidemic of myopia will almost inevitably lead to an epidemic of high myopia. Chuang (2017) reported that the prevalence has almost doubled worldwide within the past two decades and the age of onset is decreasing at an alarming rate. The National Research Council (United States) Committee on Vision, (1989) explained that amongst children with onset at age 11 years to 15 years, 66.7% had less than 3.00D of myopia at age 15 to 16 years; 32.2% ended up with 3.00D to 5.75D of myopia and 1.1% reached 6.00D or more of myopia. They also stated that the progression rate may also differ according to geographical location. The rate of progression in the United States was around the neighborhood of 0.30D to -0.60 diopter (D) yearly while that of Japan was about -0.50 diopter (D) to -0.80 diopter (D) per year.

Statement of the Problem

The visual system in humans is such that allows the eye to grow as the child grows because infants are usually born with undersized and underdeveloped eyes, however, there is an underlying mechanism that controls and regulates eye growth in children. As the child grows, the visual system must aim to achieve its normal size and functionality, which makes eye elongation a normal process in young pairs of eyes.

For children with genetic myopia, they may naturally have inherited the physiological structure of an elongated eye, thus, it is easy for the eyes to exceed their normal length as they grow. It only takes environmental risk factors to combine with genetic factors to get an eye longer than normal. Thus, the presence of risk factors not only triggers an onset

of myopia through axial elongation but also facilitates the progression of myopia to elevated levels.

The onset of myopia is generally quiet without any form of medical, physical, social, or emotional discomfort because it is an internal structural defect. There is usually no tearing, swelling, itching, redness, and/or pain in the eye. The only early sign is the inability to see distant objects causing blurring of images. Blurring is often unnoticed externally and so it is often ignored by parents, teachers, or those who are in direct contact with the child.

Blurring occurs when light rays do not get to the retina but converge in front of it because of an elongation of the eyeball. For children with parental myopia, the level of myopia tends to increase more than children with emmetropic parents. Unlike juvenile myopia, high myopia may start before six years or at about school age and progress gradually into adulthood without stabilising. At about -6.00 diopters (D) and above, the axial exceeds the normal length of about 24 millimeters into an alarming length of about >26.5 millimeters and/or more. It is described as high myopia where excess elongation may cause stretching and thinning of the globe which may create visual complications at the posterior pole of the eye. High myopia may become obvious in children through poor academic performance, sensitivity to light or glare, unusual choice of color, low contrast sensitivity, low visual acuity, and other behavioural traits associated with difficulties in visual tasks.

At this level, it is seen as degenerative in which the internal structures of the eye are unable to withstand the effects of the stretching eye. The internal structures begin to undergo pathological changes affecting the major parts of the eye responsible for clear vision. The macular at the centre of the retina responsible for clear central vision begins to thin even if peripheral vision is not directly affected. Thus, the ability to see gradually diminishes until it may be completely lost. As it gradually progresses to high levels, dioptric reading increases, the near point becomes shorter, blurring increases, and stretching and thinning of the globe occurs as a result of axial elongation and successive myopic shift which may subject the eye to irreversible visual complications such as visual impairment and/or blindness.

As a norm, children with elevated levels of myopia find it very difficult to cope with any visual task with long working distances due to limitations in central vision. Peripheral vision may not be affected but central vision diminishes gradually as focusing on objects straight-on becomes progressively difficult. This is the major reason why such children continually change their prescriptive spectacle lenses to one with a higher power that may help them see better as their vision diminishes. At this level, low vision begins to set in.

Firstly, excess elongation of the globe above the norm may prevent nutrients from reaching the lens, making them lose their clarity (formation of cataracts). Secondly, elongation may lead to pulling and tearing of the retinal layer from the choroid and sclera layers, a condition known as retinal detachment. Thirdly, elongation may lead to pressure in the aqueous humor, subjecting the eye to glaucomatous damage at the optic disk (glaucoma). Again, degeneration may occur at the macular, a part of the retina concentrated with rods and cones. These cells need light to function properly and become weak with disuse and gradually begin to wear out as light rays do not get to them (macular degeneration). Thus, central vision begins to diminish gradually with time, a category of visual impairment known

as low vision.

At one point or the other, prescriptive spectacle may help the child see better and slow down its progression but it does not reverse the anatomical damage that has been done. This condition may create economic and social burdens, and affect academic performance, self-esteem/self-confidence, career choice, and quality of life in general. With an early onset, these irreversible complications of visual impairment and/or blindness may be the result of eye elongation, the structural definition of myopia, found in children with high myopia.

The study assessed genetic traits of high myopia at onset and progression amongst school-aged children with visual impairment in Rivers State, Nigeria. Specifically, the study examined the extent to which parental refractive error is a factor of high myopia at onset and progression amongst school-aged children with visual impairment in Rivers State, Nigeria, based on gender. The research questions raised to guide the study was:

1. What is the mean rating on the extent to which parental refractive error is a factor of high myopia at onset and progression amongst school-aged children with visual impairment in Rivers State, Nigeria, based on gender?

The following null hypothesis was formulated to guide the conduct of the study:

1. There is no significant difference between the mean rating of school-aged children with visual impairment on the extent to which parental refractive error is a factor of high myopia at onset and progression in Rivers State, Nigeria, based on gender.

Methodology

The research design adopted in this study was the survey research design. Maduabum (2007) explained that a survey research design is one in which data is collected from a relatively large number of people or items considered to be representative of the entire group. The process involves the collection of data to test certain hypotheses or answer research questions generated in the study. It also specifies who and what are to be measured in a study. The sample findings are generalised to the population from which the sample is drawn.

The population of the study comprised all school-aged children with visual impairment (low vision) as a result of high/elevated levels of myopia in Rivers State, Nigeria. This figure was obtained from the eye clinics of the University of Port-Harcourt Teaching Hospital, and the Rivers State University Teaching Hospital, Port-Harcourt, Rivers State. The choice of these major hospitals is because smaller clinics may not have the specialized gadgets, equipment, and professionals to manage visual impairment and blindness, especially a progressive case like high myopia, thus, most children with high myopia may be referred to these facilities for treatment.

The sample of the study was sixty-three (63) school-aged children with visual impairment as a result of elevated levels of myopia at onset and progression in Rivers State, Nigeria. The sample was made up of twenty-eight (28) male children and thirty-five (35) female children from the eye clinics of the University of Port-Harcourt Teaching Hospital and the Rivers State University Teaching Hospital, Port-Harcourt.

Two instruments were used for data collection. A self-structured instrument titled “Risk Factors of Myopia Questionnaire,” (RFOMQ) was divided into two sections, A and B. Section A of the instrument contained information on the personal data of the respondents such as age, sex, and educational level. Section B contained information on the Risk Factors of Myopia. The instrument contained (47) items in (6) sub-scales. Section B of the instrument was patterned alongside the modified Likert scale. The responses and weights are as follows: Strongly Agree (SA)=4, Agree (A)=3, Disagree (DA)=2 and Strongly Agree (SA)=1.

The second instrument employed in this study was a self-structured instrument titled “Demographics on Children with Myopia Form,” (DCMF). It was segmented into five sections namely: Sex, Age, Dioptric Reading, Visual Acuity, and Level of Impairment. The RFOMQ and DCMF were given to experts in Special Needs Education, and in Measurement and Evaluation. The corrections of these experts were incorporated into the final draft of the instrument.

The reliability of the RFOMQ was determined using the Cronbach alpha reliability method. The instrument was administered to 10 students with myopia in Bayelsa State. The choice of Bayelsa State was due to the proximity of the state to Rivers State. The instrument was administered to the 10 students and their responses to the items were subjected to statistical analysis. The instrument yielded a reliability of 0.79 which was considered adequate.

Method of Administration of Instrument

The information contained in the DDCMF was provided by eye specialists in the eye clinics of the hospitals. The DCMF provided information on the demographics and visual status of children with visual impairment (low vision) as a result of high myopia. The RFOMQ provided information on the risk factors.

A mean rating was used in answering the research question and an independent sample t-test was used to test the hypothesis at a 0.05 level of significance. The Statistical Package for Social Sciences (SPSS) version 23.0 aided the data analysis.

Results

Research Question

What is the mean rating on the extent to which parental refractive error is a factor of high myopia at onset and progression amongst school-aged children with visual impairment in Rivers State, Nigeria, based on gender?

The extent to which parental refractive error is a factor of high myopia at onset and progression amongst school-aged children with visual impairment in Rivers State, Nigeria, based on gender was subjected to mean and standard deviation.

Table 1: Mean and Standard Deviation of the Extent to which Parental Refraction Error is a

factor of High Myopia at Onset and Progression amongst School Aged Children Based on Gender

S/N	Items	Gender						Mean Set	
		Male N = 28			Female N = 35				
		\bar{X}	SD	Rm ks	\bar{X}	SD	Rm ks		
1	Parents may have a refractive error and this may result in high myopia onset and progression being transferred to school-aged children	2.83	.71	HE	2.85	.81	HE	2.84	
2	Most cases of high myopia may be transferred from parents to children	2.79	.72	HE	2.83	.72	HE	2.81	
3	Parents may neglect their refractive error which could be transferred to their children	2.88	.76	HE	2.81	.74	HE	2.85	
4	High myopia due to parental refractive error is difficult to detect at a very early age	2.86	.79	HE	2.84	.71	HE	2.85	
5	Single parent with myopia may cause an onset in the child	2.84	.92	HE	2.86	.75	HE	2.85	
6	Both parents with high myopia may trigger an onset of high myopia in the child	2.64	.58	HE	2.63	.59	HE	2.64	
7	Other family member with refractive error is a sign of inherited high myopia gene in the family	2.66	.59	HE	2.68	.64	HE	2.67	
8	All cases of high myopia are genetic	2.78	.72	HE	2.74	.69	HE	2.76	
9	High myopia may be acquired due to the environment	2.69	.63	HE	2.67	.63	HE	2.68	
Grand Mean Rating		2.77	.65		2.78	.61			

Table 1 reveals the mean rating of school-aged children on the extent to which parental refractive error is a factor of high myopia at onset and progression amongst children with visual impairment in Rivers State, Nigeria, based on gender. The mean rating of both male and female school-aged children with visual impairment on the extent to which parental refractive error is a factor of high myopia at onset and progression indicated that parental refractive error to a high extent is a factor of high myopia at onset and progression. The mean rating of the school-aged children is greater than 2.5. This is also confirmed by the grand mean ratings of both male and female school-aged children (2.77 and 2.78 respectively). This is further confirmed by the mean set of each item which is greater than 2.5. The standard deviation revealed the extent to which the mean rating of school-aged children is in agreement that parental refractive error is a factor of high myopia at onset and progression.

Hypothesis

There is no significant difference between the mean rating of school-aged children with visual impairment on the extent to which parental refractive error is a factor of high myopia at onset and progression in Rivers State, Nigeria, based on gender.

The difference between the mean rating of school-aged children with visual impairment on the extent to which parental refractive error is a factor of high myopia at onset

and progression in Rivers State, Nigeria, based on gender was subjected to independent samples t-test analysis.

Table 2: Independent t-test analysis of the Mean Rating of School Aged Children with Visual Impairment on the Extent to which Parental Refractive Error is a Factor of High Myopia at Onset and Progression based on Gender

Gender	N	X	SD	Df	Cal. t-value	p-value	Remarks
Male	28	2.77	.65				
Female	35	2.78	.61	61	-.062	.568	H_0 is not significant $p > .05$

Alpha level = .05

Table 2 reveals that calculated t-value is not significant (Cal t-value = -.062; df = 61; $p > .05$). The null hypothesis is therefore not rejected while the alternate hypothesis is rejected. The result of hypothesis one is that the difference between the mean rating of school aged children with visual impairment on the extent to which parental refractive error is a factor of high myopia at onset and progression in Rivers State, Nigeria based on gender is not statistically significant at 0.05 level of significance.

Discussion of the Findings

The result of research question one Table 1 revealed that to a high extent prenatal refractive error is a factor of myopia at onset and progression among school aged children with visual impairment in Rivers State, Nigeria based on gender. When the mean rating of school aged children with visual impairment in Rivers State, Nigeria, on the extent to which parental refractive error is a factor of myopia at onset and progression was subjected to independent samples t-test Table 2 the calculated t-value was found not to be statistically significant at 0.05 level of significance. This result is in agreement with Low, Dirani, Gazard, Chan, Zhou, Selvarag, Au Eong, Young, Mitchell, Wong and Saw (2000) that family history such as parental refractive error is a factor of myopia at onset and progression among school aged children with visual impairment. The present finding may be due to the following: most cases of myopia may be transferred from parents to children, other family members with refractive error is a sign of inherited myopia in the family, and myopia due to parental refractive error is difficult to detect at a very early age.

Conclusion

A parental refractive error to a high extent is a factor of high myopia at onset and progression amongst school aged children with visual impairment in Rivers State, Nigeria, based on

gender.

The mean rating of school aged children with visual impairment in Rivers State, Nigeria, on the extent to which parental refractive error is a factor of high myopia at onset and progression is not statistically significant based on gender

Recommendations

The following recommendations are given based on the findings of the study:

1. Successive change in prescriptive optical device is a sure sign of progression. Such children need timely visits to ophthalmologists and optometrists on regular basis.
2. Young school age children presenting with elevated levels of juvenile myopia should be given immediate attention because no level of myopia in young children is considered safe. New outbreaks should not be ignored.
3. Near work activities should be reduced in young pair of eyes, if this is done, intermittent breaks should be fashioned into the activity to reduce eye strain.
4. Low visual acuity is an obvious sign of high myopia in children and/or short reading distance. Teachers and caregivers may need to watch out for that and alert the relevant authorities and parents.
5. Parents should permit their young children access to quality outdoor time in general and natural vitamin D in particular.
6. Use of screen devices in children should be strictly regulated.

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