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Refractive Errors and Visual Function in Normal Hearing and Hearing-Impaired Schoolchildren: A Comparative Study

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Abstract

Background: Visual impairment has been reported in children with other forms of disabilities. This paper sought to investigate the prevalence of refractive error, as well as compare some visual functions among hearing-impaired children and children whose hearing abilities are within the normal range.

Method: This comparative study, which involved 251 children, was undertaken in two basic schools in the Ashanti Region of Ghana. A simple random sampling technique was used to select the participants. Visual acuity was recorded using LogMAR chart and contrast sensitivity was assessed with a standard Pelli-Robson contrast charts. The anterior segment and fundus were examined with an ophthalmoscope. Streak retinoscopy was used to determine the refractive status of the participants. Data was entered and analysed using Statistical Package for Social Scientists (SPSS) version 23 and the level of significance was set at a p-value of 5%.

Results and Discussion: Data The prevalence of refractive error in the 170 normal children was 8.8% while that of the 81 hearing-impaired children was 29.6%. In assessing the types of refractive errors within the groups, 50% of the hearing-impaired participants with refractive error had myopia (≥ 1.00D). Hyperopia (≥ 1.00D) was detected in 37.5% of the hearing-impaired population with refractive error while 12.5% of the same population had astigmatism (≥ ± 1.00 D). In the hearing group, the following refractive errors were detected amongst the sampled population with refractive error: 46.59% had myopia (≥ 1.00D), 20.46% had hyperopia (≥ 1.00D) and 32.95% had astigmatism (≥ ± 1.00 D). The study showed a weak positive association between visual acuity and the hearing status of participants ($r = 0.249$, $p = 0.01$) and an almost zero correlation between the contrast sensitivity and the hearing status of the participants ($r = -0.01$ $p = 0.02$).

Conclusion: Persons with various degrees of hearing impairment, as opposed to persons with normal hearing status, are more likely to suffer one visual aberration or the other, which could negatively affective their ability to navigate through their daily activities. Hence, refractive errors and other visual dysfunctions among hearing-impaired children should be detected at the earliest and the appropriate management given.

Keywords: *Refractive Error; Visual Function; Normal Hearing; Hearing-impaired; Schoolchildren*

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Abbreviations: ICF: International Classification of Functioning; LogMAR: Logarithm of Minimum Angle of Resolution; VA: Visual Acuity

Introduction

The International Classification of Functioning Disability and Health defines disability as an umbrella term for impairments, activity limitations and participation restrictions [1]. ICF estimates over a billion people (corresponding to about 15% of the world's population) living with some form of disability. Amongst these, between 110 million and 190 million are 15 years and older having significant difficulties in functioning [1].

The UN Convention on the Rights of Persons with Disabilities Article 25 reinforces the right of persons with disabilities to attain the highest standard of health care, without discrimination [1].

Visual impairment is defined as a functional limitation of the visual system that can manifest as reduced visual acuity or contrast sensitivity, visual field loss, photophobia, diplopia, visual distortion, visual perceptual difficulties, or any combination of the above. A visual impairment can cause disability by significantly interfering with one's ability to function independently, to perform activities of daily living [2,3].

In 2006, the World Health Organization reported the global estimate of visual impairment to be approximately 314 million. Out of this number, 45 million people were blind. Among aged 5-15 years children, visual impairment due to uncorrected refractive errors accounts for at least 13 million and in working age adults (aged 16-49), it accounts for an estimated 45 million. Major risk factors of visual impairment include age and gender. Although the prevalence of blindness among children is about ten times lower than that among adults, childhood blindness remains a high priority because of the expected number of years to be lived in blindness [4].

Cumulative incidence of severe visual impairment in the general population is 6 per 10,000 by 16 years of age in over 75% of children [5-7]. The higher prevalence of visual problems in children with disabilities is accounted for by the several underlying causes of their disability. Visual problems are particularly increased in the following children; preterm children, children with cerebral palsy, children with learning disability, children with Down syndrome and children with hearing impairment [8].

Visual impairment in preterm children has been reported in 1%-3% with causes including retinopathy of prematurity [9]. Refractive errors have also been reported to be four times more common in those born preterm (29.6%) than those born at full term (7.8%) [10]. While hyperopia is common in full term children, myopia is more common in preterm children with and without retinopathy of prematurity [9].

Children with cerebral palsy have been reported to show a range of neuro-ophthalmological abnormalities including reduced acuity, refractive errors, strabismus, oculo-motor abnormalities and field alterations [11]. Previous studies have found that premature birth and its sequelae are common precursors to cerebral palsy. The prevalence of severe visual impairment (i.e. visual acuity < 6/60) in children with cerebral palsy in Europe is reported to be 11% [12,13].

Salt and Sargent found trisomy 21 to be one of the most common genetic disorders. Children with this disorder are at high risk of ocular abnormalities including refractive errors, strabismus, keratoconus, etc. [14,15]. Several studies have reported an increased risk of visual impairment in children with learning disability [7,16,17].

Lastly, extant literature had reported higher prevalence of ophthalmologic abnormalities among hearing-impaired population compared with the normal hearing population of the same age. The incidence of ophthalmologic abnormalities ranges from 44%-65% in hearing-impaired population [18-20].

From the concept of sensory substitution, sight is the core sense used to compensate for hearing loss in the hearing-impaired population [21]. In addition, there is a strong connection between ocular health and academic performance for all school children, and in particular, for hearing-impaired children, good vision becomes a necessity for learning [22].

This study, therefore, sought to determine the prevalence of refractive errors and as well, compare some visual functions between two groups of school children: one with normal range hearing and the other with impaired hearing.

Methodology

Study Participants: The subjects recruited for the study were the hearing-impaired students from the Ashanti School for the Deaf in Jumasi and normal hearing students from the St. Joseph Anglican School in Ayeduase, both in Ashanti Region of Ghana.

Sampling Size and Sampling Technique: A simple random sampling technique was used to select the participants for the study. With the ratio of hearing-impaired students to normal hearing students being 1:2, the STATCAL of Epi Info 7 (Centres for Disease Control and Prevention, Atlanta, GA, USA) was used to calculate the minimum sample size for the study.

The minimum sample size required was 71 for the hearing-impaired schoolchildren and 142 for the normal hearing schoolchildren.

Data Collection Procedures: To obtain data for this study, visual examinations were carried out on each participant, following the taking of basic history. Visual acuity was measured using the illiterate 'E' LogMAR chart held at 6m whilst contrast sensitivity was assessed using the standard Pelli-Robson contrast sensitivity chart at a distance of 1m. In addition, the anterior segment and fundus were examined with an ophthalmoscope to rule out abnormalities of the eyelid, conjunctiva, cornea, lens, vitreous and retina. Pupillary reaction was assessed with the aid a penlight and refractive status determined via streak retinoscopy.

Ethical Consideration

Informed consent was sought from the management or administrative heads of the schools involved in the study. The examination procedures were explained to the teachers and their assistance was solicited where necessary. The schoolchildren were informed about the purpose of the study and those who consented to partaking of the study were recruited. The participants were informed of the confidentiality of all information obtained and were assured that the data obtained would be used solely for academic purposes. The study protocol was in conformity with the principles of the declaration of Helsinki [23].

Data Analysis

Statistical Package for Social Scientist software version 23.0 (SPSS Inc., Chicago, IL, USA) was used to analyse the collected data. Descriptive statistics was computed and Pearson's coefficient of correlation was employed to compare the visual outcomes between the two eyes for the two groups. In addition, an independent t-test was used to establish the existence of any significant difference in gender and age between the two groups –the normal-hearing group and the hearing-impaired group. The level of significance was set at a p-value of 5%. Effects were considered 'significant' when $p \leq 0.05$.

Results

Participants' Demographics

In all, a total of 251 participants were sampled for this study. This comprises a normal hearing group made up of 170 children (68% of the sampled population) and a hearing-impaired group of 81 children (32% of the sampled population). Out of the normal hearing population, 69 were males while 101 were female. The gender distribution of the hearing-impaired group was 51 males to 30 females.

The mean ages for the normal-hearing and hearing-impaired groups were 14.99 ± 1.34 years and 17.63 ± 2.13 years respectively; which showed that the mean age of the hearing-impaired group was approximately 3 years higher than that of the normal hearing group. Information on participants' demographics is illustrated in Table 1 below.

Hearing Status of participants	Gender of participants		Total (n)
	Female (n)	Male (n)	
Normal Hearing	101	69	170
Hearing-impaired	30	51	81
	131	120	251

Table 1: *Participants' Demographics.*

Independent t-test

The test revealed a significant difference in gender ($F = 1.267$, $p < 0.01$, CI = 95%), as well as a significant difference in age ($F = 28.95$, $p = 0.00$, CI = 95%) between the two groups.

Prevalence of Refractive Errors in the Sampled Population

The prevalence of refractive errors in the normal hearing and hearing-impaired groups was 8.8% and 29.6% respectively. The distribution of refractive error type in the normal hearing group was 4.1% myopic, 1.8% hyperopic and 2.9% astigmatic whilst 14.8% myopic, 11.1% hyperopic and 3.7% astigmatic impaired-hearing schoolchildren were recorded. The refractive status of the sampled population is shown in Table 2 below.

Refractive status of the participants	Status of Sampled Participants	
	Normal hearing group (%)	Hearing-impaired group (%)
With refractive error	8.8	29.6
Without refractive error	91.2	70.4
	100	100

Table 2: *Refractive Status of the Sampled Population.*

Types of Refractive Error within the Groups

Having assessed the types of refractive error within the groups, the following results were recorded: Within the normal hearing group, 46.59% of the refractive errors recorded were myopia, 20.46% were hyperopia whilst astigmatism formed 32.95% of the refractive errors. Amongst the hearing-impaired group, half (50%) of all refractive errors were myopia, 37.5% were hyperopia and 12.5% were astigmatism.

Refractive status of the participants	Status of Sampled Participants	
	Normal hearing group (%)	Hearing-impaired group (%)
With refractive error	8.8	29.6
Without refractive error	91.2	70.4
	100	100

Table 3: *Types of Refractive Errors in the Sampled Population Visual Acuity of the Sampled Population.*

Levene's test was performed to compare the right eye VA between the two groups. The test revealed a difference of statistical significance (F = 37.167, p = 0.00, CI = 95%).

Pearson's correlation analysis was also performed to determine an association between VA and status of participants, which showed a weak positive association between the two parameters. (r = 0.249, p = 0.01).

Table 4 below details the mean right VA of the two groups.

Hearing Status of Participants	Mean VA ± SD (Log MAR)
Normal hearing group	0.100 ± 0.131
Hearing-impaired group	0.197 ± 0.247

Table 4: *Mean Right Visual Acuity of Participants.*

Contrast Sensitivity and Hearing Status of Participants

The mean CS of the normal hearing population was 2.032 ± 0.304 while that of the hearing-impaired population was 1.903 ± 0.412. An independent T test was performed to compare contrast sensitivity between the two groups. The test showed no significant difference between the two groups (F = 36.82, p = 0.1).

Pearson's coefficient test was also performed to determine the association between contrast sensitivity and the hearing status of participants, which showed approximately no association between the contrast sensitivity and the status of the participants (r = -0.01 p = 0.02).

Discussion

Age

The mean ages for the normal hearing group and the hearing-impaired group were 14.99 ± 1.34 years and 17.63 ± 2.13 years respectively. This difference in age could be attributed to the fact that most hearing-impaired children in the region tend to start school late due to their impairments. Thus, even though the students recruited for this study were of the same educational and class level, their ages differs.

Prevalence of Refractive Errors in the Sampled Population

In this study, the prevalence of refractive error in normal hearing children and hearing-impaired children was 8.8% and 29.6% respectively. The prevalence rate in the hearing-impaired children was 11% higher than that recorded in some studies [24,25]. This marginal disparity could be ascribed to the differences in sample size, ethnic backgrounds of the study participants as well as the age ranges considered for the different studies.

The study of ophthalmologic abnormalities in children from a Turkish school for the deaf reported a similar prevalence of refractive errors as recorded in this study [21]. Meanwhile, a study among 70 children with special needs and 175 healthy children in Oman, reported refractive error prevalence of 58.5% and 2.9%, respectively [26] that is about twice the prevalence rate among the hearing-impaired children in this study. The above-mentioned study provides no basis for comparison with the current study, as the study encompassed all forms of disabilities and was not restricted to only hearing impairment.

Prevalence of Hyperopia in the Sampled Population

In line with the present study, the prevalence of hyperopia in the normal hearing and the hearing-impaired groups was 1.8% and 11.1% respectively. It has been reported in literature that, the prevalence of hyperopia varies between hearing-impaired and normal populations [27,28].

In addition, further variation is observed when hyperopia is measured with and without cycloplegia between the two groups. Within the hearing-impaired populations, a non- cycloplegic hyperopic refraction prevalence of 8% was recorded [29] whilst a cycloplegic hyperopic refraction prevalence of 31.5% was recorded [20].

Amongst normal populations, previous studies reported a cycloplegic hyperopic refraction prevalence of 4% and 12.8% respectively [27,28] while other studies reported a non- cycloplegic hyperopic refraction prevalence of 7.7% [30].

In the present investigation, no cycloplegia was done, and so the prevalence of hyperopia observed was analogous to two of the above-mentioned studies [29,30].

Prevalence of Myopia in the Sampled Population

In this survey, the prevalence of myopia was 14.8% for hearing-impaired group and 4.1% for the normal population. There is a high prevalence of myopia in hearing-impaired individuals [19] even when allowing for the increase in myopia with age [31,32].

Estimates of the prevalence of myopia (> 1.00 D) in hearing-impaired population as reported in extant literature ranged from 6% to 20.9% [21,33]. This is consistent with the current study.

Prevalence of Astigmatism in the Sampled Population

The present study revealed an astigmatism prevalence of 3.7% and 2.9% in the hearing-impaired and the normal hearing group respectively. Astigmatism of prevalence 7.3%-14% has been reported in previous studies among hearing-impaired children [21,29].

In other related studies, astigmatism prevalence (> 1.00D) in seven to fifteen-year old schoolchildren was found to be 1.7% [34]. The astigmatism prevalence reported in the above-mentioned studies and that of the present study is a reflection of a variation of this type of refractive error among the population.

Visual Acuity of the Sampled Population

This study investigated the association of hearing impairment with distance vision. The results of the study revealed a lower visual acuity measure in the deaf (0.197 ± 0.247) when compared with hearing group (0.0995 ± 0.130). The present study also revealed a positive association between visual acuity and the hearing status of participants.

In contrast, no association between visual acuity and varying grades of hearing impairment was observed in other studies, adding that the risk of low vision among children with profound hearing loss was similar to those with severe hearing loss [35].

The dissonance in results between the foregoing study and the present study could be attributed to the difference in methodology, as the study in question did not compare VA in hearing-impaired and normal-hearing participants, but rather to the severity of hearing impairment.

For this research, difference in ages between the two groups could have played a role with respect to the positive association found between visual acuity and the hearing status of participants, as hearing and vision are reported to be affected differently in early ages depending on the type and degree of visual function and hearing impairment [36].

Contrast Sensitivity of the Sampled Population

A close-to-zero association between the contrast sensitivity and the hearing status of the participants was observed in this study. Contrast sensitivity was not associated with the severity of hearing loss in a study conducted in Oman [35]. Again, when contrast sensitivity was measured in hearing-impaired and hearing subjects via moving stimuli over a range of speeds, no absolute difference in performance across subject groups was noted [37].

Conclusion

The current study showed that the prevalence of refractive errors was higher in the hearing-impaired group than the normal hearing group. The study further revealed lower visual acuity measurements in the hearing-impaired group relative to the normal population. A positive association between hearing and visual acuity was also reported in this study. However, contrast sensitivity values did not differ markedly between the two groups and there was no association between contrast sensitivity and the hearing status of participants as observed in this study. Persons with various degrees of hearing impairment, as opposed to persons with normal hearing status, are more likely to suffer one visual aberration or the other, which could negatively affective their ability to navigate through their daily activities. Hence, refractive errors and other visual dysfunctions among hearing-impaired children should be detected at the earliest and the appropriate management given.

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References

1. International Classification for Functioning Disability and Health (2002). Towards a Common Language for Functioning, Disability and Health: ICF, World Health Organisation.
2. Medicare CF, Services M. & Association, A. H. (1997). International Classification of Diseases, Ninth Revision, Clinical Modification. ICD-9-CM, American Hospital Association.
3. West SK., *et al*. "How Does Visual Impairment Affect Performance on Tasks of Everyday Life?: The SEE Project. Salisbury Eye Evaluation". *Archives of Ophthalmology* 120.6 (2002): 774-780.
4. Resnikoff S., *et al*. "Global Magnitude of Visual Impairment Caused by Uncorrected Refractive Errors in 2004". *Bulletin of the World Health Organization* 86.1 (2008): 63-70.
5. Rahi JS and Cable N. "Severe Visual Impairment and Blindness in Children in the UK". Lancet 362.9393 (2003): 1359-1365.
6. Woodhouse JM., *et al*. "Ocular and Visual Status among Children in Special Schools in Wales: The Burden of Unrecognised Visual Impairment". *Archives of disease in childhood* 99.6 (2014): 500-504.
7. Welinder LG and Baggesen KL. "Visual Abilities of Students with Severe Developmental Delay in Special Needs Education–A Vision Screening Project in Northern Jutland, Denmark". *Acta ophthalmologica* 90.8 (2012): 721-726.
8. Sonksen PM and Dale N. "Visual Impairment in Infancy: Impact on Neurodevelopmental and Neurobiological Processes". *Dev Med Child Neurol* 44.11 (2002): 782-791.

9. O'connor A., *et al.* "Ophthalmological Problems Associated with Preterm Birth". *Eye* 21.10 (2007): 1254-1260.
10. O'connor A., *et al*. "Visual Function in low Birthweight Children". *British Journal of Ophthalmology* 88.9 (2004): 1149-1153.
11. Fazzi E., *et al*. "Neuro-ophthalmological Disorders in Cerebral Palsy: Ophthalmological, Oculomotor, and Visual Aspects". *Developmental Medicine & Child Neurology* 54.8 (2012): 730-736.
12. Surman G., *et al.* "UKCP: A Collaborative Network of Cerebral Palsy Registers in the United Kingdom". *Journal of Public Health* 28.2 (2006): 148-156.
13. Krägeloh-Mann I and Horber V. "The Role of Magnetic Resonance Imaging in Elucidating the Pathogenesis of Cerebral Palsy: A Systematic Review". *Developmental Medicine & Child Neurology* 49.2 (2007): 144-151.
14. Salt A and Sargent J. "Common Visual Problems in Children with Disability". *Arch Dis Child* 99.12 (2014): 1163-1168.
15. Haugen OH., *et al*. "Refractive Development in Children with Down's Syndrome: A Population-based, Longitudinal Study". *British journal of ophthalmology* 85.6 (2001): 714-719.
16. Nielsen LS., *et al.* "Visual Dysfunctions and Ocular Disorders in Children with Developmental Delay- Prevalence, Diagnoses and Aetiology of Visual Impairment". *Acta Ophthalmol Scand* 85.2 (2007): 149-156.
17. Woodruff M. "Prevalence of Visual and Ocular Anomalies in 168 Non-institutionalized Mentally Retarded Children". *Canadian Journal of Public Health/Revue Canadienne de Sante'e Publique* 68.3 (1977): 225-232.
18. Regenbogen L and Godel V. "Ocular Deficiencies in Deaf Children". *Journal of Pediatric Ophthalmology and Strabismus* 22.6 (1985): 231-233.
19. Leguire L., *et al.* "A Prospective Study of Ocular Abnormalities in Hearing Impaired and Deaf Students". *Ear, Nose, & Throat Journal* 71.12 (1992): 643-646, 651.
20. Siatkowski RM., *et al*. "Visual Function in Children with Congenital Sensorineural Deafness". *Trans Am Ophthalmol Soc* 91 (1993): 309-18;
21. Hanioğlu-kargı Ş., *et al.* "Ophthalmologic Abnormalities in Children from a Turkish School for the Deaf". *The Turkish Journal of Pediatrics* 45.1 (2003): 39-42.
22. Nikolopoulos T., *et al*. "Evidence-based Overview of Ophthalmic Disorders in Deaf Children: A Literature Update". *Otology & Neurotology* 27.2 (2006): S1-S24.
23. World Medical Association. "World Medical Association Declaration of Helsinki. Ethical Principles for Medical Research Involving Human Subjects". *Bulletin of the World Health Organization* 310.20 (2013): 2191-2194.
24. Gogate P., *et al.* "Visual Impairment in the Hearing Impaired Students". *Indian J Ophthalmol* 57.6 (2009): 451-453.
25. Bist J ., *et al*. "Ocular Morbidity in Hearing Impaired Schoolchildren". *Child Care Health Dev* 37.3 (2011): 394-397.
26. Vora U., *et al*. "Refractive Error and Visual Functions in Children with Special Needs Compared with the First Grade School Students in Oman". *Middle East African Journal of Ophthalmology* 17.4 (2010): 297-302
27. Fan DS., *et al*. "Prevalence, Incidence, and Progression of Myopia of Schoolchildren in Hong Kong". *Investigative Ophthalmology & Visual Science* 45.4 (2004): 1071-1075.
28. Kleinstein RN., *et al*. "Refractive Error and Ethnicity in Children". *Archives of ophthalmology* 121.8 (2003): 1141-1147.
29. Pollard G and Neumaier R. "Vision Characteristics of Deaf Students". *Optometry & Vision Science* 119.6 (1974): 750-755.
30. Junghans B., *et al*. "Referral Rates for a Functional Vision Screening among a Large Cosmopolitan Sample of Australian Children". *Ophthalmic and Physiological Optics* 22.1 (2002): 10-25.
31. Coleman HM. "An Analysis of the Visual Status of an Entire School Population". *Journal of the American Optometric Association* 41.4 (1970): 341-347.
32. Saw SM., *et al*. "Incidence and Progression of Myopia in Singaporean Schoolchildren". *Investigative Ophthalmology & Visual Science* 46.1 (2005): 51-57.
33. Guy R Nicholson J., *et al*. "A Clinical Evaluation of Ophthalmic Assessment in Children with Sensori-neural Deafness." *Child: Care, Health and Development* 8. 29 (2003): 377-384.

34. Laatikainen L and Erkkilä H. "Refractive Errors and other Ocular Findings in Schoolchildren". *Acta Ophthalmologica* 58.1 (1980): 129-136.
35. Khandekar R., *et al.* "Visual Function and Ocular Status of Children with Hearing Impairment in Oman: A case series". *Indian Journal of Ophthalmology* 57.3 (2009): 228-229.
36. Sadeghi AM., *et al*. "Longterm Visual Prognosis in Usher Syndrome Types 1 and 2". *Acta Ophthalmologica Scandinavica* 84.4 (2006): 537-544.
37. Finney EM and Dobkins KR . "Visual Contrast Sensitivity in Deaf Versus Hearing Populations: Exploring the Perceptual Consequences of Auditory Deprivation and Experience with a Visual Language". *Cognitive Brain Research* 11.1 (2001): 171-183.