Strabismus Prevalence and Associated Factors Among Kindergarten School Children, Northwest Ethiopia

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Abstract: *Introduction:* Strabismus is misalignment of the eyes in which both are not simultaneously directed at the object of regard. It is usually attributable to refractive, sensory, organic, anatomic, motor or innervation causes. The global prevalence varies and ranges from 1 - 5%. Though strabismus is a common presenting ocular problem, there are limited data in the study area about the prevalence and associated factors. The purpose of this study was to determine the prevalence and associated factors of strabismus among kindergarten school children in Gondar city. *Methods:* School based cross-sectional study design and Multistage random sampling technique was applied to select 848 study participants. The data was collected by semi-structured questionnaire and through eye examination with different ophthalmic instruments. Data was entered into Epi-info version 3.5.1 and analyzed using statistical package for social sciences version 20. Bivariable followed by multivariable binary logistic regression was fitted to test the strength of association with the variable and variables with P value < =0.05 were considered as statistically significant. *Result:* A total of 784 study subjects were included in this study, giving a response rate of 92.5%. The median age was 6 (+/-5.6) years. The overall prevalence of strabismus was 3.1% [AOR 95% CI: 1.8%-4.2%]. Prematurity [AOR=2.8 (95% CI: 1.0-8.2)], parents with strabismus [AOR=5.8 (95% CI: 1.5-22.6)] and children with refractive error [AOR=16 (95% CI: 5.4-48.1)] were significantly associated factors with strabismus. *Conclusion:* The overall prevalence of strabismus in this study was within the range of the global magnitude. Prematurity, parents with strabismus and children with refractive error were independently and significantly associated with strabismus. As vision loss and amblyopia are the major complications of strabismus, early school vision screening is important.

Keywords: Strabismus, Children, Kindergarten School, Gondar, Ethiopia

1. Introduction

Strabismus is a misalignment of the eyes, such that the visual axes of each eye are not simultaneously directed at the object of regard [1]. Strabismus is classified as esotropia, exotropia, vertical and cyclic. Esotropia (manifest convergent misalignments) is the most common type of strabismus, accounting for more than 50% of ocular deviations in the pediatric population. An exotropia is an outward drift of the eye that can be latent (controlled by fusion) or manifest. In vertical misalignment of the visual axes one eye is either constantly or intermittently upward, and downward [2].

Strabismus may be accompanied by abnormal movement of one or both eyes, double vision, decreased vision, visual confusion, suppression, ocular discomfort, headaches, or abnormal head posture. It may be the result of multiple factors: usually attributable to refractive, sensory, organic, anatomic, motor or innervation causes [3] and it occurs more frequently in children with neurodevelopmental conditions and born prematurely or of low birth weight [4].

Population studies, from Western European and North American revealed the prevalence of strabismus is between 2% and 5% with esodeviations outnumbering esodeviations [5]. However, data from some Asian studies report prevalence between 0.8% and 5.65% [6, 7] and exodeviations

being more common than esodeviations [8, 9]. In Africa a study done in Nigeria showed that the prevalence to be 0.43% [10]. A study done in Ethiopia, Butajira town reveals the prevalence be 1.53% [11].

Strabismus can result in amblyopia (lazy eye), impaired stereopsis (binocular depth perception) and diverse psychosocial impacts. The most common form of amblyopia develops in the constantly deviating eye of a child with strabismus. Constant, unilateral tropias (typically esodeviations) are most likely to cause significant amblyopia. Early identification and treatment of strabismic children may prevent amblyopia [12].

Strabismus has also psychosocial impact in both children and adults. Negative attitudes toward strabismus emerge at a young age, as early as 6 years, as shown in one study done in Houston, Texas. Better understanding about when and why children first recognize strabismus may help guide the appropriate timing of medical and surgical intervention and may help parents' better deal with strabismus in their young child [13-16].

In the majority of cases, strabismus is a treatable condition that requires identification and treatment at early age, particularly before the age of two years. Treatment at early age will result in best visual acuity in each eye, better three dimensional visions (stereopsis) and acceptable cosmetic appearance [17].

For the above reasons, continued epidemiological research into the prevalence and risk factors for strabismus and the impact on the visual function of young children is of public health importance.

In Ethiopia, strabismus is one of the common childhood eye problems, which is frequently seen at the outpatient departments. Furthermore, Strabismus has public health significance since it leads to monocular vision loss, reduced or absent depth perception, multiple life-long surgeries, bad cosmetic appearance which in turn lead to stigma and social interaction problems of children. However, there is limited data about the magnitude and potential risk factors to strabismus. Therefore, this study aims to determine the prevalence and associated factors of strabismus among kindergarten school children in Gondar city.

2. Methods

2.1. Study Design, Setting and Population

School based cross-sectional study design was conducted in Gondar city, Northwest Ethiopia. A data obtained from Gondar city administration statistical office indicates that Gondar city is located 738 kilometers from Addis Abeba in the North of Lake Tana on the lesser Angereb River and Southwest of the Simian Mountains. According to 2007 census Gondar city has a total population of 351,675 [30]. There are 10 sub cities and 21 kebeles and within these, there are 25 kindergarten schools with 4628 students, 64 primary schools and 14 secondary schools. There is one tertiary eye care center in the city which provides different services and training for candidate Optometry and Ophthalmology

students and residents. The study population was all kindergarten school children in the selected schools and the randomly selected children were included in the study.

2.2. Sample Size and Sampling Technique

The minimum sample size was determined using single population proportion formula for strabismus with the assumption of 95% confidence interval, 1% marginal error, and proportion (P=1.53%) which is obtained as 514. In addition, for the most common independent variable using computer generated sample it has been calculated with assumption of 80% power, control to case ratio 1:1, and proportion of 43.5%. By anticipating 10% non-response rate and a design effect of 1.5, the final sample size used was 848.

Multistage sampling technique was applied. To ensure representativeness, sample was taken from 30% of the schools. First, 8 schools out of 25 schools were selected using simple random sampling method. In eight selected schools there were 1764 preschool children. Then systematic random sampling technique (K=2, n /N) was used to select the first participant in the class room.

2.3. Operational Definitions

Strabismus was defined as eye deviation of $\geq$10 prism diopter magnitude at distance or near fixation either vertically or horizontally in either eye.

Prematurity: Parents' report of birth history that takes place before 36 weeks of gestation [26].

Refractive error was defined as a child who had myopia of ≥ -0.50DS or hyperopia of $\geq +2.00$DS or astigmatisms of ≥ -0.75DC, or anisometropia: difference of ≥ 2.00DS between eyes [11].

2.4. Data Collection Tools and Procedure

Pretested semi structured questionnaire was used to collect children's socio- demographic and maternal and child history related data. In addition, materials like occluder, prism bar, pen torch, Snellen letter charts, direct ophthalmoscope, retinoscope and full trial set were used to collect ocular health condition related data. Clinical Assessment of Strabismus was conducted with the following procedure.

The eye examination was performed by 7 senior optometrists. Visual acuity was measured at 3-meter distance using Snellen chart.

Ocular alignment was assessed by using the Hirschberg corneal light reflex test, and cover test was performed at both distance and near fixation target using pen torch. The presence or absence of strabismus was determined after occlusion of each eye for a minimum of 3 seconds at both distance and near fixation. The movement of the uncovered eye was observed and type of strabismus was recorded. Binocular and monocular ocular movements were examined at nine diagnostic positions of gaze. The magnitude of strabismus was estimated by Hirschberg corneal reflex test. Refractive error was also determined at 3 meter in all children using dry retinoscopy.

2.5. Data Quality Control

Training was given to data collectors. The collected data was checked out for the completeness, accuracy and clarity by the Investigator on daily basis. The investigator checked the filled data daily and amendments were done at the spot. Data clean up and cross-checking was done before analysis.

2.6. Data Management and Analysis

The data was entered into EPI INFO version 3.5.1, and analyzed using SPSS version 20. Data coding, cleaning and checking was done before analysis. Multi- collinearity among independent variables was checked using variance inflation factor and tolerance. Bivariable and multivariable logistic regression model was fitted to identify factors associated with strabismus. Adjusted Odds Ratio (AOR) with 95% confidence interval (CI) was used to show the strength of association and variables with p-value < 0.05 were considered as statistically significant.

2.7. Ethical Considerations

Before conducting the study, ethical clearance was obtained from the institutional ethical review board of University of Gondar. In addition, official letters were obtained from Gondar district education bureau. Written Informed consent was obtained from parents and was informed about the purpose of the study. Eye examination and interview was done only with those who agreed to give a written consent to participate. Moreover, the confidentiality of information obtained was guaranteed by using code numbers rather than personal identifiers. Children found with strabismus were referred to Gondar university tertiary eye care ad training center for further diagnosis and management.

3. Results

In this study, total of seven hundred eighty-four study participants were included with response rate of 92.5%. The median age was 6 (IQR 5.6) years. More than half of the study participants (55.1%) were females. Majority (92.7%) of the study participants were Orthodox Christians and Amhara (94.1%) in ethnicity. About one third of parents (35.5%) attained higher education (see Table 1 below).
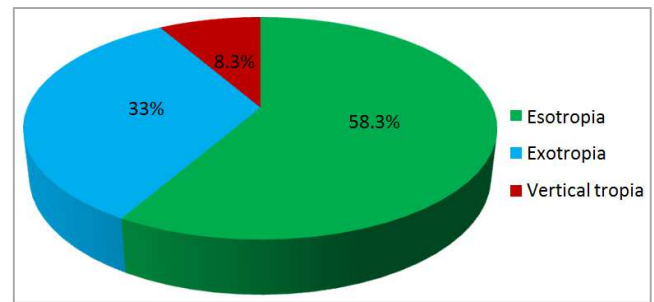
Figure 1. The classification of strabismus among study participants, Gondar city, Northwest Ethiopia, 2020.

Table 1. Socio-demographic characteristics of the study participants in Gondar city Northwest Ethiopia, 2020 (n=784).

Variables	Frequency	Percent
Sex		
Male	352	
Parental educational status	44.9	
Female	432	55.1
Age in year		
3-5	334	42.6
6-8	450	57.4
Uneducated	72	9.2
Read and write only	156	19.9
Primary education	80	10.2
Secondary education	198	25.3
College and above	278	35.5

3.1. Prevalence of Strabismus in Children

The overall prevalence of strabismus was 3.1% (95% CI: 1.8%-4.2%). Of those children who had strabismus most (58.3%) had esotropia and about 33% had exotropia. Five children with esotropia were hyperopic between 1.00Ds and 4.00Ds. Down syndrome had been found in two children with alternating esotropia. A higher proportion (62.5%) of intermittent exotropia was diagnosed among children with exotropia. (see figure 1).

Refractive error was found in 10 (41.6%) of children with strabismus. The most common type of refractive error was hyperopia (20.8%), followed by myopia (12.5%), and astigmatism (8.3%). (See Figure 2).
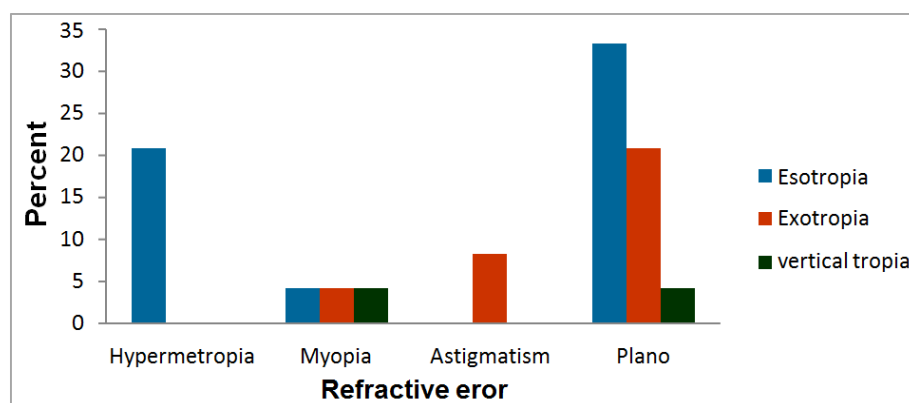
Figure 2. Distribution of refractive error among strabismus group, Gondar city, Northwest Ethiopia, 2020.

Table 2. *Factors associated with strabismus among kindergarten school children in Gondar city Northwest Ethiopia, 2020 (n=784).*

Strabismus				
Variables	**Yes** **(n=24)**	**No** **(n=760)**	**COR, (95% CI)**	**AOR, (95%CI)**
Age				
3-5	10	324	1.0 (0.42-3.6)	
6-8	14	436	1.00	
Sex				
Male	10	342	0.9 (0.3-2.5)	
Female	14	418	1.00	
Birth weight in kilogram				
<2.5 Kg	5	115	1.4 (0.5-4.0)	
≥2.5 Kg	19	645	1.00	
Gestational age				
<36 weeks	10	79	6.1 (2.6-14.3)	2.8 (1.0-8.2)**
≥36 weeks	14	681	1.00	1.00
Breast feeding				
<6 months	7	101	2.6 (1.0-6.6)	2.1 (0.7-6.2)
≥6 months	17	659	1.00	1.00
Admission to NICU				
Yes	6	38	6.3 (1.2-11.6)	2.8 (0.7-11.3)
No	18	722	1.00	1.00
Birth order				
First-born child	13	316	1.00	
Others	11	444	0.6 (0.2-1.3)	
Maternal age				
16-30	17	648	1.00	1.00
31-41	7	112	2.3 (0.9-5.8)	2.2 (0.7-6.4)
Mode of delivery				
Vaginal	19	667	1.00	
Cesarean section	5	93	1.8 (0.6-5.1)	
Took alcohol during pregnancy				
Yes	5	142	1.1 (0.4-3.1)	
No	19	618	1.00	
Maternal illness during pregnancy				
Yes	6	42	5.6 (0.3-6.8)	
No	18	718	1.00	
Parents with strabismus				
Yes	5	15	13.0 (4.3-39.6)	5.8 (1.5-22.6)*
No	19	745	1.00	1.00
Parents with refractive error				
Yes	6	93	2.3 (0.9-6.1)	2.9 (0.9-9.1)
No	18	667	1.00	1.00
Refractive error				
Yes	10	26	20.1 (8.1-49.6)	16 (5.4-48.1)**
No	14	734	1.00	1.00

* P value <0.05 ** P value.

3.2. Factors Associated with Strabismus

After adjusting for sociodemographic, child and maternal birth history, family and child's ocular condition the multivariable logistic regression revealed that prematurity (P=0.04), family history of strabismus (P=0.01) and refractive error (P=0.001) were found significantly associated factors with strabismus. (see table 2).

Children who were born prematurely were 2.8 times (AOR=2.8, 95% CI: 1.0-8.2) more likely to develop strabismus than those who were born maturely. Children who had parents with strabismus were more than 5 times (AOR=5.8, 95% CI: 1.5-22.6) to be affected by strabismus than their counter parts. Refractive error was significantly associated with strabismus. Children who had refractive error

were 16 times (AOR=16, 95% CI: 5.4-48.1) more likely to develop strabismus than those who were emmetropic.

4. Discussion

Strabismus is a common ophthalmic problem in young children. An understanding of the prevalence of strabismus and the factors associated adds a new knowledge a leading to better detection and management of the condition.

The overall prevalence of strabismus in this study was 3.1% (95% CI: 1.8%-4.2%) which is in line with some of the studies reported across the world [18, 19, 26, 28, 29] but higher than reports of previous studies in Butajira town, Ethiopia 1.53% [11],

Nigeria (0.43%) [10], Singapore (0.80%) [22], Iran (1.68%)

[28] and Japan (1.28%) [6]. This discrepancy might be due to the inclusion criteria. In this study kindergarten school children were included, age between 3 years up to 8 years. While the Butajira study included children less than five years which misses most of school age children. Children after entering school they spent much of their time at near and may become myopic which is a risk for exotropia. In Nigeria and Japan, they have included elementary school children by which time the refractive status of most children stabilizes and the risk of strabismus may decrease. In Iran they included only children aged seven years old. In addition to the age difference seen in these studies, there is also ethnic difference between this study and the reported studies, which greatly influences strabismus prevalence as reported in many studies [19, 23, 27].

The variation in the definition of strabismus might be the possible reason for various reported results. The definition used in some studies [10, 28] differs from this study with strabismus defined as a deviation (inward or outward) present for both near and distance fixation, i.e., only a constant deviation which did not include if manifested at one distance only. However, in this study strabismus was taken as present for near or distance fixation, therefore included both constant and intermittent deviations in ether distances. So this could give relatively higher prevalence. Despite the above reason, the prevalence found in this study is lower than a study conducted in Eastern China (5.65%). It may be due to the variation in race between this study participants and Asian descent. Most Asian nations are more myopic as a result of complex genetic trait responsible for myopia and in turn could be a risk for exotropia as exodeviations outnumber in this population [21, 22].

Refractive error, which is repeatedly reported in other studies [10, 22, 23, 24, 27] was also found to be an important predictor of strabismus this study. Children who had refractive error were found to be 16 times more likely to have strabismus as compared to those who had no refractive error. This may be due to high possibility of developing strabismus in the presence of significant refractive error. The uncorrected hyperopia forces the patient to accommodate to sharpen the retinal image, thus inducing more converging status of the two eyes. If the patient's fusional divergence mechanism is insufficient to compensate for the increased convergence tonus, strabismus specifically esotropia will be developed [2]. In addition, children who have ample accommodation may underaccomodate for appropriate working distance and thus resulted less convergence or more divergence state of the eyes. If this continues for longer period and adapted as normal behavior exotropia may resulted.

Children who had parents with strabismus were 5.8 times more likely to be strabismic in compared to those with parents who had no strabismus which is in agreement with Singaporean study [22]. This is due to the inheritance nature of strabismus. A family history of strabismus is often present, but well defined genetic patterns are unusual [2].

Prematurity was another important viable significantly associated with strabismus. Children who were born prematurely were 2.8 times more likely to be strabismic than those who were born maturely. Studies from Denmark [25] and Australia [26] supported this result. This could be due to risk of myopia in premature infants which could be associated with amblyopia or strabismus and prematurely developed sensory and motor system.

5. Conclusion

Prevalence of strabismus in this study was within the range of the global magnitude. These finding is significant as strabismus is the major cause of amblyopia and visual loss in children and will help clinicians to better understand the patterns of strabismus. Prematurity, parents with strabismus and children with refractive error were independently significantly associated variables with strabismus.

Conflict of Interest

All authors declare that no conflict of interest.

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