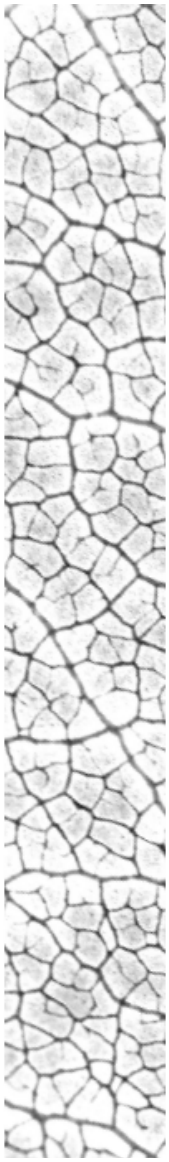

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Refractive error and its correlation with eye deviation as examined with the Hirschberg test in elementary and junior school students in Lesanpuro, Malang

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Abstract
Refractive error and eye deviation are two common pediatric eye conditions. Ophthalmic screening in children is essential for protecting against vision loss. In 2010, the WHO estimated that refractive error causes 42% of vision disturbances globally. Uncorrected refractive error can cause eye deviation. In this study, we report the characteristics of refractive error and its correlation with eye deviation, as examined with the Hirschberg test, in children from elementary and junior schools in Lesanpuro, Malang. This study involved 606 children aged 6-17 years, from elementary and junior schools. This was a cross-sectional observational descriptive study. Data was obtained from refraction examinations and the Hirschberg test. Each subject underwent one refraction test and one test of eye position. The results showed emmetropia, myopia, astigmatism, and hyperopia in 450 (74.26%), 131 (21.62%), 56 (9.24%), and 5 (0.83%) children, respectively. Eye deviation was found in six children (1.65%), all of which showed extropia (100%). Eye deviation occurred together with myopia in one child (17%), and with astigmatism in three children (50%). Two further children (33%) had other conditions such as amblyopia and corneal scar. Eye deviation is most common in astigmatism. For refractive errors, myopia is the most common condition while hypermetropia is the least common.

Keywords: eye drop, normal tension glaucoma, therapeutic compliance

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BACKGROUND

Refractive disorder is a major health issue worldwide, the prevalence of which has sharply increased over the past decade. In 2010, data from the WHO indicated that refractive disorder is the most common cause of vision impairment globally (42%). Glasses provide a safe and cheap solution to this problem. In a study conducted in China, 60% of people needed glasses, but two-thirds of them did not have corrective eyeglasses. In India, the prevalence of myopia is in the range of 61-82%. Corrective eyeglasses, even if used infrequently, can affect visual function (Dandona and Dandona 2001, World Health Organization 2010, Zhang et al. 2011).

The Hirschberg test is one of the simplest tests to determine misaligned eyeball position. Strabismus or misalignment of the eyes may result in loss of binocularity and depth perception if it is not given appropriate therapy. Globally, the prevalence of strabismus in children varies between 0.20-6.2%. One of the causes of strabismus is uncorrected refractive error, which results in disorders in accommodation, and subsequently affects the convergence of the eyeball; this ultimately results in misalignment of the eyes or strabismus (Chia et al. 2010, Kekunnaya et al. 2015).

In this study, the measurement of eye position and refraction status was performed among elementary school and junior high school children, ranging in age from 6-16 years. This is the period of eyeball growth, so it is expected that early detection would lead to immediate correction. The purpose of this study is to determine the characteristics of the eyeball position among this group, as assessed with the Hirschberg test, and the association between eyeball position and refractive disorders in 1st to 9th grade students in elementary and junior high school, in Lesanpuro, Malang.

PATIENT AND OBSERVATION

This study was a cross-sectional observational descriptive study. The research was conducted in SDN

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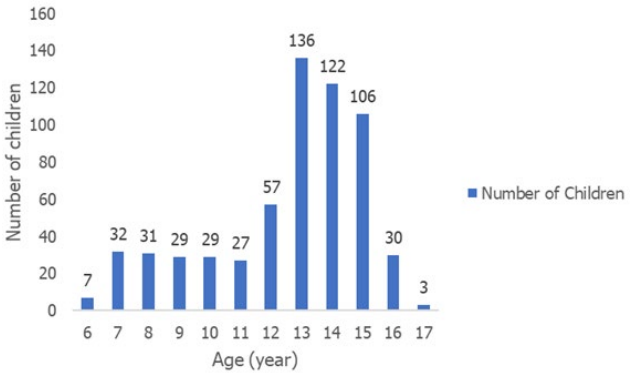

Fig. 1. Age Distribution

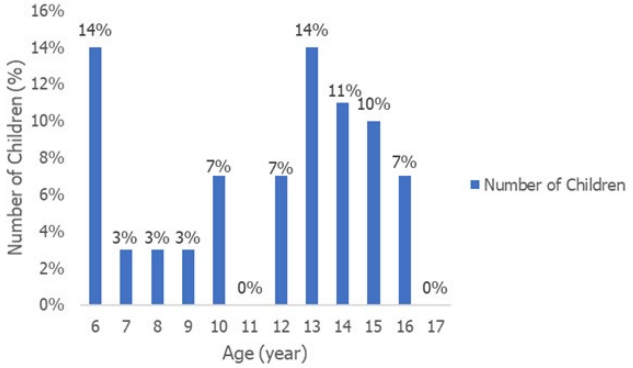

Fig. 2. Astigmatism distribution according to age

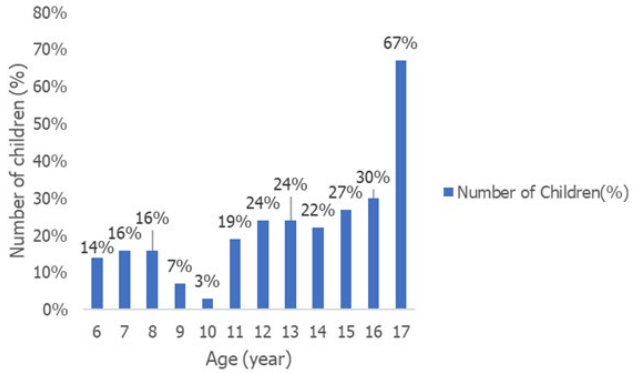

Fig. 3. Myopia distribution according to age

(elementary school) Lesanpuro 2 and SMPN (junior high school) 27 Malang, between February and April 2017. The sample comprised students from the 2016/2017 academic year; in total, 606 students took part in this study. Every subject was asked to obtain permission from their parents before participation in the study, and the test procedures were also explained. The collected data included name, age, gender, and history of eye problems. The refractive test was performed by asking the subject to sit six feet away from the Snellen chart, with sufficient lighting. If the subject was unable to read the chart up to line 6/6, corrective glasses were applied using a spherical lens minus, plus, or cylinder. The observer then sat in front of the subject in a parallel position. A penlight was used to test the subject's eyes position. The light was observed for its spot on the eye. The results of the test were recorded. The refraction and position of eyes tests were performed by 10 observers over a few different days. Each subject underwent one refraction test and one test of eye position. The obtained data were then analyzed manually and described.

The sample comprised a total of 606 students, 182 of which were elementary school students and 424 of which were junior high school students. There were 301 male students (49.67%) and 305 female students (50.33%). The frequency distribution of the age of the participants, from 6 to 17 years old was 7, 32, 31, 29, 29, 27, 55, 136, 122, 106, 30, and 3 people. Emmetropia was observed in 450 students (74.26%), myopia in 131 students (21.62%), astigmatism in 56 students (9.24%), and hypermetropia in five students (0.83%). The distribution of astigmatism among participants aged 6 to 17 years was 14%, 3%, 3%, 3%, 7%, 0%, 7%, 14%, 11%, 10%, 7%, and 0%. The distribution of myopia from age 6 to 17 years was 14%, 16%, 16%, 7%, 3%, 19%, 24%, 24%, 22%, 27%, 30%, and 67%. The distribution of hypermetropia from age 6 to 17 years was 0%, 3%, 0%, 3%, 3%, 4%, 0%, 1%, 0%, 0%, 0%, and 0% (**Fig. 1**).

Among the 606 subjects, there were six students found to have eye deviation (0.99%); five of these were male (83% of the students with the eye deviation) and one was female (17%). The subjects with eye deviation were 8, 9, 13, and 16 years old (17%), and 2 others were 15 years old (33%). There were four students found to have eye deviation together with amblyopia (66.67%). There was one student found to have eye deviation together with anisometropia (17%) (**Fig. 2**).

Based on the examination of refractive status, one student was found to have eye deviation with myopia (17%), three students had eye deviation with astigmatism (50%), and no students had eye deviation with hypermethropia (0%). There were two students (33%) found to have other conditions, such as amblyopia and corneal leukoma (**Fig. 3**).

In the study subjects with eye deviation, two students (33%) were found to have anisometropia. In both students, uncorrected visual acuity (UCVA) of their right eye was 5/5, and UCVA of their left eyes were 2/60 and 5/20, respectively. Therein another two students (33%), isometropia was found, with right and left eye (RLE) UCVA of 5/60 and RLE UCVA of 5/20 in these two students (33%). All subjects with eye deviation were found to have exotropia (100%), four students with leading right eye (67%), and two students with leading left eye (33%); there were no students found to have alternating type (0%). The degree of the eye deviation was 7° in five students (83%), and 15° in one student (17%) (**Fig. 4**).

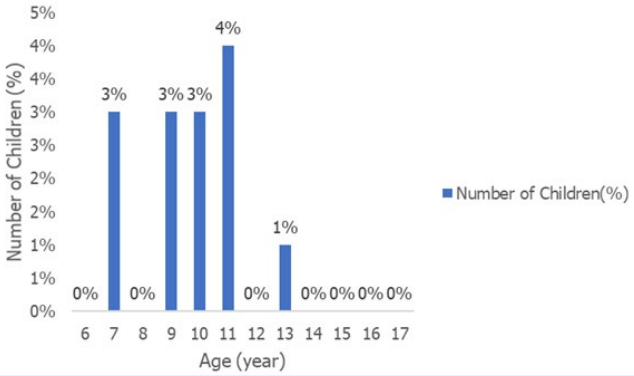

Fig. 4. Hyperopia distribution according to age

DISCUSSION

The composition of refractive disorders in this study did not differ greatly from a similar study conducted in a similar school in 2016, which showed a prevalence of 23% for myopia, 9% for astigmatism, and 0.8% for hypermetropia. The study conducted by Saw et al., in West Sumatra in 2002, showed prevalence rates of myopia, hyperopia, astigmatism, and anisometropia of 26.1%, 9.2%, 18.5%, and 15.1%, respectively (Flitcroft 2014, Vafidis 2005, Zhu et al. 2015).

Age is one of the decisive factors in the distribution of refractive disorders. In this study, the lowest prevalence of myopia was at the age of 10, and it increased thereafter until the age of 17. According to Benjamin, 2006, at the age of formal school, around the age of 6 years old, children generally do not have myopia. Between the age of 6 to 8 years old, the prevalence of myopia is at a low to moderate level. The rate of myopia development is -0.40 (± 0.25) on average and the development of myopia is complete at the age of 14 to 15 years for females and 15 to 16 years for males (Benjamin 2006).

In this study, the highest rate of hypermethropia was at the age of 11 years; no cases were observed at the ages of 6, 8, 12, and 14 to 17 years. According to Benjamin, 2006, refractive disorder shifts from hypermetropia to emmetropia as a result of emetropization (Benjamin 2006).

The highest rate of astigmatism was at the ages of 6 and 13 years, while the lowest rate was at the ages of 11 and 17 years. According to Benjamin, 2006, half of infants aged < 1 year of age experience significant astigmatism (> 1.00 D). Over time, the prevalence of cylinder declines in school-aged children due to decreased corneal toricity and anterior surface of the lens. The prevalence of astigmatism declines with increasing school-age (Benjamin 2006).

Among the 606 subjects, there were six subjects (1.65%) found to have eye deviation. Zhu found a prevalence of strabismus of 1.2-5% in children in China. Vafidis reported that strabismus affects 1 in every 50 children (2%). Akpe conducted a study on 2139 students and obtained a prevalence of tropia of 0.89% (Akpe et al. 2014, Lin 2014, Saw and Gazzard 2002).

In this study, the incidence of eye deviation was relatively small, 1.65%. This may be because this was a school-based study design. Lithander (1998) suggested that a school-based study indirectly excludes children with developmental delay and physical disability. The prevalence of strabismus may be higher in these children (Akpe et al. 2014).

Based on refractive status, the prevalence of strabismus with myopia was 17%, and with astigmatism was 50%; the remaining 33% had amblyopia and corneal leukoma. Among the six subjects with eye deviation, all were found to have exotropia; there was no esotropia or vertical strabismus found. Zhu found that those with refractive disorders that are at risk for esotropia have anisometropia of 0.50 D or more and hypermetropia of 2.00 D or more. For exotropia, the risk for myopia, then hypermetropia is between 1.00 to 5.00 D; those at risk for astigmatism and hypermetropia have 0.50 to less than 1.00 D, and astigmatism myopia. This is consistent with the current study where the risk factors for esotropia were not found (Lin 2014, Zhu et al. 2015).

The Multi-Ethnic Pediatric Eye Disease Study (MEPEDS) and the Baltimore Pediatric Eye Disease Study (BPEDS) investigated esotropia and exotropia, and found that hypermetropia and anisometropia were the risk factors for esotropia, whereas astigmatism increased the risk of exotropia; however, there was no further explanation about the mechanisms. The results of both studies are consistent with this study (American Academy of Ophthalmology 2014).

Data from a population-based observational study showed that, in children with intermittent exotropia, there is a trend toward myopia over time, but the relationship between intermittent exotropia and myopia has not yet been clarified. One possible explanation is that intermittent exotropia increases the need for accommodation, whereas reductions in accommodation have been found to decrease the progression of moderate myopia. However, it cannot be stated that myopia is a risk factor for exotropia, or vice versa. Further studies are needed to confirm the relationship between these two disorders (Cotter et al. 2011, Rajendran 2014).

The absence of hypermetropia with eye deviation in this study may be due to the low number of hypermetropia cases observed (0.83%); in addition, hypermetropia is found in the range between 0.25 and 0.75 diopters, which is classified as light hypermetropia, and there was no amblyopia found in the subjects with hypermetropia. In accordance with the study conducted by Ip et al., strabismus is more commonly found in moderate hypermetropia (+2.25 to +5.00 diopters) (Ekdawi et al. 2010).

Most of the subjects with eye deviation were male. This is in contrast to the study conducted by Lin among

7464 subjects, which found a slightly higher prevalence of strabismus in females (7.4%) than males (6.2%) (Li-Ju et al. 2014).

In the current study, there were two students (33%) with anisometropia. While another two subjects had amblyopia and corneal leukoma conditions. Visual development depends on sensory input during the critical period of vision development. Deviation of the eyes (strabismus) or chronic blurred vision in one eye (anisometropia), either separately or collectively, can interfere with the formation of normal binocular interactions and the formation of spatial processes, resulting in loss of stereopsis and decreased visual function. Therefore, during the development of the eyes, strabismus and anisometropia can cause amblyopia, a visual disorder characterized by a sharp difference in interocular vision (Faghihi et al. 2010, Yekta et al. 2010).

In eyes with balanced visual acuity, there is an alternating fixation, often occurring with amblyopia. However, in this study, among subjects with balanced right and left vision, there was no alternating type found, possibly because the Hirschberg test procedure was performed briefly, and there may have been interobserver bias. These are weaknesses of the current study (Shrestha et al. 2011).

A study conducted by Robinson et al. had trained nurses in Canada perform eye position screening tests for three years. In the first year, the eye position was tested using the Hirschberg test and subjects with eye disorders were referred to the hospital. In the second year, the Hirschberg test and the stereoacuity test were performed. In the third year, only the stereoacuity test was performed. The sensitivity of the tests in the first and third year was almost equal, 61.9% and 60.4%, respectively, while in the second year, the sensitivity was 83.8%. The specificity in the third year was higher than in the first year, and lowest was in the second year. This suggests that screening using the Hirschberg test, as performed in the current study, is acceptable for early detection of eye disorders (Faghihi et al. 2010).

There were four students found to have eye deviation with amblyopia (66.67%). Chia 2010 reported that strabismus and amblyopia often occur together. The image from the eye with amblyopia is suppressed by the brain and neural development associated with visual input becomes undeveloped. Amblyopia is usually monocular, and often occurs due to differences in refractive power between the eyes (anisometropia amblyopia) or squint (strabismic amblyopia). Amblyopia affects binocularity, and squint may occur due to amblyopia because of the lack of input required to maintain the organization of eye movement (Chia et al. 2010).

Amblyopia affects refractive disorders and the strength of fusion reflexes. One of the explanations for the relationship between strabismus and amblyopia is that strabismus causes the active process to inhibit the formation of neural pathways, so that patients cannot use both eyes simultaneously, and as a result, there is adaptation through turning off the function of one eye (Vafidis 2005).

In this study, five subjects were found to have deviation of 7°, and one subject was found to have deviation of 15°. Garcia 2004 conducted a study on 1015 individuals, ranging in age from 5 to 46 years old, and suggested that exodeviation varied between micro-deviation (1 to 8 prism diopters) and 50 prism diopters, with an average of 16.25 prism diopters. Further, exodeviation varied between micro-deviation (1 to 8 prism diopters) and 40 prism diopters, with an average of 15.5 prism diopters. The greatest prevalence (31%) was exotropia with a deviation of 15 prism diopters (Shrestha et al. 2011).

There are several limitations of this study. This study was a cross-sectional design where the data collection was performed on one day; thus, students who were not present at that time were not included in this study. In addition, it is possible that selection bias influenced the results, since this study was only conducted in one school and there was no randomization; thus, the results cannot be directly generalized to the population without further study. It is also possible that there was interpersonal bias, since there were 10 observers collecting the data. This bias can actually be minimized by giving direction so that there are uniform procedures for all observers. Another method to minimize this bias is to ensure that testing of eye position is performed by observers blind to the variables being studied.

In this study, the Hirschberg test was used to test eye position; no other tests, such as the cover test, uncover test, alternating cover test, or prism test, were administered. This means that subjects with foria could not be screened. Further, administration of the Hirschberg test only one time for each subject can lead to missed alternan and intermittent conditions.

CONCLUSION

It can be concluded that, among 1st to 9th grade students in elementary and junior high school in Lesanpuro, Malang, disorders of eye position, from the most common to the least, include astigmatism, myopia, and other conditions such as amblyopia and corneal leukoma. The most common refractive disorder found was myopia, followed by astigmatism; the least common was hypermetropia.

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