International Journal Of Health, Engineering And Technology (IJHET) *E-ISSN 2829 - 8683*
Volume 4, Number 2, July 2025, *Page. 110 - 119*
Email : editorijhess@gmail.com

Non Strabismismic Binocular Vision Anomalies Among Schoolchildren Aged 7-17 In Deli Serdang, Indonesia

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Abstract
The non strabismic binocular vision anomalies is one of the visual impairment that prevalent among children and this anomalies may negatively impact on child's school performance and future learning ability, diagnosis and treatment of binocular vision anomalies should be a primary concern. This study employed a cross-sectional method to evaluate binocular vision dysfunctions among school children in Deli Serdang, Indonesia. A history taking followed by standard subjective refraction procedures were performed for refractive errors assessment. Binocular vision assessments were done using standard vergence and accommodation tests. A total of 114 subjects (mean age = 11.81 ± 3.38; female 54%, male 47%) had completed the study. The prevalence of non-strabismic binocular vision anomalies (NSBVA) was 52% (n=60). The convergence insufficiency was the highest (23%) type of NSBVA, followed by accommodative excess (10%), accommodative insufficiency (10%), accommodative infacility (7%) and accommodation insufficiency + convergence insufficiency (3%). There was no significant difference between all the types of NSBVA and across the age group and gender. This study shows that the prevalence of NSBVA is high in the schoolchildren population in North Sumatera. There is a need for a robust vision screening strategy for early detection and intervention of NSBVA to reduce future visual impairment and blindness that may impact school performance among school children in Indonesia

Keywords: **non-strabismic binocular vision; binocular vision dysfunction; accommodation; vergency; vision screening**

INTRODUCTION

World Health Organization (WHO) reported that at least 2.2 billion individuals have vision impairment or blindness, with at least one billion having vision impairment that might have been avoided or that has yet be addressed (1). The predicted number of visual impairment in Asia reported to be 102.88 million in 2020 (2). The proportion of individuals who were blind and had moderate to severe visual impairment lived in South Asia, East Asia, and Southeast Asia (3). The non strabismic binocular vision anomalies is one of the visual impairment that prevalent among children. American Optometric Association (AOA) quoted that diagnosis and treatment of binocular vision anomalies should be a primary concern in the children population because accommodative or vergence dysfunction may negatively impact a child's school performance, particularly after third grade as the child's visual demand increase (4). In the era of digital devices, Non Strabismic Binocular Vision Anomalies (NSBVA) are a major problem in children and young adults (5). Donders initially proposed many classifications of NSBVA, which were subsequently modified by Duane, Scheiman and Wick. It encompasses 4 classifications of NSBVA which include binocular anomalies, vertical anomalies, accommodative anomalies, and oculomotor anomalies. Binocular anomalies including the convergence disorder that impair the eyes' flexibility to coordinate while focusing on a near target. Two common convergence anomalies are convergence insufficiency (CI) and convergence excess (CE) (6). The accommodative anomalies are accommodation insufficiency, ill sustained accommodation, accommodative infacility, and excessive accommodation (7).

There is a little known or limited data for binocular vision disorder among the population of Indonesia, especially among paediatric population although there are many studies conducted worldwide. In Indonesia, the age of school children is 6 to 17 years (Peraturan Mentri Pendidikan dan Kebudayaan Republik Indonesia No 14 Tahun 2018). A study done by Scheiman et. al in 1996 showed

that the most common conditions found in paediatric population are binocular vision disorder. In recent study it was found that NSBVA is second most common optometric anomaly worldwide (5). According to the study, the prevalence of accommodative and binocular (strabismic and non-strabismic) vision disorder in children aged 6 months to 5 years is 9.7 times higher than the prevalence of ocular disease in children aged 6 to 18 years, and 8.5 times higher than the prevalence of ocular disease in children aged 6 to 18 years (8). Vision is vital part to the children's educational process which involves learning through reading, both accommodation and vergence mechanism are involved in reading, hence, an imbalance of these two mechanism would results in NSBVA (9). The demand for binocular vision increases with age and with prolonged reading and writing throughout school, symptoms of binocular vision anomaly may worsen, and studies have found several unfavourable consequences related with various behavioural and academic issues (10). Studies has found that untreated NSBVA among school children is associated with visual fatigue which impair visual performance (11). With the increasing of visual demand among school children it is recommended to study the profile of NSBVA among the school children so that early intervention and detection can be done. Therefore, this study aims to determine the profile of Non Strabismic Binocular Vision Anomalies under the population of school children aged 6 to 17 years old in Deli Serdang, North Sumatera, Indonesia.

RESEARCH METHODS

114 students aged 6 to 17 years was recruited for this cross sectional study. The study included three cohorts, namely the age group of 6 – 11 years, 12 – 14 years, and 15 – 17 years that comprised students from Primary, Secondary, and High schools, respectively. The ethical approval was obtained from Research Ethics Committee of Management and Science University (MSU) Malaysia. This study conformed to the tenets of the Declaration of Helsinki regarding research involving human. Before the study started, the study protocol was reviewed with the school administration and the school provided written informed consent. Consent form including information regarding the objectives of the study written in local language (Indonesian) and sent to the parents through their children with the help of the teachers to distribute to the student.

Pilot Study

A cross sectional pilot study was done to 32 samples of school children aged 9 to 12 (10.40 ± 0.96) with 18 male students (56%) and 14 female students (44%) was recruited. The pilot study done due to limited data on the prevalence of binocular vision anomalies in Indonesia. The descriptive analysis was calculated in all NSVBA finding. The prevalence of the NSBVA in this pilot study found (n = 32) was 72%.

Table 1. Prevalence of NSBVA in Pilot Study

Category	N	%
Normal BV	9	28%
NSBVA	23	72%

Eye Examination

The socio demographics data such as gender and age, were recorded to measure the relationship between types of Non Strabismic Binocular Vision Anomalies with the socio demographic. A brief history taking regarding visual complaints or symptoms taken to support the findings. Vision screening including visual acuity and objective refraction using Autorefractometer was done and detailed binocular vision assessments was done.

Test For Accommodation: The NPA is the major marker examination used to diagnose the accommodative anomalies. The NPA was done using a push up technique with Royal Air Force (RAF) Rule and Minus Lens to blur technique for monocular and binocular. Accommodative facility test was done using the ±2.00 D Flipper lens monocular and binocularly. Monocular Estimated Method (MEM) Retinoscopy was performed to examine the visual system's response to an accommodating target. Relative accommodation test to measure the ability to increase and decrease accommodation under binocular vision condition was performed using loose lens, Negative Relative Accommodation (NRA) using a plus lens will be measured first followed by Positive Relative Accommodation (PRA) using a minus lens.

Test for Convergence: *Near Point Convergence* (NPC) is a point where an individual can maintain a single binocular vision. The NPC was measured using two methods, one is using the Royal Air Force (RAF) Rule and PLRG method by putting a red filter in front of the right eye and green filter in front of the left eye with a penlight parallel to the nose.

Statistical Analysis

All the raw data from the study were computed in Microsoft Excel for Mac to be arranged before computed into SPSS (Statistical Package for the Social Science) software version 25. The demographic data and prevalence were analysed using descriptive statistics presented in table and figure as percentage in each of the age group. The Shapiro-Wilk was used to tests for normality of the data. ANOVA and Kruskal-Wallis analysis was used to compare the variation of types of NSBVA across the aged group. The Pearson Correlation and Spearman's Correlation was used to analyse the relationship of the NSBVA with sociodemographic. For all tests, statistical significance was define by a $p < 0.05$.

RESULTS AND DISCUSSION

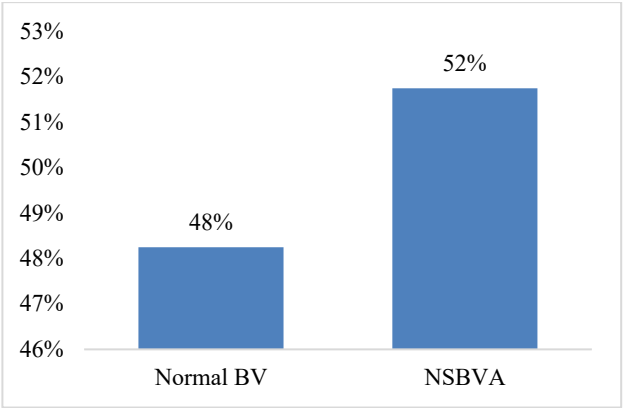
We recruited 114 samples with 6 – 11 years, 12 – 14 years, 15 – 17 years age group with the mean age of 11.81±3.38. 54% subjects were female and 47% were male students. The demographics information are provided in the Table 2.

Table 2. Demographics Information

Variables	Frequency (n)	Percentage (%)	Mean ± SD
Age Group	114	100%	11.81 ± 3.38
6 - 11 years old	56	49%	8.82 ± 1.73
12 - 14 years old	27	27%	13.22 ± 0.87
15 - 17 years old	31	24%	15.97 ± 0.83
Gender			
Female	53	54%	
Male	61	47%	

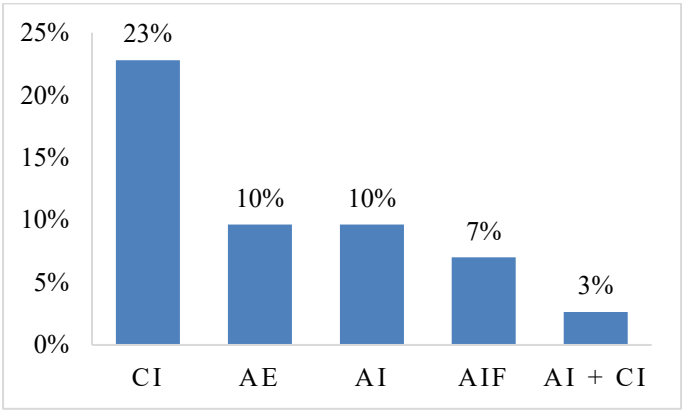
The prevalence of Non Strabismic Binocular Vision Anomalies (NSBVA) among school children in Deli Serdang, North Sumatera is 52% as showed in the figure 1. below

Figure 1. Prevalence of NSBVA



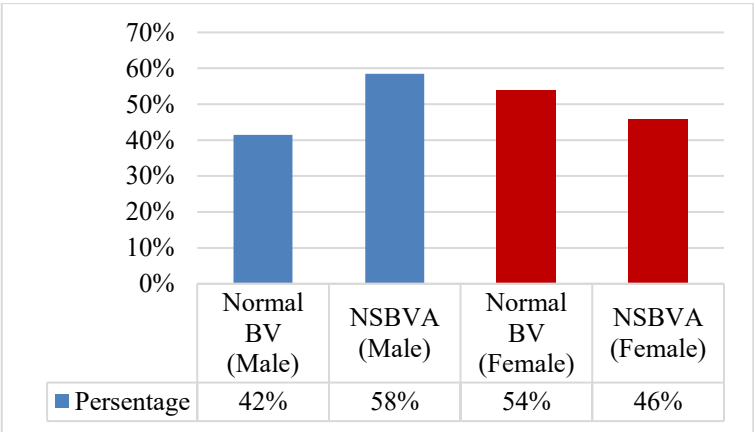
In this study, convergence insufficiency (CI) was the highest prevalence (23%) followed by accommodative excess (AE) (10%) and accommodative insufficiency (AI) (10%). Accommodative infacility (AIF) (7%) and accommodation insufficiency (AI) + convergence insufficiency (CI) (3%) are two anomalies that has the lowest prevalent of NSBVA among school children in Deli Serdang, North Sumatera as showed in figure 2. This finding of the study is similar to the finding of the studies conducted in South Korea among school children, where the prevalence of CI is the highest compared to other types of NSBVA (12).

Figure 2. Distribution of NSBVA in overall age group



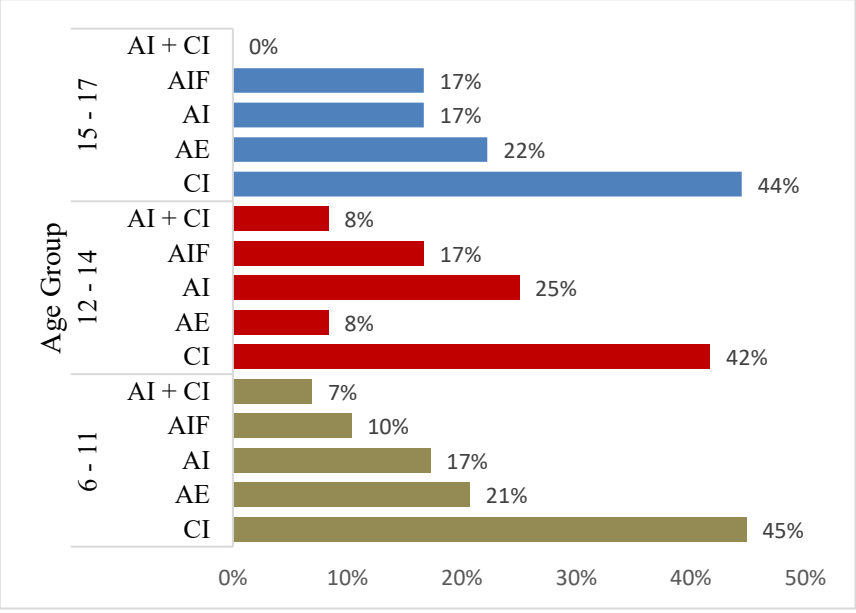
Out of one hundred fourteen samples it is found that 31 (58%) male students and 28 (46%) female students having a non strabismic binocular vision anomalies. The figure 3 below provides an overview of the prevalence of NSBVA by gender among schoolchildren aged 6 – 17 years in Deli Serdang, North Sumatera, Indonesia.

Figure 3. Prevalence of NSBVA by Gender



Age group analysis of the types of NSBVA prevalence in the age group of 6 – 11 years revealed, convergence insufficiency (CI) is the highest prevalence, which is 45%, followed by accommodative excess (AE) 21%, accommodative insufficiency (AI) 17%, accommodative infacility (AIF) 10%, and accommodative insufficiency (AI) + convergence insufficiency (CI) 7%. In the age group of 12 – 14 years, convergence insufficiency (CI) is the highest prevalence, which is 42%, followed by accommodative insufficiency (AI) 25%, accommodative infacility (AIF) 17%, and accommodative excess (AE), accommodative insufficiency (AI) + convergence insufficiency (CI) 8% respectively. In the age group of 15 – 17 years showed, convergence insufficiency (CI) is the highest prevalence, which is 44%, followed by accommodative excess (AE) 22%, and accommodative insufficiency (AI), accommodative infacility (AIF) 17% respectively. (Figure 4). These findings similar to the study done in Northeast India where it was observed that the most prevalent of NSBVA in all age group was convergence insufficiency (13).

Figure 4. Prevalence of types of NSBVA by Age Group



For comparing the variation of types of NSBVA across the aged group, the one-way ANOVA analysis was done to the variables with normal distribution, and Kruskal-Wallis analysis was done to the variables that are not normally distributed.

Table 3. Comparison types of NSBVA across Age Groups

	AGE GROUP			
	Mean ± SD 6 – 11	Mean ± SD 12 – 14	Mean ± SD 15 – 17	p value
Monocular AA (RAF)	12.53 ± 4.05	11.12 ± 3.74	13.22 ± 3.49	0.343
Binocular AA (RAF)	12.75 ± 4.28	11.25 ± 3.41	13.71 ± 3.94	0.222
Monocular AA (MLTB)	6.91 ± 2.40	6.60 ± 1.47	6.91 ± 2.30	0.967
Binocular AA (MLTB)	7.21 ± 2.53	6.75 ± 1.53	7.00 ± 2.22	0.844
MEM	1.29 ± 1.30	1.27 ± 0.71	1.05 ± 1.24	0.460

Monocular AIF	4.60 ± 2.07	5.95 ± 1.90	4.66 ± 2.69	0.200
Binocular AIF	5.96 ± 2.10	6.91 ± 3.05	5.36 ± 2.31	0.227
NRA	1.42 ± 0.56	1.39 ± 0.48	1.54 ± 0.57	0.727
PRA	1.66 ± 1.03	1.97 ± 1.03	-1.76 ± 1.01	0.574
NPC Break (RAF)	9.82 ± 5.06	8.41 ± 4.62	8.55 ± 2.81	0.889
NPC Recovery (RAF)	12.57 ± 4.98	11.50 ± 4.18	11.50 ± 2.64	0.904
NPC Break (PLRG)	16.89 ± 6.93	14.50 ± 5.56	12.44 ± 4.16	0.111
NPC Recovery (PLRG)	19.75 ± 7.03	17.75 ± 5.77	15.72 ± 4.05	0.151

Based on the Table 3 the result showed that there are no significant different between all the types of NSBVA and across the age group. In this case, the null hypothesis is accepted ($p>0.05$).

Comparison of all the types of NSBVA and across the gender were also evaluated, the results are shown in the Table 4 below

Table 4. Comparison types of NSBVA across Gender

	GENDER		
	Mean ± SD Female	Mean ± SD Male	p value
Monocular AA (RAF)	13.01 ± 3.19	11.93 ± 3.83	0.286
Binocular AA (RAF)	13.32 ± 3.45	12.15 ± 3.94	0.181
Monocular AA (MLTB)	7.23 ± 2.511	6.50 ± 1.79	0.444
Binocular AA (MLTB)	7.39 ± 2.55	6.733 ± 1.88	0.595
MEM	1.12 ± 1.13	1.30 ± 1.22	0.424
Monocular AIF	4.71 ± 2.21	5.08 ± 2.36	0.543
Binocular AIF	5.64 ± 2.46	6.28 ± 2.36	0.204
NRA	1.25 ± 0.45	1.65 ± 0.56	0.004
PRA	1.81 ± 1.16	1.72 ± 0.86	0.876
NPC Break (RAF)	9.71 ± 4.95	8.60 ± 3.74	0.386
NPC Recovery (RAF)	12.82 ± 4.48	11.26 ± 3.81	0.163
NPC Break	15.89 ± 6.62	14.20 ± 5.65	0.284

(PLRG)			
NPC Recovery (PLRG)	19.07 ± 6.61	17.16 ± 5.65	0.257

Based on Table 4 the result of the negative relative accommodation (NRA) has a significant difference across gender. NRA measures the maximum ability to relax accommodation while maintaining single and clear vision (14). In this study, the mean of NRA was higher in male students compared to female. This finding might be associated with the prolonged used of electronic gadgets which study has shown that male students are more prone in using electronic gadgets than female students (15). Study has found that male students start playing video games earlier in life and play more frequently than female (16). A prolonged near distance work such as the usage of electronic gadgets changed the accommodation systems (17).

In the other hand, majority of the result showed that there are no significant different between all the types of NSBVA and across the gender ($p>0.05$). We also identified the correlation of types of NSBVA and sociodemographic. Pearson's and Spearman's analysis was done to check the correlation.

Table 5. Relationship Between Types of NSBVA and Age

	Correlation	**Sig**
Monocular AA (RAF)	0.063	0.641
Binocular AA (RAF)	0.060	0.655
Monocular AA (MLTB)	0.015	0.910
Binocular AA (MLTB)	-0.026	0.845
Accommodative Response (MEM)	-0.179	0.180
Monocular Accommodative Facility	0.091	0.499
Binocular Accommodative Facility	-0.049	0.717
Relative Accommodation (NRA)	-0.014	0.920
Relative Accommodation (PRA)	0.012	0.927
NPC Break (RAF)	-0.045	0.737
NPC Recovery (RAF)	-0.030	0.825
NPC Break (PLRG)	-0.237	0.074
NPC Recovery (PLRG)	-0.223	0.092

Based on the Table 5, correlation coefficient was computed to assess the relationship between age and types of NSBVA. The result shows that there is negligible correlation between the age and all the types of NSBVA ($p>0.05$). The negligible relationship between the types of NSBVA and age might be related to the fact that each age group had the same amount of school time. Every Indonesian school children spends the same amount of time studying in the class and performing near task. With the development of digital technology, almost all school children are used to using mobile phones, laptop, or computer for playing video games, that can interfere to the accommodation and convergence

ability if used excessively. This may also be the reason behind the no significant relationship between age and NSBVA.

Table 6. Relationship Between Types of NSBVA and Gender

	Correlation	Sig
Monocular AA (RAF)	-0.143	0.286
Binocular AA (RAF)	-0.177	0.184
Monocular AA (MLTB)	-0.101	0.448
Binocular AA (MLTB)	-0.070	0.599
Accommodative Response (MEM)	0.106	0.429
Monocular Accommodative Facility	0.082	0.543
Binocular Accommodative Facility	0.168	0.207
Relative Accommodation (NRA)	0.369	0.004
Relative Accommodation (PRA)	-0.021	0.877
NPC Break (RAF)	-0.115	0.391
NPC Recovery (RAF)	-0.185	0.165
NPC Break (PLRG)	-0.142	0.288
NPC Recovery (PLRG)	-0.150	0.261

Based on Table 6, there is a significant relationship between negative relative accommodation (NRA) and gender. Assessment of NRA helps to detect accommodation disorders and condition affecting vision clarity. In literature there were no study found yet to demonstrate gender relationship with negative relative accommodation (NRA). Although the presence of the relationship currently is being discussed and assumption has raised that its correlate with inter-gender physiological differences in accommodation mechanism and hormonal differences, however there is still limited proof or study to confirm or reject it (18). Based on the above, there is no conclusive evidence of the relationship between the accommodation function and gender. It is recommended that this relationship can be investigated in further study.

Discussion

The findings of this study provided the profile of non-strabismic binocular vision anomalies (NSBVA) among Indonesian school children. In this study, convergence insufficiency (CI) was the highest prevalence (22.80%) followed by accommodative excess (AE) (9.65%) and accommodative insufficiency (AI) (9.65%). Accommodative infacility (AIF) (7.02%) and accommodation insufficiency (AI) + convergence insufficiency (CI) (2.63%) are two anomalies that has the lowest prevalent of NSBVA among school children in Deli Serdang, North Sumatera. This finding of the study is similar to the finding of the studies conducted in South Korea among school children, where the prevalence of CI is the highest compared to other types of NSBVA.

Age group analysis of the prevalence of NSBVA by age group revealed a highest prevalence of NSBVA among the 15 – 17 years age group, this correlate to the finding of the study in India which

revealed the increase in prevalence in the 13 – 17 years age group(19). Gender analysis of the prevalence of NSBVA showed that CI is the most prevalent in female (26%) and male (21%) students. However, few studies have reported that there was no gender predilection in NPC test (20) and no statistically significant difference observe in gender of the NSBVA in rural and urban school children (19).

Based on the finding in this study we can conclude that there is no significant difference between NSBVA and age group and gender among school children in Deli Sedang, North Sumatera, Indonesia. The negligible relationship between the types of NSBVA and age and gender might be related to the fact that each age group and gender had the same amount of school time. Every Indonesian school children spends the same amount of time studying in the class and performing near task. With the development of digital technology, almost all school children are used to using mobile phones, laptop, or computer for playing video games, that can interfere to the accommodation and convergence ability if used excessively.

The strength of this study is that based on the literature study conducted, there is no data on the prevalence of NSBVA in Indonesian schoolchildren population, this study will be the first to report the profile of NSBVA data among schoolchildren in Indonesian population. The limitation of this study is that it does not consider the refractive errors as the risk factor of NSBVA. Other than that, the reliability between two methods in the amplitude of accommodation and convergence test was not being analyzed. Binocular vision assessments are still relatively rare done in Indonesia population, so the study sample might not fully understand the instruction given by the examiner as it was not familiar to them compared to the regular refraction assessments.

CONCLUSION

In summary, this study revealed a significant prevalence of NSBVA among schoolchildren in Deli Serdang, North Sumatera. It is recommended to conduct more population-based studies to see the prevalence of binocular vision anomalies in the school and university population as Indonesia has many areas that are quite remote which are far from the reach of health facilities, including eye health facilities.

In North Sumatra alone, there are more than 1300 remote areas. Comparative studies can be carried out to find out the comparison of prevalence in remote and urban areas and the eye practitioners should start to raise awareness and building advocacy about NSBVA and its effect on quality of life.

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