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# Non-strabismic binocular vision anomalies among students of a Malaysian private university uses visual display unit

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## 马来西亚一所私立大学使用视觉显示装置的学生非斜视双眼视觉异常

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## 摘要

**目的**:评估马来西亚一所私立大学使用视觉显示装置(VDU)的学生非斜视双眼视觉异常(NSBVA)情况。

**方法**:对 2019-01/2019-05 期间每天使用 3h 及以上 VDU 的大学生进行横断面研究。使用一种简便的样本收集方法,所有受试者均通过初级视力检查且满足入选标准,对符合入选标准的学生进一步进行 NSBVA 评估。采用描述性分析排除 NSBVA 的百分比,采用 Chi-square 独立性检验,观察 NSBVA 与年龄、性别、VDU 使用时间的相关性。

**结果**:研究共纳入 140 名学生,其中女 88 名(62.9%),男 52 名(37.1%)。受试者平均年龄为 22.54±1.48a,平均 VDU 使用时间为 5.76±2.49h。使用 VDU 学生的 NSBVA 百分比为 40%。在 VDU 使用者中,调节异常和倾斜异常的发生率分别为 17.86% 和 22.14%。性别与 NSBVA 之间存在适度关联($P=0.010$)。但是,年龄($P=0.334$)和 VDU 使用时间($P=0.835$)与 NSBVA 无显著相关。

**结论**:马来西亚一所私立大学的学生中,有 40% 的人使用 VDU。在所有 NSBVA 中,VDU 用户调节异常(15%)和会聚功能异常(10%)更为常见。

**关键词**:非斜视双眼视觉异常;视觉显示装置;调节性异常;聚散度异常;大学生

## Abstract

• AIM: To determine the status of non-strabismic binocular vision anomalies (NSBVA) among students of a Malaysian private university uses visual display units (VDU).

• METHODS: A cross-sectional study was conducted among university students who use VDU 3h or more from January 2019 to May 2019. A convenient sampling method was utilized. All subjects had gone through primary eye-examinations to satisfy the inclusion criteria. Those who satisfy the inclusion criteria, further gone through the NSBVA assessment. The descriptive analysis was done to rule out the percentage of NSBVA and Chi-square test of independence was carried out to observe the association of NSBVA with age, gender and hours of VDU usage.

• RESULTS: A total of 140 students including 88 females (62.9%) and 52 males (37.1%) participated in this study. The mean age of the participants was 22.54±1.48 years and the mean VDU usage hours were 5.76±2.49h. The percentage of NSBVA is 40% among the students those who use VDU. The occurrence of accommodative and vergence anomalies among the VDU users is 17.86% and 22.14% respectively. There was a moderate association between gender and NSBVA ($P=0.010$). However, there was no significant association observed for age ($P=0.334$) and hours of VDU usage ($P=0.835$) with NSBVA.

• CONCLUSION: NSBVA is 40% among the students of a Malaysian private university uses VDU. Accommodation insufficiency (15%) and convergence insufficiency (10%) is more common among all NSBVA for VDU users.

• KEYWORDS: non-strabismic binocular vision anomalies; visual display unit; accommodative anomalies; vergence anomalies; university student

## INTRODUCTION

The state of simultaneous vision which was accomplished by the coordinated use of two eyes with the goal that separate and slightly different images emerging in each eye were appreciated as a single image by the process of fusion was expressed as binocular single vision. Consequently, binocular vision suggested fusion which is the blending of sight from both eyes to form a single image[1].

Non-strabismic binocular vision anomalies (NSBVA) were

considered as vision anomalies which affect clarity, binocularity, impair the comfort and effectiveness of visual performance when near work ( Reading, Writing and Computer-based work ) is performed[2-6]. NSBVA is mainly categorized in two groups, which are accommodative anomalies and vergence anomalies[7]. Daum stated that accommodative anomalies had resulted in blurred images created on the retina due to the difficulty of the eye muscles to focus effectively on objects at different distances[8]. On the other hand, vergence anomalies were manifested due to the inability to fixate and sustain images on the retina owing to the difficulty of the eyes to coordinate accurately[9]. Accommodative anomalies included accommodative insufficiency ( AI ), accommodative spasm, accommodative infacility ( AIF ) and ill-sustained accommodation ( ISA ) while vergence anomalies include convergence insufficiency ( CI ), convergence excess ( CE ), divergence insufficiency ( DI ), divergence excess ( DE ), basic exophoria, basic esophoria, vertical phoria and fusional vergence dysfunction ( FVD ). The common symptoms of NSBVA were blurred vision, headache, ocular discomfort, ocular or systemic fatigue, double vision, motion sickness, and inability to concentrate during task performance[7].

Visual display unit ( VDU ) displays images were generated by a computer or other electronic device has become an essential part of modern life[10]. Nowadays, people not only use a computer for work but also extensively uses in school and at home. Hence, give rise to several visual and ophthalmic problems, namely computer vision syndrome[11]. Visual problems; abnormalities of the eye surface ( dry eye ) and asthenopic problems were commonly presented with the increasing use of VDU[12]. In a study by Sen et al[13] stated that a million new cases of computer vision syndrome occur each year and it was estimated that nearly sixty million people suffered from computer vision syndrome globally. Thomson indicated that symptoms related to computer vision syndrome were seen in about 90% computer users who used a computer for prolonged hours[14]. On the other hand, a study by Hayes et al[12] estimated that the percentage of computer vision syndrome ranges from 75% – 90% among computer users. Additionally, the previous studies showed that eye symptoms were higher among the females and increases with VDU uses, especially when using a VDU for more than six hours per day[15-16].

A study carried out by Hokoda[17] reported that the prevalence of general binocular anomalies for non-presbyopes with asthenopia. The percentage of symptomatic general binocular anomalies was 21. 0%. Out of which, accommodative anomalies, symptomatic near esophoria and convergence insufficiency were 16. 8%, 5. 9%, and 4. 2% respectively. Besides, Porcar & Martinez-Palomera stated a percentage of 32.3% for NSBVA in the general population of university students[18]. Accommodation excess ( 10. 8% ) was the most prevalent anomaly followed by convergence insufficiency with accommodative excess ( 7. 7% ) and accommodative

insufficiency ( 6.2% ). Besides, another study carried out by García-Muñoz et al[19] showed a prevalence of NSBVA of 13. 15%. In Porcar et al[20] study, out of eighty-nine VDU subjects, twenty subjects ( 22. 5% ) were presented with accommodative and non-strabismic binocular dysfunctions ( $A_{NS}BD$ ). Moreover, a study by Shrestha et al[21] stated that the prevalence of distance and near exophoria among the VDU users was 13.2% and 15.8% respectively. The most prevalent NSBVA was accommodative infacility ( 35. 5% ) followed by fusional insufficiency ( 14. 8% ) and lag of accommodation ( 13.6% ). On top of that, a study by Gur et al[22] showed an occurrence of low fusional convergence, convergence insufficienc and Heterophoria among the VDU users. Till date, no such studies reported the status of non-strabismic binocular vision anomalies among visual display unit users in Malaysia. Therefore, this study aims to rule out the percentage of NSBVA among students of a Malaysian private university uses a VDU.

## SUBJECTS AND METHODS

A cross-sectional study was conducted by using aconvenient sampling method to choose study subjects from the university students those who have visited UCSI Optometry clinic. The study was conducted, including 140 students from UCSI University, Kuala Lumpur from January – May 2019 irrespective of gender and ethnicity. The age range of the study participants is from 18-35 years. The sample size was determined by using the Daniel[23] formula with the assumption of significance α= 5% ( with 95% CI ), Marginal error d = 5% and $P$ = 0.1315[19]. The $Z$ value is 1.96. The total number of sample calculated for the study was 175. A total of 140 data was analyzed. Participants have the right to decline the request of not being a subject for the study. The inclusion criteria were UCSI University students, participants of age range from 18 to 35 years old, best-corrected distance visual acuity of 6/6 and near visual acuity of N6 or better in each eye and students who have used computer or flat panel display for 3h or more in their daily life. The exclusion criteria were subjects had ocular motility dysfunctions, neurological disorders, ocular pathology, previous ocular surgery, contact lens wearer, and systemic disorders. Informed consent was obtained from the students and ethical clearance was also obtained from the UCSI University Ethical Committee ( IEC-2019 – FMHS – 008 ). All procedures were performed after following the guideline of the declaration of Helsinki.

**Procedure**　Firstly, the demographic details of the patient were documented. The reason for the visit and any symptoms reported by the patients were also recorded. A detailed history, including ocular history, medical history, and family history was also obtained. The primary eye examination was conducted to confirm the requirement of inclusion criteria. The eye examination included Inter papillary distance measurement, distance and near visual acuity by using Snellen's chart, sensory examination, motor examination, color vision, objective and subjective refraction, slitlamp examination and fundus examination were carried out. Based

on the findings of primary eye examination and inclusion criteria, subjects were incorporated into the study. Those who satisfied the inclusion criteria, gone through a series of tests necessary to identify NSBVA. The test included measurement of Heterophoria by using Maddox rod, near point of accommodation, amplitude of accommodation by using push up technique, negative relative accommodation (NRA), positive relative accommodation (PRA), accommodative facility (AF) monocular as well as binocular, AC/A ratio, MEM method, near point of convergence, positive fusional vergence (distance and near), negative fusional vergence (distance and near) and vergence facility. The data were checked according to the diagnostic criteria mentioned by Paniccia et al[24]. Those who comply with the diagnostic criteria were considered to have NSBVA. The Subject who has more than one anomaly was categorized as a separate group. In this study, none of the subjects have more than one diagnosis based on the diagnostic criteria. The diagnostic criterion has shown in Appendix A. The hours of VDU use were categorized into two groups: <6h and ≥6h. The <6h included those subjects who have used VDU greater than equal to 3h to less than 6h. All the examination procedure and instruments were standardized to obtain reliable and accurate data. All procedures were performed by sticking with the guideline of the declaration of Helsinki and all test were conducted by a single examiner to avoid intra observer bias. The recording of data was done under the supervision of another observer to overcome the data entry error.

**Statistical Analysis** The analysis was carried out by using a statistical software package IBM SPSS Statistics for Windows (IBM Corp. Released 2017. Armonk, NY, USA: IBM Corp.) version 25.0 and Microsoft Office Excel 2007. The results were expressed as mean±standard deviation if the variable is continuous and as the number (percentage) if the categorical unless otherwise mentioned. Chi-square was implemented to rule out the association of non-strabismic binocular vision anomalies with gender, age and hours of computer usage.

**RESULTS**

A total of 140 students from UCSI University, South Wing Campus, Kuala Lumpur were recruited in this study, consisting of 88 females (62.86%) and 52 males (37.14%) as shown in Figure 1. The mean age of the study participants was 22.54±1.48 years. Figure 2 showed the distribution of the age of the studied sample. The available study subjects were categorized into Chinese of 123 (87.86%), 9 (6.43%) Malay, 8 (5.71%) Indian as shown in Figure 3. The mean hours of VDU usage were 5.76±2.49h.

**Status of Non-strabismic Binocular Vision Anomalies**

The percentage of NSBVA is 40% among the university student those who have used VDU. Of the 140 subjects, 56 subjects were presented with accommodative or vergence anomalies and the remaining 84 subjects were normal. However, out of the total percentage of (40%) NSBVA, 22.14% had vergence anomalies and 17.86% had accommodative anomalies. The highest percentage observed for
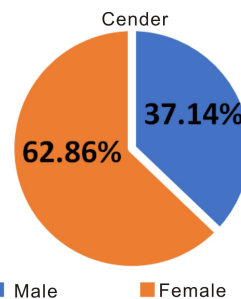


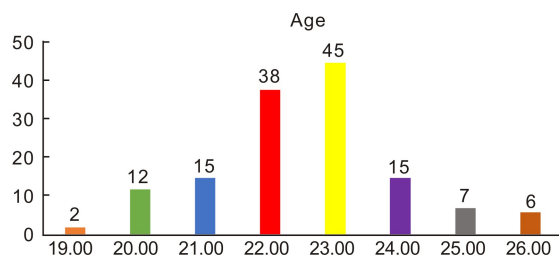**Figure 1　Distribution of the gender among study subjects.**
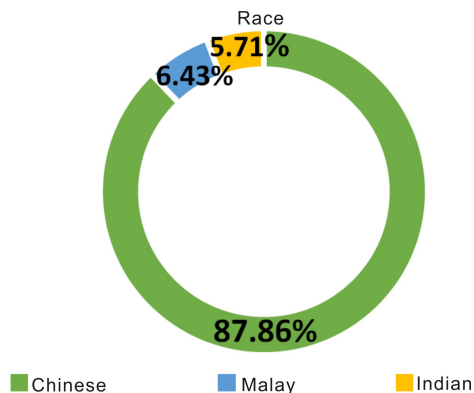


**Figure 2　Distribution of age among study subjects.**



**Figure 3　Distribution of the race among study subjects.**

**Table 1　Percentage of NSBVA**

| NSBVA | Subjects, $n = 140$ | Percentage (%) |
| --- | --- | --- |
| AI | 21 | 15.00 |
| CI | 14 | 10.00 |
| CE | 3 | 2.14 |
| DI | 1 | 0.71 |
| DE | 4 | 2.86 |
| ISA | 1 | 0.71 |
| BES | 2 | 1.43 |
| BEX | 2 | 1.43 |
| AIF | 3 | 2.14 |
| FVD | 5 | 3.57 |
| Total NSBVA | 56 | 40.00 |
| Normal | 84 | 60.00 |

NSBVA: Non-strabismic binocular vision anomalies; AI: Accommodation insufficiency; CI: Convergence insufficiency; CE: Convergence excess; DI: Divergence insufficiency; DE: Divergence excess; ISA: Ill-sustained accommodation; AIF: Accommodation in facility; FVD: Fusional vergence dysfunction; BES: Basic esophoria; BEX: Basic exophoria.

AI followed by CI, CE, DE, AIF, FVD, BES, BEX, DI, and ISA respectively. Table 1 showed the percentage of NSBVA among VDU users.

**Table 2　Distribution of gender and association of NSBVA with gender**　　　　　　　　　　　　　　　　　　　　　( $n$ = 56)

| NSBVA | Male（%） | Female（%） |
|---|---|---|
| AI | 11（52.38%） | 10（47.62%） |
| CI | 7（50%） | 7（50%） |
| CE | 2（66.67%） | 1（33.33%） |
| DI | 0（0%） | 1（100%） |
| DE | 2（50%） | 2（50%） |
| ISA | 1（100%） | 0（0%） |
| BES | 1（50%） | 1（50%） |
| BEX | 1（50%） | 1（50%） |
| AIF | 2（66.67%） | 1（33.33%） |
| FVD | 1（20%） | 4（80%） |
| Total | 28 | 28 |

NSBVA：Non – strabismic binocular vision anomalies；AI：Accommodation insufficiency；CI：Convergence insufficiency；CE：Convergence excess；DI：Divergence insufficiency；DE：Divergence excess；ISA：Ill-sustained accommodation；BES：Basic esophoria；BEX：Basic exophoria；AIF：Accommodation in facility；FVD：Fusional vergence dysfunction；$P$<0.05 is considered as significant；Cramer's $V$ shows moderate association.

**Table 3　Shows distribution of hours of VDU usage and association of NSBVA with hours of VDU usage**　( $n$ = 56)

| NSBVA | <6h | ≥6h |
|---|---|---|
| AI | 13（61.90%） | 8（38.10%） |
| CI | 7（50%） | 7（50%） |
| CE | 2（66.67%） | 1（33.33%） |
| DI | 1（100%） | 0（0%） |
| DE | 2（50%） | 2（50%） |
| IAS | 1（100%） | 0（0%） |
| BES | 1（50%） | 1（50%） |
| BEX | 1（50%） | 1（50%） |
| AIF | 1（33.33%） | 2（66.67%） |
| FVD | 2（40%） | 3（60%） |
| Total | 31 | 25 |

NSBVA：Non – strabismic binocular vision anomalies；AI：Accommodation insufficiency；CI：Convergence insufficiency；CE：Convergence excess；DI：Divergence insufficiency；DE：Divergence excess；ISA：Ill-sustained accommodation；BES：Basic esophoria；BEX：Basic exophoria；AIF：Accommodation in facility；FVD：Fusional vergence dysfunction；$P$<0.05 is considered as significant.

**Association Between Gender and NSBVA Among VDU Users**　The distribution of gender for individual NSBVA that included AI, CI, CE, DI, DE, ISA, BES, BEX, AIF, FVD and association of NSBVA with gender had shown in Table 2. A two – way contingency table analysis was conducted to evaluate the association between gender and NSBVA among VDU users. A Chi – square test of independence between gender and NSBVA showed a statistically significant association between gender and NSBVA, $\chi^2$ = 6.608（1，$N$ = 140），$P$ = 0.010，Cramer's $V$ = 0.217. The association was moderate.

**Association Between Hours of Using VDU and NSBVA Among VDU Users**　The distribution of hours of using VDU

**Table 4　Distribution of study participants based on age groups and its association with NSBVA**

| Age group，a | Subjects，$n$ | NSBVA（%） | Normal（%） |
|---|---|---|---|
| 19-22 | 67 | 24（42.86%） | 43（51.19%） |
| 22-26 | 73 | 32（57.14%） | 41（48.81%） |
| Total | 140 | 56（100%） | 84（100%） |

NSBVA：Non-strabismic binocular vision anomalies；$P$ < 0.05 is considered as significant.

for individual NSBVA included AI, CI, CE, DI, DE, ISA, BES, BEX, AIF, FVD and association of NSBVA with hours of using VDU had shown in Table 3. A two-way contingency table analysis was conducted to evaluate the association of hours of VDU usages with NSBVA among the VDU users. A Chi-square test of independence conducted between hours of using VDU and NSBVA showed no statistically significant association between hours of using VDU and NSBVA, $\chi^2$ = 0.043（1，$N$ = 140），$P$ = 0.835.

**Association Between Age and NSBVA Among VDU Users**　The mean age of the study participants was 22.54 ± 1.48 years. The age group was categorized into two groups based on the observed mean age of this study participant, which are 19-22 years and 22-26 years. The distribution of study participants based on the age group association between NSBVA and age had shown in Table 4. A two – way contingency table analysis was conducted to establish the association between age and NSBVA among the VDU users. A Chi-square test of independence conducted between age and NSBVA showed no statistically significant association age and NSBVA, $\chi^2$ = 0.935(1，$N$ = 140)，$P$ = 0.334.

**DISCUSSION**

This study was aimed to show the status of NSBVA among students of a Malaysian private university used VDU. The total number of participants for this study was 140 subjects irrespective of gender and race. This study showed the overall percentage of NSBVA was 40% among the university students those who are using VDU. In a study, Porcar et al[20] stated the prevalence of NSBVA of 22.5% among the University population that includes students, teachers, and office workers those who use VDU. The present study finding is quite higher in compared to Porcar et al[20] study, although the study population was only university students those who use VDU. However, both studies had a similar mean age（22.54± 1.48 years and 25±4 years respectively）and all subjects are asymptomatic. The possible difference in outcome for both studies may be due to the variation in sample size, geographical changes, diagnostic criteria, and ethnicity.

Additionally, this study showed a higher percentage of accommodative insufficiency（15%）followed by convergence insufficiency（10%）among NSBVA, which is supported by Shrestha et al[21] where the prevalence of accommodative insufficiency and convergence insufficiency were also showed higher（9.7% and 9% respectively）. The mean age for this study and Shrestha et al[21] study is 22.54 ± 1.48 years and 25.8±5 years respectively, which is quite similar. Although

the inclusion criteria for recruiting subjects, location of the study and sample size differ significantly still the outcome of both studies didn't disagree much. The percentage of vergence anomalies (22.14%) was higher compared to accommodation anomalies (17.86%) for VDU users in the present study. So far no such study available to compare this study finding with others.

Moreover, the present study reported a moderate association ($P=0.010$, Cramer's $V=0.217$) between gender and NSBVA among the VDU users. It was also observed that males are more affected than females. However, Shrestha et al[21] contradicted this study finding by stating that both genders were equally affected. Moreover, studies by Scheiman et al[25], Rouse et al[26], Borsting et al[27] and Wajuihian et al[28] shown that convergence insufficiency, which is a part of NSBVA don't have any significant variation between male and female subjects. A study by Letourneau et al[29] found CI to be marginally more frequent in girls (2.1%) than boys (1.9%) in a population of Canadian schoolchildren. No available study has compared the association of all NSBVA with gender for those who were using computer among university students.

On the contrary, this study showed no significant ($P>0.05$) association between hours of VDU usage and NSBVA. Gur et al[22] in his study reported that the VDU users had a higher percentage of low fusional convergence (46.9%), convergence insufficiency (28.1%) and heterophoria (34.4%) for those who use a computer for $5-6h/d$. Till date, association between VDU usage hours with NSBVA among university students were not established.

Moreover, the present study didn't report any significant association between age and NSBVA among VDU users. A few studies related to age and NSBVA in general population were available, but no study finds out the association between age and NSBVA among the VDU users. Wajuihian et al[30], Dusek et al[31], Scheiman et al[25], Dwyer et al[32] showed CE which is one of the NSBVA has significantly higher in younger age groups than older age groups. However, Harris[33] and Abdi et al[34] showed a higher prevalence of CI with increasing age. Lastly, a study by Hussaindeen et al[35] stated that there's a significant increase in the prevalence of NSBVA between 13 to 17 years of age group. So far, no such study available to support or contradict the present study finding.

Ethnicity is a limitation of works as most of the participants in this study involved Chinese only. Therefore, the association between race and non-strabismic binocular vision anomalies cannot be carried out. Lastly, this study could not able to fulfill the targeted sample size, which is also considered another limitation of the study.

The percentages of non-strabismus binocular vision anomalies are 40% among the students of a Malaysian private university using a visual display unit. The percentage of accommodative and vergence anomalies among the visual display unit users are 17.86% and 22.14% respectively. Accommodation insufficiency (15%) and convergence insufficiency (10%) are more prevalent among accommodative and vergence anomalies for visual display unit users. Moreover, the percentage of others NSBVA that includes fusional vergence dysfunction, divergence excess, convergence excess, accommodative infacility, basic esophoria, basic exophoria, divergence insufficiency and ill-sustained accommodation are 3.57%, 2.86%, 2.14%, 2.14%, 1.43%, 1.43%, 0.71% and 0.71% respectively. There is a moderate association ($P=0.010$) established between gender and non-strabismic binocular vision anomalies among the VDU users. However, no significant association was observed for age and hours of visual display unit usage with non-strabismic binocular vision anomalies.

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