Evaluating Normative Values of Vergence Parameters among University Students in Malawi

Augustine Mvula  
Mzuzu University

Thokozani Mzumara  
Mzuzu University  https://orcid.org/0000-0002-0011-269X

Joseph Afonne (drchinkatan@gmail.com)  
Mzuzu University

Research Article

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Abstract

**Clinical relevance:** Diagnosis and management of vergence dysfunctions are largely dependent on normative measures of vergence parameters which differ across populations.

**Background:** Globally Myopia is on the rise and vergence has been strongly linked to the development of Myopia. Understanding vergence parameters is key to mitigation of Myopia.

**Aim:** This study aimed at evaluating differences in vergence parameters among university students in Malawi.

**Methods:** This cross-sectional quantitative study was conducted among Mzuzu University students from September 2021 to March 2022. A total of 99 healthy participants comprising 62 males (62.6%) and 32 females (37.4%) were recruited using a stratified random sampling technique. AC/A ratio was measured using the gradient method, and Positive Fusion Vergence (PFV) and Negative Fusion Vergence (NFV) using horizontal prism bars recorded as blur, break, and recovery points.

**Results:** The mean age was 23.37 ± 3.95 years (range; 18-33). The mean AC/A ratio was 4.24 ±0.74, the mean PFV was 17/24/15 and the mean NFV was 17/20/14. There was no significant correlation between the AC/A ratio and age (p = 0.194) nor was there a significant association between AC/A and sex (p = 0.170). Both PFV and NFV had no statistically significant correlation with age (all p ≥ 0.306) or association with sex (all p ≥ 0.253).

**Conclusion** This study confirms that the pattern of vergence parameters differs with ethnicity. Furthermore, ACA ratio and fusion vergences are most not affected by age and sex.

Introduction

Majority of university students suffer from vergence dysfunctions due to increased reading activities and near work at tertiary education levels. Moreover, vergence parameters play a major role in the development of Myopia. Consequently, vergence-dysfunction affects academic performance negatively. For instance, about 78.6% of students have been reported to achieve poor academic performance due to vergence dysfunctions. Vergence dysfunction can disrupt a student's quality of life due to their myriad of visual symptoms including asthenopia, diplopia, and ill-sustained focus during reading and other near work activities.

Vergence eye movements are disjunctive movement of eyes in opposite directions either inward or outward. The movements are based on Hering's law of equal innervation which posits that both eyes receive equal innervation. The vergence system is responsible for coordinating eye movements fusing retinal images together to ensure alignment of the eyes and maintain binocular single vision. According to Maddox, the vergence system consists of 4 subtypes namely tonic vergence, accommodative vergence, fusional vergence and proximal vergence. The accommodative and vergence systems...
interact together to form a clear bifoveal retinal image which is fused in the visual cortex into a single percepts. Accommodation and vergence are guided by the negative feedback control system under the control systems theory.

Normative data is needed to compare with clinical findings and make a diagnosis on non-strabismic binocular visual anomaly including dysfunction of the vergence system. Needless to say, early diagnosis and management of vergence dysfunctions, which usually involve measurement of AC/A ratio and fusion vergences, is critical for the improvement of student's quality of life and academic performance.

Currently, diagnosis of vergence dysfunctions in Malawi is guided by conventional clinical normal values derived from the Caucasian population. Accordingly, the majority of population specific ethnic based normative studies of non-strabismic binocular vision anomalies have been conducted in Europe followed by Asia and a few in Africa. Notably, the common utilized guidelines include Scheiman and Wick, and the Optometry Extension Programme table of expected findings. Nevertheless, normative values differ among and within continents as a factor of ethnicity.

A recent study in Malawi reported the normative values of accommodative parameters among university students, but to the best of our knowledge the normative values for vergence parameters for this group remains a conundrum. In addition, little is known about the relationship between sex and age on vergence parameters. Therefore, the aim of this is to evaluate the normative values of vergence parameters and the effect of age and sex among university students in Malawi. This information will aid clinicians to identify abnormal vergence conditions in this population and eventually improve the quality of life and academic performance of university students.

**Methods**

This cross-sectional quantitative study was conducted among students at Mzuzu University. The study employed a multi-stage stratified sampling technique. First, the study population was divided into six strata according to faculties, then we divided the population further into Males and Females. Next, we used a random sampling method to select participants within each gender group.

As an inclusion criterion, we recruited participants with normal internal and external ocular conditions. In addition, we recruited participants with visual acuity $\geq 20/25$ and those with normal motility. On the other hand, we excluded all participants 40 years and older. In addition, we excluded all participants with a history of intraocular surgery or trauma, heterotropia on cover test, patients on medications, patients with diabetes and anisometropia. To ensure eligibility, we screened all participants before recruiting. The screening procedures consisted of case history, visual acuity, broad H, pupil reaction, cover test, refraction and slit lamp examination.

**Procedure**
All the tests were conducted at the Mzuzu University Optometry Clinic under standard test illumination. All vergence tests were conducted in the morning hours between 08.30 am to 11.30 am to reduce the effect of daytime and fatigue. A practice session for 30 seconds was provided to each participant before each vergence test. Two-minute rest periods between the tests were given to subjects. We measured each parameter twice and regarded the average as final reading. All measurements were conducted by one practitioner to avoid inter-observer variability. Finally, we recorded the data on a preform. In addition, we recorded participants’ demographics such as sex and age. To allow for analysis, we categorized age into 3 age groups namely 17-22 years, 23-28 years and 29-34 years.

**AC/A ratio**

Accommodation in response to blur causes a corresponding change in vergence such as stimulating accommodation leads to convergence while relaxing accommodation leads to divergence. Clinically this is quantified AC/A ratio. AC/A ratio was measured using the gradient method determined as the change in heterophoria with -1.00 D lens. We measured the subjects near phoria at 40 cm using horizontal prism bars. Then, we introduced a -1.00 D lens before each eye and measured the near phoria using the prism bars again. We recorded the difference between the two measurements as AC/A ratio.

**NFV and PFV**

Fusion vergence is driven by retinal disparity which is the difference in binocular angle between the target and position of bi-fixation and it controls allows both eyes to fixate on a target. Fusion vergences were measured using horizontal prism bars. The target, a 6/7.5 sized Snellen letter, was placed at 40 cm before the subject. Noteworthy, NFV was measured first before PFV to avoid prismatic adaptation induced by base out prisms. We measured NFV by introducing base-in horizontal prism bars of equal amounts in front of each eye at a constant velocity \(2\Delta/s\) until the subject first reported blurred image (blur point) and further increased until the subject reported horizontal diplopia (break value). Then, the amount of prism was then rapidly increased by \(3\Delta\) in each eye and subsequently reduced (at \(2\Delta/s\)) by moving the prism bar in the opposite direction until the subject reports a single fused image (recovery point). The break and recovery points were objectively checked by testing deviation of one of the eyes. Next, we repeated the procedure using base-out horizontal prisms to measure PFV.

**Data Analysis**

We entered the data into SPSS software, version 20.0 (SPSS Inc., Chicago, USA) and Microsoft Excel 2016. In addition, we employed descriptive statistics including frequency, percentages, range, mean and standard deviation. We illustrated the data graphically using graphs, scatter plots and tables. To compare means between groups we used the independent t-test. The Kormogorov-Smirmov normality test revealed that the variables were not normally distributed \((p <0.001)\). Therefore, we employed non-parametric techniques. Accordingly, we used Kruskal-Wallis and Mann Whitney U-test to assess association within age groups and gender. Furthermore, we used Pearson Correlation coefficient test to analyze the
correlation between variables and age where appropriate. We considered the value of \( p < 0.05 \) statistically significant.

**Ethics**

The study obtained Ethical Clearance from Mzuzu University Research Ethics Committee. Furthermore, we obtained informed consent from all the participants. Moreover, we kept all participants anonymous during and after the study. And no one was harmed during the study.

**Results**

**Demographic Data**

The study participants comprised 62 (62.6%) male students and 37 (37.4%) female students. The participants' ages ranged from 18 to 33 years old and the mean age was 23.37 ±3.95 years. The mean age was 23.66 ±3.96 and 22.89 ±3.92 years among males and females respectively. An independent sample t-test portrayed that the difference was not statistically significant \( (p = 0.938) \). The majority of the participants were within the age groups 17-22 years (47.5%, \( n = 47 \)) and 23-28 years (38.4%, \( n = 38 \)).

The mean AC/A ratio was 4.24±0.74. The Mean NFV was 16.16, 19.62 and 13.7 respectively while mean PFV was 16.72, 24.28 and 14.59. (Table 1)

**Distribution of AC/A Ratio according to Age**

The mean AC/A ratio in the age groups 17-22 years and 23-28 years were 29 (±0.65) and 4.29 (±0.91) respectively while the age group 29-34 years had a mean AC/A ratio of 3.96 (±0.41) as shown in table 4. Kruskal-Wallis test showed statistically non-significant differences among the age groups \( (p = 0.282) \). When the participants were split into two sexes, and Kruskal-Wallis test re-performed among age groups, results still showed no significant difference in AC/A ratio among age groups in both males \( (p = 0.820) \) and females \( (p = 0.252) \). (Table 2)

**Relationship between AC/A ratio and age**

Pearson correlation was conducted to determine the relationship between AC/A and age. The results showed that AC/A ratio is negatively correlated with age \( (r = -0.132, R^2 = 0.017) \) but not statistically significant \( (p = 0.195) \) (Figure 1).

**Association between AC/A Ratio and Gender**

Males had a mean AC/A ratio of 4.15 ±0.6 while females had a mean AC/A ratio of 4.39 ±0.91. The Independent Samples Mann-Whitney test revealed that there was no statistically significant difference between the two genders \( (p = 0.17) \).

**Distribution of Negative and Positive Fusion Vergence according to Age**
Kruskal-Wallis test showed that there was no statistically significant difference in vergence parameters according to age. NFV, mean blur point, break point and recovery point among three age groups was not statistically different (p = 0.36, p = 0.306 and p = 0.744 respectively) (Table 3). PFV had no significant difference in mean blur point, break point and recovery point among the age groups (p = 0.612, p = 0.630 and p = 0.253).

**Relationship between NFV and age**

Results of Pearson Correlation test showed a positive correlation in all the NFV points Blur (r = 0.058, p = 0.570, $R^2 = 0.003$), Break, (r = 0.130, p = 0.199, $R^2 = 0.017$); Recovery, r = 0.077, p = 0.449, $R^2 = 0.006$).

**Relationship between PFV and age**

For PFV, there was negative correlation between age and all Blur (r = -0.612, p = 0.286, $R^2 = 0.012$), Break (r = -0.102, p = 0.316, $R^2 = 0.010$) and Recovery points (r = -0.100, p = 0.375, $R^2 = 0.01$).

**Association of Fusion Vergences with Gender**

Mann-Whitney test showed that there were no significant differences in NFV and PFV between males and females as all parameters showed p > 0.05. (Table 4)

**Discussion**

Vergence dysfunctions causes a myriad of visual symptoms leading to poor academic performance among students. Key to diagnosis of vergence problems is measuring vergence parameters. This paper provides an overview of BV functions including AC/A ratio and fusion reserves.

In this study, the AC/A ratio is similar to the expected findings suggested by Scheiman and Wick guideline. Nevertheless, it is slightly lower than previous studies in Iran, Nepal and South Africa. In comparison, the AC/A ratio in this report is higher than reported among Taiwanese young adults and Malaysians. We attribute the variation to differences in measurement techniques. For instance, this study employed a 1 D lens while others used a 3 D lens. The current study confirms that the distribution of AC/A varies with instruments used.

Similar to previous studies, this report found no significant association between sex and AC/A ratio. In disagreement, Vesely and Svatopluk in Czech found a significant relationship between gender and AC/A ratio. The variation can be explained by the difference in sample composition. For instance, the current study sample consisted of disproportionate number of males and females recruited. In general, males have lower AC/A ratio compared to females which predisposes females to a higher prevalence of vergence dysfunctions. This study did no assess prevalence of symptoms of vergence dysfunction among this group.
In agreement with previous documents, our study found no relationship between age and AC/A ratio. In contrast, Vesely and Svatopluk found a significant relationship between age and AC/A ratio. We attribute the results of this report to the narrow age range used which could have masked the effect of age.

In the current study, the PFV was similar to a study conducted among optometry students in Bangalore, India and the expected findings postulated by the OEP. Nevertheless, PFV was lower than previously reported by a study in South Africa while it was larger than reported in India. In this report, NFV was larger compared to a study in South Africa and India. However, they are lower than the expected findings suggested by the OEP guidelines. The variation in the pattern of fusion vergence can be explained by differences in ethnicity among study populations.

This study found that there is no significant relationship between fusion vergences and age. This concurs with Zhou and colleagues in China. However, it is in contrast with studies conducted in Spain, which found significant associations between fusion vergence and age. Again the finding of this study may be attributed to differences in study population as the current review enrolled young participants only.

The current study found that there was no significant association between fusion vergences and sex similar to a study in China, and in Czech. On the contrary, others reported significant variations in some fusion vergence parameters between males and females. The differences could be due to variations in study populations. The result of this paper could be due to the lesser number of female participants as opposed to male subjects.

**Limitations**

The study was not without drawbacks. First the study recruited Unequal distribution of male and female participants. Furthermore, the study employed a narrower age range masking the effect of age. In addition, this study did not assess the distance fusional vergences among this group. Moreover, the study did not assess the prevalence of vergence dysfunction and common symptoms.

**Conclusion**

In conclusion, the Mean AC/A ratio in this review is similar to established guidelines hence they can be used interchangeably. With respect to the Optometric Extension Programme expected findings NFV was lower whereas, PFV was similar to the well-established clinical guideline. Considering age and Sex the study suggests no effect on vergence parameters among the study population.

**Declarations**

**ACKNOWLEDGEMENTS**
References


Tables
### Table 1: Demographic characteristics of participants

<table>
<thead>
<tr>
<th></th>
<th>Mean (Std. dev.)</th>
<th>Range</th>
</tr>
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<tbody>
<tr>
<td>Age</td>
<td>23.37 (±3.95)</td>
<td>18 - 33</td>
</tr>
<tr>
<td>AC/A</td>
<td>4.24 (±0.74)</td>
<td>3 - 6</td>
</tr>
<tr>
<td>NFV Blur</td>
<td>16.16 (±2.74)</td>
<td>11 - 22.5</td>
</tr>
<tr>
<td>NFV Break</td>
<td>19.62 (±1.95)</td>
<td>16 - 25</td>
</tr>
<tr>
<td>NFV Recovery</td>
<td>13.7 (±1.62)</td>
<td>10 - 18</td>
</tr>
<tr>
<td>PFV Blur</td>
<td>16.72 (±1.78)</td>
<td>12 - 20</td>
</tr>
<tr>
<td>PFV Break</td>
<td>24.28 (±3.25)</td>
<td>18 - 30</td>
</tr>
<tr>
<td>PFV Recovery</td>
<td>14.59 (±1.73)</td>
<td>12 - 19</td>
</tr>
</tbody>
</table>

### Table 2: distribution of AC/A ratio according to age groups

<table>
<thead>
<tr>
<th></th>
<th>17-22 years</th>
<th>23-28 years</th>
<th>29-34 years</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>4.29 (±0.65)</td>
<td>4.29 (±0.91)</td>
<td>3.96 (±0.41)</td>
<td>0.282</td>
</tr>
<tr>
<td>Males</td>
<td>4.16 (±0.52)</td>
<td>4.18 (±0.75)</td>
<td>4.06 (±0.39)</td>
<td>0.820</td>
</tr>
<tr>
<td>Females</td>
<td>4.47 (±0.78)</td>
<td>4.50 (±1.15)</td>
<td>3.96 (±0.42)</td>
<td>0.252</td>
</tr>
</tbody>
</table>

### Table 3: distribution of fusion vergence according to age.
<table>
<thead>
<tr>
<th></th>
<th>17-22 years</th>
<th>23-28 years</th>
<th>29-34 years</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFV Blur</td>
<td>15.79 (±2.60)</td>
<td>16.67 (±2.96)</td>
<td>16.00 (±2.51)</td>
<td>0.360</td>
</tr>
<tr>
<td>NFV Break</td>
<td>19.27 (±1.52)</td>
<td>19.92 (±2.43)</td>
<td>19.93 (±1.69)</td>
<td>0.306</td>
</tr>
<tr>
<td>NFV Recovery</td>
<td>13.57 (±1.26)</td>
<td>13.82 (±2.00)</td>
<td>13.79 (±1.63)</td>
<td>0.744</td>
</tr>
<tr>
<td>PFV Blur</td>
<td>16.98 (±1.59)</td>
<td>16.47 (±1.98)</td>
<td>16.50 (±1.79)</td>
<td>0.612</td>
</tr>
<tr>
<td>PFV Break</td>
<td>24.47 (±2.80)</td>
<td>24.33 (±4.01)</td>
<td>23.5 (±2.27)</td>
<td>0.630</td>
</tr>
<tr>
<td>PFV Recovery</td>
<td>14.68 (±1.73)</td>
<td>14.71 (±1.84)</td>
<td>13.93 (±1.27)</td>
<td>0.253</td>
</tr>
</tbody>
</table>

Table 4: Distribution of NFV and PFV according to gender

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th>Females</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFV Blur</td>
<td>16.36 (±2.66)</td>
<td>15.82 (±2.88)</td>
<td>0.3</td>
</tr>
<tr>
<td>NFV Break</td>
<td>19.41 (±1.73)</td>
<td>19.96 (±2.26)</td>
<td>0.33</td>
</tr>
<tr>
<td>NFV Recovery</td>
<td>13.56 (±1.73)</td>
<td>13.92 (±2.26)</td>
<td>0.25</td>
</tr>
<tr>
<td>PFV Blur</td>
<td>16.67 (±1.91)</td>
<td>16.78 (±1.57)</td>
<td>0.81</td>
</tr>
<tr>
<td>PFV Break</td>
<td>24.2 (±3.16)</td>
<td>24.41 (±3.43)</td>
<td>0.76</td>
</tr>
<tr>
<td>PFV Recovery</td>
<td>14.51 (±1.65)</td>
<td>14.7 (±1.87)</td>
<td>0.68</td>
</tr>
</tbody>
</table>

p < 0.05 statistically significant

Figures
Figure 1

*Correlation between AC/A ratio and age*
Figure 2

Correlation between NFV blur point and age
Figure 3

Correlation between NFV break point and age
Figure 4

correlation between NFV recovery point and age
Figure 5

correlation between PFV blur point and age

\[ r = -0.108, R^2 = 0.012, p = 0.286 \]
Figure 6

correlation between PFV break point and age
Figure 7

correlation between NFV recovery point and age