Original Research

Spherical Equivalent Refraction, Amplitude of Accommodation, and Relative Accommodation in a Young Nigerian Population

Eghosasere Iyamu, B.Sc, O.D., Ph.D., FNPCO, FAAO, Professor, ORCID 0000-0002-1833-3175

Godsgift Onyinyechukwu Obi, O.D., Senior optometrist, ORCID 0009-0006-1017-097X

Clinton Ifeanyi Okechukwu, O.D., Senior optometrist, ORCID 00009-0005-3428-1562

Department of Optometry, Faculty of Life Sciences, University of Benin, Edo State, Nigeria.

Abstract

Introduction

We investigated the relationship between spherical equivalent refraction (SER), amplitude of accommodation (AA), and relative accommodation (RA) in young adults in Nigeria to improve understanding of accommodative function across refractive groups.

Methods

We conducted a prospective observational study at the optometry clinic at the University of Benin with 70 patients (35 males and 35 females) who came in, aged 17-35 years. Measurements included SER, AA (using push-up to blur, minus-lens to blur, and modified push-up to blur methods), RA (negative relative accommodation [NRA], and positive relative accommodation [PRA]) without wearing corrective lenses. Maximum plus and minus lenses were used to assess accommodation. We analyzed data using analysis of variance (ANOVA), Duncan's multiple range test for pairwise comparisons, linear regression, and *t*-test.

Results

AA varied significantly across refractive groups, with patients with myopia showing higher AA (10.93 ± 1.10 D) than patients with hyperopia (far sightedness) (9.00 ± 0.59 D). Mean NRA and PRA were +2.25 ± 0.29 D and –2.43 ± 0.37 D, respectively. NRA was significantly higher in patients with hyperopia (+2.51 ± 0.19 D), while PRA was higher in patients with myopia (–2.72 ± 0.20 D). AA decreased with age ($r = –0.66$, $P < .001$), while NRA increased with age ($r = 0.45$, $P = .001$).

Discussion

Patients with myopia exhibited greater PRA, while patients with hyperopia had higher NRA, aligning with their respective accommodative needs. The decline in AA with age highlights the need for early assessment of accommodation function. The correlations between age, NRA, and PRA suggest that accommodation changes dynamically over time.

Conclusion

The findings highlight the significant influence of refractive error on accommodation, with patients with myopia having greater accommodative reserves, potentially allowing for sustained near-vision tasks with comfort. In contrast, patients with hyperopia experiencing higher accommodative needs, which may lead to visual fatigue or discomfort over time. In other words, these findings underscore the clinical importance of accommodation assessments in refractive error management, particularly in prescribing lenses that optimize visual comfort and performance.

Keywords

amplitude of accommodation, spherical equivalent refractive error, relative accommodation, Nigeria

The eye's primary function is to provide clear and comfortable vision. However, having a healthy eye does not guarantee clear and comfortable vision within a given range of distances for an individual. Accommodation plays a very significant role in the formation of a clear retinal image. It is a mechanism that affects visual clarity and binocular vision.[1] A clear single binocular vision is the result of the interaction between accommodation and vergence systems.[2]

According to Hofstetter, accommodation is the process by which the dioptric power of the crystalline lens is increased to bring the image of a near object to focus on the retina.[3] It is also a dynamic optical change in the dioptric power of the eye, allowing the point of focus of the eye to be changed from distance to near.[4] Helmholtz's relaxation theory of accommodation states that when the eyes are in their unaccommodated state and focused on distance, the ciliary muscle is relaxed. This relaxation causes the elastic zonular fibres to be in a state of tension, pulling the crystalline lens outward at the equator and maintaining the lens in a somewhat flattened state. During accommodation, the ciliary muscle contracts, causing a reduction in the zonular tension that allows the increase in curvature of the crystalline lens.

Suggested citation

Iyamu E, Onyinyechukwu G, Okechukwu CI. Spherical equivalent refraction, amplitude of accommodation, and relative accommodation in a young Nigerian population. *Can J Optom.* 2026;88(3):17-27. https://www.doi.org/10.65636/cjo.v88i3.6404

The amplitude of accommodation (AA) reflects the maximum accommodative response of an individual and has been defined as the dioptric distance between the far point (i.e., point conjugated with the retina when accommodation is fully relaxed) and the near point (i.e., point conjugated with the retina when accommodation is fully exerted) of accommodation.[5] The measurement of the AA is a component of the routine clinical tests used to assess an individuals' accommodative function. There are several methods to measure the AA subjectively, including:

- push-up to blur (PUB), which involves moving a text object closer to the eyes;
- minus-lens to blur (MLB), which involves placing minus lenses in front of the eyes till a sustained blur is achieved; and
- modified push-up to blur method (MPUB).

Abbreviations

AA	amplitude of accommodation
MLB	minus-lens to blur
MPUB	modified push-up to blur
NRA	negative relative accommodation
PRA	positive relative accommodation
PUB	push-up to blur
RA	relative accommodation
SER	spherical equivalent refraction
VA	visual acuity

AA can also be measured objectively during dynamic retinoscopy and refractometry, but the results may differ from those obtained subjectively.[6]

Refractive error is a complex interaction of the eye, its anatomical factors, genetics, and environmental influences. Light from an external object focuses before the retina (myopia), behind the retina (hyperopia), or fails to come to a single point focus on the retina (astigmatism) when accommodation is maximally relaxed.[7]

Emmetropia, which is the optimum refractive status of the eye, occurs when rays of light fall directly on the retina. According to Duke-Elder and Abrams, emmetropia is when parallel rays of light strike a physiologically normal eye and are refracted to converge on the retina where they focus forming a circle of least confusion with the eye in a state of rest.[8]

Functional visual acuity is compatible with mild myopia, emmetropia, and even substantial hyperopia where accommodation can be used to bring the image into focus on the retina.[9]

RA is the maximum ability of the eye to relax accommodation (i.e., negative relative accommodation [NRA]) or stimulate accommodation (i.e., positive relative accommodation [PRA]) while maintaining single clear binocular vision with constant total convergence demand. An evaluation of the relationship between refractive errors and RA can demonstrate accommodative facility in different types of refractive errors. This will provide comprehensive information on the functional status of patients' visual systems and binocular vision.[10]

There is no existing literature on the association between spherical equivalent refraction (SER), AA, and RA in a Nigerian population. Hence, our study investigates the relationship between these variables.

Methods

We conducted an observational and prospective study in the optometry clinic at the University of Benin. We recruited male and female patients ages 17 to 35 years. Admittance into the study was made after patients provided written informed consent. We took detailed history and completed optometric examinations to ensure each patient fulfilled the inclusion criteria. Patients were included if their best corrected VA ≤ 6/9 in each eye, and they had:

- no anomalies of binocular vision nor accommodation;
- no manifest strabismus;
- no history of systemic disease such as diabetes;
- no history of ocular surgery; and
- no use of medications including antihistamines, antidepressants, anticholinergics, topical cycloplegics, or miotics that could affect accommodation.

Ethical approval was obtained from the Research and Ethics Committee of the Department of Optometry at the University of Benin, according to the tenets of the *Declaration of Helsinki 2000*.

The refractive status of the patients was determined using a handheld retinoscope and subjective refraction. The SER for each patient was obtained by adding half of the cylinder power to the spherical component.

The AA was measured with the PUB, MLB, and MPUB methods.

The PUB was done monocularly. With the final prescription in place, we gave each patient their best near point visual acuity (VA) letter (i.e., a single optotype, smallest readable line) on the N-notation card at 40 cm away. The print was moved gradually toward the patient's eye until they noticed the first sustained blur. We measured the distance between the blur point and the spectacle plane using a meter rule and converted it into diopters to give the AA.

For the MLB method, we gave each patient their best near point VA letter on the N-notation card at 33 cm, gradually increasing minus lenses until they noticed the first sustained blur. The amount of minus lens added before the eye plus the dioptric value of the target distance gave the AA.

Additionally, AA was measured using the modified PUB technique with –4.00 DS in a MPUB procedure.[11] The amount of minus lens placed before the eye plus the dioptric value of the distance between the blur point and the spectacle plane gave the AA.

In measuring NRA and PRA with correction, we asked patients to focus on the 6/6 line on a high

Table 1. Descriptive statistics of age, myopia, hyperopia, and negative and positive relative accommodation

Variables	*n*	Minimum	Maximum	Mean (SE)	SD	Standard skewness (SE)	Standard kurtosis (SE)
Age	70	17	35	23.88 (.743)	5.752	0.574 (0.309)	-0.979 (0.608)
SER	70	–3.00	+2.50	–0.17 (.188)	1.458	–0.238 (0.309)	-0.933 (0.608)
Hyperopia	27	+0.75	+2.50	+1.26 (.0816)	0.4244	0.907 (0.309)	–0.933 (0.608)
MLB	70	7.50	14.75	10.06 (.1704)	1.32017	0.969 (0.309)	1.883 (0.608)
PUB	70	7.50	14.50	10.23 (.2197)	1.70163	0.541 (0.309)	0.536 (0.608)
MPUB	70	7.75	14.25	10.25 (.1877)	1.45373	0.990 (0.309)	1.454 (0.608)
NRA	70	+1.75	+3.00	+2.26 (.0371)	0.28733	0.280 (0.309)	–0.424 (0.608)
PRA	70	–1.50	–3.00	–2.43 (.0484)	0.37479	0.057 (0.309)	–0.957 (0.608)
Myopia	33	–0.75	–3.00	–1.34 (.139)	0.798	–1.25 (0.409)	0.197 (0.797)

Abbreviations: MLB, minus-lens to blur; MPUB, modified push-up to blur; NRA, negative relative accommodation; PRA, positive relative accommodation; PUB, push-up to blur; SD, standard deviation; SE, standard error; SER, spherical equivalent refraction.

contrast near chart at 40 cm and changed the accommodation using plus and minus lenses. We added the lenses binocularly in 0.25 D steps until the patient's first slight sustained blur, which was the end point of the test. At this point, letters were not as sharp and readable as the primary status. We recorded the total plus lenses for NRA testing and minus lenses for PRA testing. NRA was tested before PRA to avoid any influence of accommodation on the measurements.

AA, NRA, and PRA measurements were performed without spectacle or contact-lens correction in place. We determined refractive status by non-cycloplegic subjective refraction before testing.

We used Statistical Package for Social Sciences version 24.0 (SPSS Inc., Chicago, IL, USA) for statistical analyses. The measured variables were tested for normality of distribution using the Kolmogorov-Smirnov Z test with standardized kurtosis and standardized skewness, which were ± 1.96. We compared AA obtained by the MLB, PUB, and MPUB techniques using the one-way analysis of variance (ANOVA). Post hoc test was performed for pairwise comparison using the Duncan's New Multiple Range test. We assessed the relationship between the measured variables using linear regression analysis and sex-related differences between variables with unpaired *t* test. Statistical significance was declared when $P \leq .05$.

Results

We recruited 70 patients (35 males, 35 females), aged 17 to 35 years (mean age = 23.88 ± 5.75 years). The standardized skewness and kurtosis of the data lie within ±1.96 and the Kolmogorov-Smirnov test ($P > .05$) showed that all data were normally distributed, so we used parametric test statistics in the data analysis.

Table 1 shows the descriptive statistics of measured variables. The mean SER was –0.17 ± 1.46 D, while mean myopia and hyperopia were –1.34 ± 0.80 D (range: –0.75 to –3.00 D) and +1.26 ± 0.42 D (range: +0.75 to +2.50 D).

Table 2 shows the distribution of NRA, PRA, and AA by sex, age group, and refractive error. The mean difference in AA between age groups was statistically significant ($P < .001$). AA was significantly higher in the 17- to 20-year-old group, followed by the 21 to 25 group, then 26 to 30 and 31 to 35 groups ($P < .05$).

Table 3 shows the distribution of NRA and PRA by sex, age group, and refractive error according to different studies. The differences in mean NRA and

Table 2. Distribution of negative relative accommodation, positive relative accommodation, and amplitude of accommodation by sex, age group, and refractive status

Variable	*n*	NRA, D, mean ± SD	PRA, D, mean ± SD	AA, D, mean ± SD
Total	70	+2.26 ± 0.29	−2.43 ± 0.37	10.06 ± 1.32
Sex				
Male	35	+2.27 ± 0.35	−2.43 ± 0.38	10.10 ± 1.18
Female	35	+2.25 ± 0.21	−2.42 ± 0.37	10.02 ± 1.46
Age group, years				
17-20	25	+2.11 ± 0.24	−2.65 ± 0.26	11.03 ± 1.32
21-25	18	+2.15 ± 0.23	−2.60 ± 0.31	9.93 ± 0.73
26-30	11	+2.69 ± 0.18	−2.06 ± 0.26	9.13 ± 0.87
31-35	16	+2.38 ± 0.13	−2.04 ± 0.14	9.00 ± 0.68
Refractive status				
Emmetropia	10	+2.30 ± 0.31	−2.41 ± 0.45	9.70 ± 0.61
Hyperopia	27	+2.51 ± 0.19	−2.06 ± 0.16	9.00 ± 0.59
Myopia	33	+2.05 ± 0.16	−2.72 ± 0.20	10.93 ± 1.10

Abbreviations: AA, amplitude of accommodation; NRA, negative relative accommodation; PRA, positive relative accommodation.

mean PRA between age groups was significant ($P < .001$ for each). NRA was significantly higher in the 26- to 30-year-old group than the 17 to 20 and 21 to 25 groups, and the least in 31 to 35 group. PRA was significantly higher in the 17 to 20 and 21 to 25 groups than in the 26 to 30 and 31 to 35 groups.

Sex-related differences in AA, NRA, and PRA were not statistically significant ($P > .05$) (Table 4).

The difference in mean AA across MLB, PUB, and MPUB for patients with hyperopia group was not significant ($P > 0.05$). In all the methods of assessing the AA, patients with myopia consistently had a significantly higher AA than patients with hyperopia. (Table 5).

The mean NRA of patients with hyperopia (+2.51 ± 1.99 D) was significantly higher than that of patients with myopia (+2.05 ± 1.60 D) by 0.46 D ($P < 0.001$). However, the mean PRA of patients with myopia (–2.72 ± 0.20 D) was significantly higher than that of patients with hyperopia (–2.06 ± 0.16 D) by 0.65 D ($P < .001$).

Linear Regression Between Measured Variables

We found significant inverse linear relationships between age and PUB, MLB, and MPUB (all $P < 0.001$). Also, inverse associations were found between SER and AA assessed by different methods (all $P < .001$). Table 6 shows the relationships.

A significant positive association was seen between age and NRA ($r = 0.45$, $r^2 = 20.0\%$, $P < .001$). The 20% variability in NRA was explained by the regression model represented by NRA = 1.73 + 0.022 x Age. Similarly, a positive linear association was seen between age and PRA ($r = 0.66$, $r^2 = 43.6\%$, $P < .001$). The model as fitted is represented by PRA = –3.45 + 0.043 x Age. From the regression models, we can predict a 0.20 D increase in NRA and a 0.40 D decrease in PRA per decade of age.

For further analysis, the AA obtained by MLB was used. Table 7 shows the associations between age, AA measured by different techniques, RA, and SER.

Table 3. Distribution of negative relative accommodation and positive relative accommodation by different studies

Variable	Yekta et al.[10]			Masihuzzaman et al.[22]			Iyamu et al (present study)		
Study population	Indian			Nepalese			Nigerian		
Age, years	18–35			18–35			17-35		
Variable	n	NRA (D)	PRA (D)	n	NRA (D)	PRA (D)	n	NRA (D)	PRA (D)
Age, years									
<20	135	+2.10 ± 0.29	–3.00 ± 0.72	29	+2.67 ± 0.50	–3.23 ± 1.17	2	+2.11 ± 0.24	–2.65 ± 0.26
21 – 25	202	+2.05 ± 0.32	–2.97 ± 0.67	53	+3.07 ± 0.88	–3.79 ± 1.24	18	+2.15 ± 0.23	–2.60 ± 0.31
26 – 30	29	+2.10 ± 0.27	–2.96 ± 0.69	26	+2.74 ± 0.55	–3.38 ± 0.79	11	+2.69 ± 0.18	–2.06 ± 0.26
>30	16	+1.89 ± 0.62	–1.55 ± 1.04	—	—	—	16	+2.38 ± 0.13	–2.04 ± 0.14
Sex									
Male	102	+2.06 ± 0.36	–2.73 ± 0.89	59	+2.78 ± 0.61	–3.38 ± 1.01	35	+2.27 ± 0.35	–2.43 ± 0.38
Female	280	+2.09 ± 0.31	–3.00 ± 0.69	49	+3.01 ± 0.86	–3.74 ± 1.28	35	+2.25 ± 0.21	–2.42 ± 0.37
Refractive status									
Emmetropia	185	+2.21 ± 0.26	–2.80 ± 0.68	67	+2.88 ± 0.76	–3.36 ± 1.23	10	+2.30 ± 0.31	–2.41 ± 0.45
Myopia	145	+2.00 ± 0.39	–3.09 ± 0.82	30	+2.81 ± 0.61	–3.84 ± 1.23	33	+2.05 ± 0.16	–2.72 ± 0.20
Hyperopia	52	+2.13 ± 0.30	–2.90 ± 0.77	11	+3.09 ± 0.97	–3.86 ± 1.37	27	+2.51 ± 0.19	–2.06 ± 0.16
Total	382	+2.08 ± 0.33	–2.92 ± 0.76	108	+2.88 ± 0.74	–3.54 ± 1.15	70	+2.26 ± 0.29	–2.43 ± 0.37

Discussion

Refractive errors, encompassing myopia, hyperopia, and astigmatism, occur when light rays fail to focus precisely on the retina, often due to a combination of genetic and environmental factors.[7] While emmetropia is the optimal refractive status where light rays converge on the retina, mild refractive errors may still allow functional VA, especially in people with hyperopia, due to the compensatory role of accommodation.[8] RA, comprising NRA and PRA, reflects the eye's ability to relax or stimulate accommodation while maintaining clear, single binocular vision.[10] The relationship between SER, AA, and RA is critical for understanding visual performance and binocular stability, yet limited studies have explored these interactions in diverse populations.

Our study showed that MLB had the lowest value (10.06 ± 1.32 D), which is in line with the findings of previous studies.[10] Contrary to previous studies,

Table 4. Distribution of age, minus-lens to blur, push-up to blur, modified push-up to blur of accommodation, and negative and positive relative accommodation by sex

Variable	Sex	Mean ± SD	*P* value	95% CI, mean ± 1.96 SEM
Age (years)	Male	23.00 ± 4.35	.24	21.43 to 24.57
	Female	24.77 ± 6.84		22.32 to 27.22
Minus-lens to blur (D)	Male	10.11 ± 1.18	.79	9.68 to 10.54
	Female	10.02 ± 1.46		9.49 to 10.55
Push-up to blur (D)	Male	10.34 ± 1.33	.60	9.87 to 10.81
	Female	10.11 ± 2.03		9.42 to 10.80
Modified push-up to blur (D)	Male	10.30 ± 1.36	.78	9.81 to 10.79
	Female	10.19 ± 1.56		9.64 to 10.74
Negative relative accommodation (D)	Male	+2.27 ± 0.35	.82	+2.15 to +2.39
	Female	+2.25 ± 0.21		+2.17 to +2.33
Positive relative accommodation (D)	Male	–2.43 ± 0.38	.87	–2.29 to –2.57
	Female	–2.42 ± 0.37		–2.28 to –2.56

Abbreviations: CI, confidence interval; SD, standard deviation; SEM, standard error of the mean.

Note: None of the *P* values were significant.

Table 5. Distribution of amplitude of accommodation by method and refractive error

Refractive error	Minus-lens to blur	Push-up to blur	Modified Push-up to blur
Hyperopia (n = 27)	9.00 ± 0.59	9.01 ± 1.14	9.28 ± 0.91
Myopia (n = 33)	10.93 ± 1.10	11.22 ± 1.42	11.04 ± 1.33
P value	< .001	< .001	< .001

Note: *P* < .05 is considered significant.

Table 6. Associations of measured variables represented by Pearson correlation coefficients

Variable	PRA	NRA	MPUB	PUB	MLB
PRA	—	—	—	—	—
NRA	0.77	—	—	—	—
MPUB	-0.63	-0.52	—	—	—
PUB	-0.63	-0.47	0.97	—	—
MLB	-0.7	-0.66	0.93	0.91	—
Age	0.6	0.45	-0.68	-0.74	-0.64

Abbreviations: MLB, minus-lens to blur; MPUB, modified push-up to blur; NRA, negative relative accommodation; PRA, positive relative accommodation; PUB, push-up to blur.

Note: All P values < .001.

Table 7. Associations between age, spherical equivalent refraction, and amplitude of accommodation assessed by different method and relative accommodation

Association	Pearson's correlation coefficients	*P* value	Coefficient of variability	Linear regression model
Age and PUB	−0.74	<.001	54.8%	PUB = 15.45 − 0.22 × Age
Age and MLB	−0.64	<.001	41.5%	MLB = 13.59 − 0.15 × Age
Age and MPUB	−0.68	<.001	46.5%	MPUB = 14.36 − 0.17 ×Age
PUB and SER	−0.60	<.001	35.5%	SER = 5.05 − 0.51 × PUB
MLB and SER	−0.75	<.001	56.7%	SER = 8.19 − 0.83 × MLB
MPUB and SER	−0.59	<.001	34.9%	SER = 5.90 − 0.59 × MPUB
Age and NRA	0.45	<.001	20.0%	NRA = 1.73 + 0.022 × Age
Age and PRA	0.66	<.001	43.6%	PRA = −3.45 + 0.043 × Age

Abbreviations: MLB, minus-lens to blur; MPUB, modified push-up to blur; NRA, negative relative accommodation; PRA, positive relative accommodation; PUB, push-up to blur; SER, spherical equivalent refraction.

MPUB had the highest value (10.25 ± 1.45 D). This can be attributed to the combined effect of proximal convergence, depth of focus, and the effect of accommodation stimulated by the –4.00 D lens introduced before the person's eyes. Proximal vergence is the subtype of vergence that is stimulated by visual cues other than blur and disparity. In other words, it is the vergence eye movement driven by an "awareness of nearness." Iyamu et al.[12] and Mathebula et al.[13] found that the mean PUB was higher than the mean MLB. This was attributed to the effect of depth of focus that comes into play during the PUB measurement of AA.

Momeni-Moghaddam et al.[14] compared four subjective methods of measuring AA (PUB, push down to clear, MLB, and MPUB). They found that PUB produced the highest AA value, whereas MLB produced the lowest. According to our study, the higher AA from PUB was likely due to additional proximal convergence and accommodative cues when the target is moved closer. The MLB yielded lower AA because the minus lenses minify the target at a fixed distance. This pattern is consistent with the role of depth of focus in PUB.

NRA is a measure of the maximum ability to relax accommodation while maintaining clear and single binocular vision, while PRA is a measure of the maximum ability to stimulate accommodation when clear and single binocular vision is maintained.[15] In both cases, there is no associated change in vergence.[15] Previous studies have reported normal values for NRA and PRA.[9, 16-21] According to the table of expected values,[15] the reported range of NRA and PRA were +1.50 to +2.50 D and –1.25 to –3.50 D, respectively. In our study, the range of NRA and PRA was reported as +1.75 to +3.00 D and –1.50 to –3.00 D, which was slightly different from the range for NRA and PRA of +2.00 to

+2.50 D and –2.37 to –3.37 D stated by Padavettan et al.[21]

The mean SER was –0.17 ± 1.46 D. An inverse linear association was found between SER and AA (MLB) (r = –0.75, r^2 = 56.7%, P < 0.001) and a regression model of AA = 8.194 – 0.831 x SER. From the model, an increase of 1.0 D in myopia, the AA is increased by about 0.83 D, while an increase of 1.0 D in hyperopia will result in a decrease of 0.83 D in AA. The mean SER hyperopia and myopia for our study, and Yekta et al.[10] were +1.26 ± 0.42 D, –1.34 ± 0.80 D; +0.79 ± 0.85 D, –2.44 ± 2.45 D, respectively.

The mean NRA of the group with hyperopia was significantly higher than that of the group with myopia by 0.46 D. This was consistent with the reports of Yekta et al.[10] and Masihuzzaman et al.[22] The higher NRA seen in the group with hyperopia showed the accommodative effort needed for people with hyperopia to perform near visual task without vision correction.

While the PRA did not demonstrate any significant variation in the groups with hyperopia or myopia in previous studies by Masihuzzaman et al.[22] and Yekta et al.,[10] our study found a significantly higher PRA in patients with myopia than in patients with hyperopia. This shows that the group with myopia has a significant amount of accommodation in reserve that guarantees clarity and single binocular vision.

The PRA was greater than NRA in the group with myopia. This was consistent with the findings of Yekta et al. and Masihuzzaman et al.[10,22] The PRA of the group with hyperopia was less than the NRA in our study, which was consistent with the findings of Yekta et al. and Masihuzzaman et al.[10,22]

Comfortable and efficient reading potentials can be achieved by prescribing plus lenses. On the other hand, the higher PRA reported in the group with myopia shows that those patients have the potential for prolonged or sustained near task with comfort.[15] The RA plays a significant role in the detection of accommodative dysfunction, like accommodative insufficiency, and accommodative excess.

No significant linear correlation was found between myopia and NRA or PRA, nor between hyperopia and NRA or PRA. In our study, the mean NRA was highest in the 26-30 age group and lowest in the 31-35 group, while the mean PRA was highest in the 17-20 group and lowest in the 31-35 group. Masihuzzaman et al. reported highest mean NRA and PRA values for their 21-25 age group.[22] Yekta et al.[10] reported highest NRA for the 20 and younger and 26-30 age groups, while the highest PRA value was observed in the 20 and younger group.

A positive linear association in our study was found between age and NRA. From the regression equation, a +0.22 D increase in NRA could be predicted for every decade of age. This was contrary to the finding of Yekta et al.[10] who found no relationship between NRA and age.

A significant inverse association in our study was found between age and PRA. From the model as fitted, a decrease of 0.43 D in NRA could be predicted per decade of age.

A significant inverse association was seen between AA and NRA (P < .001), with a model of NRA = +3.711–0.144 x AA, suggesting that a reduction in AA is associated with greater reliance on NRA to maintain clear vision during near tasks. Similarly, a significant inverse association was found between PRA and AA, with a regression model of PRA = –0.428–0.198 x AA. This shows that an increase of 1.0 D in AA would result in an increase in PRA of about –0.20 D. This clearly shows that the addition of plus lenses to increase accommodation would increase the PRA, which is the reflection of accommodation in reserve that would consequently result in comfortable, clear, and single binocular vision in near visual task. Our study has shown that the NRA and PRA have been affected by refractive status and accommodation.

Overall, our research contributes valuable data to the existing body of literature on refractive errors and accommodation dynamics (AA and RA) in a Nigerian context, filling a notable knowledge gap. Our study used multiple measurement techniques (that is, MLB, PUB, and MPUB) to assess AA, ensuring robust comparisons.

Limitations

A larger sample size may improve generalizability of findings.

A possible shortcoming of our study is that refraction was performed without cycloplegia. As a result, accommodative spasm may have been present in some patients and could have influenced the refractive findings.

In addition, the absence of binocular function measures (e.g., near phoria, fusional vergence, AC/A ratio) may have affected the interpretation of PRA and NRA comparisons.

Conclusion

Our study provides valuable insights into the relationship between SER, AA, and RA in a young Nigerian population.

The findings highlight significant variations in accommodative function across different refractive statuses, with patients with myopia exhibiting higher AA and PRA, while patients with hyperopia demonstrate greater NRA.

Additionally, we found age to be inversely correlated with AA, indicating a gradual decline in accommodative ability over time, while NRA increased and PRA decreased with age.

Our study confirms that refractive error significantly influences accommodation, with patients with myopia demonstrating greater accommodative reserves, potentially allowing for sustained near-vision tasks with comfort. In contrast, patients with hyperopia experience higher accommodative demands, which may lead to visual fatigue or discomfort over time. These findings underscore the clinical importance of accommodation assessments in refractive error management, particularly in prescribing lenses that optimize visual comfort and performance.

While our research fills a critical gap in understanding accommodation dynamics in the Nigerian population, further studies are recommended. Future research should incorporate larger and more diverse samples, longitudinal assessments, and objective accommodation measurement techniques to enhance clinical applicability and improve vision care strategies.

Disclosures

Funding Source: This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interest: None of the authors has declared any conflicts of interest.

Ethical Approval: Ethical approval was obtained from the ethical committee of the Department of Optometry at the University of Benin, under the *Declaration of Helsinki*. Patients provided written informed consent after a thorough explanation of the purpose of the study.

AI Statement: The authors confirm no generative AI or AI-assisted technology was used to generate content.

Corresponding Author: Eghosasere Iyamu, eghosasere.iyamu@uniben.edu

References

1. Hoffman DM, Girshick AR, Akeley K, Banks MS. Vergence–accommodation conflicts hinder visual performance and cause visual fatigue. *J Vis*. 2008;8(3):1-30. https://doi.org/10.1167/8.3.33
2. Rucci M, Victor JD. Perspective: Can eye movements contribute to emmetropization? *J Vis*. 2018;18(7):10. https://doi.org/10.1167/18.7.10
3. Hofstetter HW, Griffin JR, Berman MS, Everson RW. *Dictionary of vision science and related clinical terms*. Boston: Butterworth-Heinemann; 2000.
4. Croft MA, Glasser A, Kaufman PL. Accommodation and presbyopia. *Int ophthalmol Clin.* 2001;41(2):33-46. https://doi.org/10.1097/00004397-200104000-00005
5. Doshi S, Harvey W. *Investigative Techniques and Ocular Examination*. Elsevier Health Sciences; 2003. https://doi.org/10.1016/B978-0-7506-5404-3.X5001-6
6. Glickstein M, Millodot M. Retinoscopy and eye size. *Science*. 1970;168(3931):605-606. https://doi.org/10.1126/science.168.3931.605
7. Rosenfield M, Logan N (eds.). *Optometry: Science, Techniques and Clinical Management*. Elsevier Health Sciences; 2016.
8. Duke-Elder, S., Abrams, D. *Practice of Refraction* (9th ed.). Churchill Livingstone; 1993.
9. Morgan IG, Rose KA, Ellwein LB, Refractive error study in children survey group. Is emmetropia the natural endpoint for human refractive development? An analysis of population-based data from the refractive error study in children (RESC). *Acta*

ophthalmol. 2010;88(8):877-884. https://doi.org/10.1111/j.1755-3768.2009.01800.x

10. Yekta A, Hashemi H, Khabazkhoob M, Ostadimoghaddam H, Ghasemi-Moghaddam S, Jafarzadehpur E, Shokrollahzadeh F. The distribution of negative and positive relative accommodation and their relationship with binocular and refractive indices in a young population. *J Curr Ophthalmol*. 2017;29(3):204-209. https://doi.org/10.1016/j.joco.2017.01.001
11. Abu EK, Ocansey S, Yennu J, Asirifi I, Marfo R. Comparing different methods of measuring accommodative amplitude with Hofstetter's normative values in a Ghanaian population. *Curr Eye Res*. 2018;43(9):1145-1150. https://doi.org/10.1080/02713683.2018.1480044
12. Iyamu E, Iyamu JE, Oghovwerha L. Anthropometry, amplitude of accommodation, and spherical equivalent refractive error in a Nigerian population. *International Scholarly Research Notices*. 2012; 2012:295613. https://doi.org/10.5402/2012/295613
13. Mathebula SD, Ntsoane MD, Makgaba NT, Landela KL. Comparison of the amplitude of accommodation determined subjectively and objectively in South African university students. *Afr Vis Eye Health*. 2018;77(1). https://doi.org/10.4102/aveh.v77i1.437
14. Momeni-Moghaddam H, Kundart J, Askarizadeh F. Comparing measurement techniques of accommodative amplitudes. *Indian J Ophthalmol*. 2014;62(6):683-687. https://doi.org/10.4103/0301-4738.126990
15. Cooper JS, Burns CR, Cotter SA, Daum KM, Griffin JR, Scheiman MM. *Care of the Patient with Accommodative and Vergence Dysfunction.* American Optometric Association, 2011. https://www.aoa.org/AOA/Documents/Practice%20Management/Clinical%20Guidelines/Consensus-based%20guidelines/Care%20of%20Patient%20with%20Accommodative%20and%20Vergence%20Dysfunction.pdf
16. Scheiman M, Wick B. *Clinical management of binocular vision: Heterophoric, accommodative, and eye movement disorders.* Lippincott Williams & Wilkins; 2008.
17. Morgan MW Jr. The clinical aspects of accommodation and convergence. *Am J Optom Arch Am Acad Optom.* 1944;21(8):301-313. https://doi.org/10.1002/j.2330-9474.1944.tb00044.x
18. Chen AH, Abidin AHZ. Vergence and accommodation system in Malay primary school children. *Malays J Med Sci*. 2002;9(1):9-15.
19. Borsting E, Rouse M, Shin S, Dold E, McClallen A. Repeatability of the visagraph II in the analysis of childrens eye movements during reading. *Optom Vis Dev*. 2007;38(2):67-73.
20. Jorge J, de Almeida JB, Parafita MA. Binocular vision changes in university students: A 3-year longitudinal study. *Optom Vis Sci*. 2008;85(10):E999-E1006. https://doi.org/10.1097/OPX.0b013e3181890d35
21. Padavettan C, Nishanth S, Vidhyalakshmi S, Madhivanan N, Madhivanan N. Changes in vergence and accommodation parameters after smartphone use in healthy adults. *Indian J Ophthalmol*. 2021;69(6):1487-1490. https://doi.org/10.4103/ijo.IJO_2956_20
22. Masihuzzaman M, Dhakal P, Gautam K. Relationship of negative, positive relative accommodation and negative, positive fusional vergence in ametropes and emmetropes in young population of Nepal. *Acta Sci Ophthalmol*. 2021;4(1): 3-8. https://actascientific.com/ASOP/ASOP-04-0191.php