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Research Article

Comparison of Accommodation Amplitude Measured by Autorefractometry and the Negative Lens Test

Otorefraktometri ve Negatif Lens Testi ile Elde Edilen Akomodasyon Amplitüd Değerlerinin Karşılaştırılması

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Aim: To compare accommodation amplitude (AA) values obtained using an objective technique (autorefractometry) with those derived from a subjective method (negative lens test).

Material and Method: In this prospective study, 142 participants were stratified into two age groups: <40 years (Group 1) and ≥40 years (Group 2). The dominant eye of each subject was identified using the Miles test. AA was first measured with an autorefractometer (Tonoref III, NIDEK Co., Ltd.) and subsequently with the negative lens test. Anterior segment biometric parameters were also recorded with an optical biometer (LS-900, Haag-Streit AG, Switzerland). Measurements were analyzed according to refractive status within each age group.

Results: The mean age of the cohort was 36.4 ± 11.9 years (range, 18–60). Mean AA determined by autorefractometry was 1.89 ± 1.74 D, significantly lower than that obtained with the negative lens test (6.01 ± 2.56 D; p<0.001). In Group 1, no significant differences in AA were observed among myopic (n=48), hyperopic (n=10), and emmetropic (n=25) subjects using either method (p=0.430 and p=0.320, respectively). In Group 2, autorefractometric AA was significantly higher in myopic (n=11) and emmetropic (n=18) eyes compared with hyperopic eyes (n=30) (p=0.030 and p=0.020), whereas there was no difference between myopic and emmetropic eyes (p=0.980). Negative lens test results showed no significant intergroup differences (p=0.200).

Conclusion: AA values measured with the negative lens test are not interchangeable with those obtained by autorefractometry. Additionally, objective methods yield lower AA values in hyperopic individuals over 40 years of age.

Keywords: Accommodation amplitude, Autorefractometry, Negative lens test

Amaç: Akomodasyon amplitüdü (AA) değerlerini objektif yöntemlerden otorefraktometre kullanarak ve subjektif yöntemlerden negatif lens testi ile ölçerek karşılaştırmayı amaçladık.

Gereç ve Yöntem: Prospektif olarak planlanan çalışmaya toplam 142 hasta dahil edilmiştir. Hastalar, yaşa göre 40 yaş altı (Grup 1) ve 40 yaş üstü (Grup 2) olarak 2 gruba ayrıldı. Hastaların baskın gözleri Miles testi ile belirlenerek önce otorefraktometre (Tonoref III, NIDEK Co., Ltd.) kullanılarak daha sonra da negatif lens testi ile AA hesaplandı. Ayrıca optik biyometri (LS-900, Haag-Strait AG, İsviçre) cihazı ile hastaların ön segmente ait biyometrik parametreleri ölçüldü. Elde edilen veriler her iki grupta hastaların refraksiyon durumlarına göre karşılaştırıldı.

Bulgular: Ortalama yaş 36,39± 11,93(18-60) yıldı. Otorefraktometre ile ölçülen ortalama AA değeri 1,89±1,74 D iken negatif lens testi ile ölçülen ortalama AA değeri ise 6,01±2,56 D idi (p<0,001). Grup 1'de miyop (n=48), hipermetrop (n=10) ve emetrop (n=25) hastalar arasında hem otorefraktometre ile ölçülen AA hem de negatif lens testi ile bulunan AA açısından refraksiyon durumlarına göre anlamlı fark bulunmamıştır (p değeri sırasıyla 0,430 ve 0,320). Grup 2'de otorefraktometre ile ölçülen AA miyop(n=11) ve emetrop(n=18) hastalarda hipermetrop(n=30) hastalara göre anlamlı düzeyde yüksek (p=0,030, p=0,020) iken, miyop ve emetrop hastalar arasında ise anlamlı farklılık gözlenmemiştir (p=0,980). Negatif lens testi ile ölçülen AA gruplar arasında farklılık göstermemiştir (p=0,200).

Sonuç: Negatif lens testi ile ölçülen AA otorefraktometre ile ölçülen AA ile aynı sonucu vermemekte olup birbirlerinin yerine kullanılamayacağı sonucuna ulaştık. Ayrıca 40 yaş üstündeki hipermetrop bireylerde AA değerleri objektif yöntemler ile daha düşük bulunmuştur.

Anahtar Kelimeler: Accommodation amplitude, Autorefractometry, Negative lens test

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INTRODUCTION

Accommodation is a dynamic optical process that enables the eye to shift its focus from distant to near objects through changes in refractive power (1). During near fixation, contraction of the ciliary muscle relaxes the zonular fibers, increasing lens curvature and allowing the image to be focused on the retina (1–3). Presbyopia is an age-related refractive disorder characterized by a progressive decline in accommodative ability due to reduced elasticity of the crystalline lens and diminished ciliary muscle function (1,4).

Accommodation amplitude (AA) is defined as the difference between the refractive state measured during distance fixation and that during near fixation (2–5). In young individuals, the eye can adjust focus from infinity to a distance as close as 6.5 cm. This corresponds to approximately 15 diopters (D) of refractive change, primarily resulting from ciliary muscle contraction and the consequent relaxation of the zonules. It has been shown that AA, which is 10-16 D in the first two decades, decreases to 4-6 D in the 4th decade, 1-2 D in the 5th decade, and becomes zero in the 6th or 7th decade. (4,5).

AA can be assessed using subjective and objective methods. Subjective techniques include the push-up, push-down, and negative lens tests, whereas objective methods include dynamic retinoscopy and autorefractometry. Dynamic retinoscopy is particularly useful in pediatric examinations. Subjective measurements primarily reflect the functional capacity of near vision, while objective assessments more accurately represent the true refractive changes (2). The Tonoref III autorefractometer (NIDEK Co. Ltd., Gamagori, Japan) is capable of objectively quantifying AA within 30 seconds and provides additional measurements including autorefractometry, keratometry, non-contact tonometry, and pupil diameter (2).

The purpose of this study was to compare AA measurements obtained by an objective method (autorefractometry) with those obtained by a subjective method (negative lens test).

MATERIALS AND METHODS

This prospective study enrolled 142 adult volunteers (18–60 years) who presented to the Ophthalmology Department of Aksaray Training and Research Hospital between January 1, 2022, and January 1, 2025. Written informed consent was obtained from all participants. The study adhered to the tenets of the Declaration of Helsinki and was approved by the Clinical Research Ethics Committee of Aksaray University (Approval No: 2021/10-10).

Inclusion criteria included the absence of acute or chronic ocular disease, refractive error less than ±3.00 D (spherical) and less than 1.25 D (cylindrical), no history of intraocular or extraocular surgery, and a best-corrected visual acuity of 1.0 in both eyes. Exclusion criteria comprised the use of topical mydriatics or medications known to influence accommodation (e.g., phenothiazines, tricyclic antidepressants), systemic conditions associated with early accommodative decline (e.g., diabetes mellitus, Down syndrome), previous laser refractive surgery, strabismus, and history of ocular trauma.

Each participant underwent objective refraction with an autorefractometer (TONOREF III, NIDEK Co., Ltd., Japan), followed by subjective refraction. Based on the refraction, participants were classified as emmetropic (+0.50 to −0.50 D), hyperopic (>+0.50 D), or myopic (<−0.50 D). During the objective refraction, AA was automatically measured by the TONOREF III device. Comprehensive examinations, including best-corrected visual acuity, detailed anterior and posterior segment evaluation, determination of ocular dominance, and the negative lens test, were then performed. Biometric parameters of the anterior segment—axial length (AL), central corneal thickness (CCT), anterior chamber depth (ACD), and keratometry—were obtained with a low-coherence optical biometer (LS-900, Haag-Streit AG, Switzerland).

Ocular dominance, defined as the eye preferentially used for monocular tasks, was determined using the Miles test. For this test, the subject, with both eyes open, formed a small triangular aperture with the hands and aligned a distant object (6 m) within it. When one eye was closed, persistence of the object indicated dominance of the open eye; displacement indicated dominance of the other eye.

Following identification of the dominant eye, the non-dominant eye was occluded, and the negative lens test was performed. A near vision chart was positioned at 40 cm. After the participant focused on the 20/20 line, minus lenses were introduced in 0.25 D increments until the letters were completely blurred. Because the test distance was 40 cm, +2.50 D was added to the measured value. The examiner performing the negative lens test (M.D.) was masked to the AA results obtained by autorefractometry, which were measured independently by another examiner (F.S.). Autorefractometry measurements were taken from 3 consecutive measurements of the patient, and the average was taken, and the measurement was performed at certain times of the day; between 10:00 and 12:00, with ambient light restricted to minimize pupil movement.

Data were analyzed using SPSS software (version 26.0; IBM Corp., Armonk, NY, USA). The normality of numerical data was assessed with the Kolmogorov-Smirnov and Shapiro-Wilk tests. Between-group comparisons were performed using independent samples t-tests and chi-square tests, while comparisons among three groups were conducted with one-way analysis of variance (ANOVA) followed by Bonferroni-adjusted post-hoc tests when appropriate. The Kruskal-Wallis test was used for non-parametric data, and correlations between non-parametric variables were assessed using Spearman's rank correlation. A p-value <0.05 was considered statistically significant.

RESULTS

The study included 142 eyes from 142 participants, of whom 83 (58.5%) were female and 59 (41.5%) were male. The mean age was 36.4 ± 11.9 years (range, 18–60). Fifty-nine participants (41.5%) were myopic, 40 (28.2%) hyperopic, and 43 (30.3%) emmetropic. Ocular dominance testing revealed right-eye dominance in 113 individuals (79.6%) and left-eye dominance in 29 (20.4%).The distribution of sex across refractive groups was similar: myopic group, 33 males (55.9%) and 26 females (44.1%); hyperopic group, 25 males (62.5%) and 15 females (37.5%); emmetropic group, 25 males (58.1%) and 18 females (41.9%) (p=0.861).

For the entire cohort, the mean AA measured with autorefractometry was 1.89 ± 1.74 D, which was significantly lower than that obtained using the negative lens test (6.01 ± 2.56 D; p<0.001).Subgroup analysis showed that in myopic eyes, mean AA values were 2.46 ± 1.81 D (autorefractometer) and 7.19 ± 2.36 D (negative lens test); in hyperopic eyes, 1.15 ± 1.66 D and 4.78 ± 2.28 D, respectively; and in emmetropic eyes, 1.82 ± 1.48 D and 5.54 ± 2.43 D, respectively. Across all refractive subgroups, there was a statistically significant difference between the AA values obtained with the two methods (all p<0.001).

Participants were divided into two age groups: Group 1 (18–40 years, n=83) and Group 2 (40–60 years, n=59). In group 1, no significant differences were observed in AA measured by either method among myopic (n=48), hyperopic (n=10), and emmetropic (n=25) subjects (p=0.430). Negative lens test results were also comparable among these refractive groups (p=0.320) (Table 1).In Group 2, AA values obtained with autorefractometry were significantly higher in myopic (n=11) and emmetropic (n=18) eyes compared to hyperopic eyes (n=30) (p=0.030 and p=0.020, respectively), with no significant difference between myopic and emmetropic groups (p=0.980). The negative lens test revealed no significant differences among these refractive groups (p=0.200) (Table 2).

Table 1. Comparison of accommodation amplitude measured by autorefractometry and the negative lens test according to refractive status in patients aged 18–40 years

	Myopia (n=48)	**Hyperopia (n=10)**	**Emmetropia (n=25)**	**P value***
AA measured by autorefractometry (D)	2.76 ± 1.83	3.24 ± 2.29	2.38 ± 1.65	0.430
AA measured by negative lens test (D)	7.82 ± 2.08	7.67 ± 2.63	7.04 ± 2.00	0.320
Age (years)	27.83 ± 7.34	25.80 ± 5.92	30.36 ± 6.08	0.153

**One-way ANOVA test.*
AA: Accommodation amplitude.

Table 2. Comparison of accommodation amplitude measured by autorefractometry and the negative lens test according to refractive status in patients aged 40–60 years

	Myopia (n=48)	**Hyperopia (n=10)**	**Emmetropia (n=25)**	**P value***
AA measured by autorefractometry (D)	**1.08±0.73**	**0.45±0.22**	**1.05±0.68**	**<0.001**
AA measured by negative lens test (D)	4.10±0.41	3.81±0.99	3.45±1.02	0.200

**One-way ANOVA test.*
AA: Accommodation amplitude.

Correlation analysis demonstrated that in Group 1, age was negatively correlated with AA measured by both autorefractometry and the negative lens test (p=0.009 and p<0.001; r=−0.289 and −0.500, respectively). A significant positive correlation was also observed between ACD and AA measured with the negative lens test (p=0.008, r=0.289). In Group 2, age was negatively correlated with AA measured by the negative lens test (p=0.005, r=−0.325), and AL showed a positive correlation with AA measured by autorefractometry (p=0.001, r=0.414). No other significant correlations were detected (all p>0.050).

DISCUSSION

This study demonstrated a significant difference between AA values measured with autorefractometry and those obtained with the negative lens test across all age groups and refractive categories. These findings indicate that these two methods are not interchangeable. In younger participants (Group 1), no significant differences were observed between refractive groups with either method. However, in older participants (Group 2), AA values obtained by autorefractometry were significantly higher in myopic and emmetropic eyes compared with hyperopic eyes, whereas the negative lens test showed no such difference.

Subjective methods such as the push-up test, push-down test, and negative lens test are the most commonly employed for

AA assessment, while objective methods include dynamic retinoscopy and autorefractometry. Previous studies consistently report that subjective techniques yield higher AA values than objective methods, a finding corroborated by our study (1,2). This overestimation is largely attributed to factors such as depth of field, visual acuity, contrast, and illumination, which can influence subjective responses (1,2,6). Only one study has reported results to the contrary (7). In 2014, Anderson et al. (8) compared subjective and objective methods across a wide age range from preschool children to presbyopic adults and found markedly lower objective values in the preschool group, likely due to uncorrected hyperopia.

Momeni et al. (9) compared four different AA assessment methods and concluded that combining multiple methods helps offset the limitations of each. They also highlighted that the negative lens test tends to produce lower amplitudes than other subjective methods, whereas the push-up technique often produces higher amplitudes due to the increased accommodative stimulus associated with closer target distances. In a subsequent study (3), they compared measurements taken at 33 cm and 40 cm, finding higher amplitudes at 33 cm but ultimately recommending 40 cm for standardization—a protocol adopted in our study.

Autorefractometry objectively measures the difference between distance and near refraction and eliminates the influence of subjective factors. Consequently, objective methods are considered more reliable than subjective tests (1,6). Supporting this view, Aboumourad (5) advocated for dynamic retinoscopy over the push-up method in 2019.

Our findings showed that AA was highest in myopic eyes and lowest in hyperopic eyes, and that AA correlated positively with both AL and ACD. These associations differ from those reported by Leon et al. (10) but are consistent with the majority of previous research (1,2,6).

Chang-Chi Weng et al. (2) validated the repeatability of AA measurements using the same TONOREF III autorefractometer applied in this study and emphasized the need for further research in hyperopic populations due to their limited representation. Similarly, Harb et al. (11) compared AA between myopic and emmetropic adults and found no significant differences.

The main limitations of this study include the use of a single subjective and a single objective test, the cross-sectional single-session design, and the relatively small sample size. Strengths include the masked measurement design and the comparison of AA across multiple refractive subgroups using two different techniques.

CONCLUSION

In conclusion, although autorefractometry yielded significantly higher AA values in myopic and emmetropic participants than in hyperopic participants, the negative lens test did not reveal similar differences. Based on these results, subjective AA assessment by negative lens testing cannot be substituted for objective measurements. Future research with larger sample sizes, diverse refractive groups, and multiple assessment methods is warranted to enhance understanding of the mechanisms and age-related changes in accommodation.

Declarations

Ethics Committee Approval: Ethics committee approval was obtained from the Human Research Ethics Committee of a hospital (Date: September 9, 2021, Decision No: 2021/10-10)). This study was conducted according to the principles of the Declaration of Helsinki.

Authors' Contributions

FS: Conceptualization, data collection, statistical analysis, manuscript writing

MD: Data verification, data collection, critical manuscript review

EU: Data verification, data collection, critical manuscript review

Both authors have read and approved the final version of the manuscript. Each author meets the ICMJE authorship criteria and accepts responsibility for the integrity and accuracy of the work.

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