Amplitude of Accommodation and Add Power in An Adult Population of Tehran, Iran

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Abstract

***Purpose*:** To determine add power (AP) and amplitude of accommodation (AA) in a sample of Iranian population and its relationship with refractive errors

***Methods*:** This cross-sectional study enrolled people of 35-70 years old by simple random sampling. Exclusion criteria were myopia or hyperopia over 6 diopter (D) and astigmatism more than 0.75 D. Those with a history of eye disorders and taking certain medicines that affect on vision were excluded. After correcting refractive errors, distance and near visual acuity (VA) and APs were determined considering subject's age and AA at a distance of 33 cm. The AA was measured using a Royal Air Force (RAF) rule with push up method.

***Results*:** Of 422 participants, 205 (48.6%) were males with a mean age of 50.2±8.8 years old, mean AP of 1.57±0.82 D, and average AA of 3.48±2.5 D. For each year of age, AP raised 0.1 D and AA decreased to 0.23 D ($p<0.001$). The need for AP occurs when AA was less than 6 D.

***Conclusion*:** The results of this study showed the distributions of AP and AA in a sample of Iranian population. The AA in this study was mid-range in comparison with other studies. It was found that females became presbyopic earlier than males and hyperopes became presbyopic earlier than emmetropes and myopes. These results pointed out that decreasing in AA less than 6 D requires AP.

***Keywords*:** Amplitude of Accommodation, Add Power, Presbyopia, Adult, Refractive Errors

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Introduction

Presbyopia is the most common age-related vision impairment in people over 40 years old, and all persons are expected to experience blurred near vision after the age of 50.[1-5] The decrease in amplitude of accommodation (AA) with age is the main reason for add to correct near vision, which occurs because of changes in viscoelasticity and geometry of the lens.[6] AA has been reported from 19.7 to 0.7 diopter (D) at ages of 10 and over 60 years.[7-8] Different studies have reported different AA even at same ages.[8,9] Accordingly, the prescribed add for myopia is different at different ages.[10] Some reports show amounts of add for different ages, but it seems that findings of one study cannot be generalized to another community due to racial and genetic diversity.[8-10]

Even the age of onset for presbyopia is different in countries.[7-9] In addition to age, another factor related to AA is refractive errors in that hyperopes have less AA than myopes and emmetropes.[10] So far, three population-based studies on refractive errors have been conducted in Iran.[11-13] On the basis of these studies, hyperopia is the most common refractive error in elderly and middle-aged people. Since no studies have been reported distribution of AA and Add power (AP) in Iran yet, it is necessary to determine AA, AP distribution and their relationship with refractive errors in Iran.

Methods

Population and samples

In this cross sectional study, target population was people between 35 and 70 years old who came to optometry clinics of Tehran University of Medical Sciences and Noor Eye Hospital, Iran. The study population was randomly selected from these people. Inclusion criteria were age over 35 years, best corrected visual acuity (BCVA) of at least $^{20}/_{25}$ in each eye. Exclusion criteria were myopia or hyperopia over 6 D, astigmatism over 0.75 D, history of diabetes, eye trauma, glaucoma, retinal photocoagulation, uveitis, lens opacity based on LOCS classification (nuclear opalescence and nuclear color of LOCS III grade 4 or more in either eye were defined as nuclear cataract. Cortical cataract and PSC cataract were defined as a LOCS III score of two or more in either eye), long-term application of topical cycloplegia, phenothiazine, medications for dizziness, alcohol, antihistamine, and ophthalmic surgery. After implementing inclusion and exclusion criteria, 422 people were selected for the study.

Examinations

Habitual VA was measured at standard luminance using Snellen chart at a distance (6 m), and near (40 cm). In the next stage, non-cycloplegic objective refraction was measured five times using autorefractometer (Topcon RM8000), and the mean was recorded and checked with the retinoscopic results. After that, subjective refraction was determined with the maximum spherical convex lens and minimum spherical concave lenses, and the optimal VA was recorded. Jackson cross cylinder ±0.25 D was used to determine the axis and amount of astigmatism subjectively. Royal Air Force **(**RAF) rule was used to measure AA. RAF rule is 50 cm long with two plastic edges on each end with a 45 degree downward slope. These edges rest on patient's cheek and the other side is held by the examiner. Monocular and binocular AA were measured three times and their mean were recorded by push up method from the plane of trial frame that placed at 15 mm from the eyes with full distance correction. To measure AA, the eye with lower refractive error, and in case of equal refractive error in both eyes, the eye with better acuity was selected. If the near point of accommodation (NAP) was more than 50 cm, +2 D spherical lens was placed in trial frame in front of patient's eye, and NPA was measured again. Then +2 D was deducted from AA. After determining AA, AP was calculated by considering patient's age, AA at the distance of 33 cm and luminance of 50-120 cd/m^2.[14] Considering the fact that 0.5 of the AA is reserved, 0.5 D of AA was measured and deducted from 3 D (the distance of 33 cm) to determine patient's addition. To prevent the impact of back vertex distance in AA, for patients with spherical refractive error more than 2 D, soft contact lens was used.

Definitions

Refractive errors were defined based on spherical equivalent. Myopia was defined as spherical equivalent worse than -0.5 D, and

hyperopia was defined as spherical equivalent of over +0.5 D.

Statistical analysis

Mean and standard deviation of AA and AP were reported in this study. Linear regression was used to show the relationships. One-way analysis of variance and *t*-test were used to compare these indexes among groups of different sex, age and refractive errors. Coefficient of correlation and scatter plot were used to show correlation between amplitude of accommodation and AP. To compare the present study with other studies, participants were classified in seven age groups from 35 to 70 years with a 5-year interval.

Ethical issues

All participants signed informed written consent form after learning about the objectives of the study. The permission to conduct this study had been taken from ethics committee of Mashhad University of Medical Sciences before examinations began.

Results

Of 422 participants, 205 (48.6%) were males with the mean age of 50.2±8.8 years, their mean AP was 1.57 D with standard deviation of 0.82 (from 0 to 2.75). As it can be seen in table 1, there was no significant difference between two genders for AP (p=0.987). However, for each year, AP increased 0.1 D (p<0.001). Moreover, mean AP ranged from 0.29 D in 35-40 year of the subjects to 2.57 D in 66-70 years.

Our findings showed that 14.7% and 13.7% of the participants needed less than 0.5 D and 0.5-1 D near add respectively. Based on our findings, 18.7%, 19%, 30.6%, 3.3% of participants needed 1 to 1.5, 1.5 to 2, 2 to 2.5, and more than 2.5 D near AP, respectively. AP has been shown in different age groups in table 2.

Mean AA of the participants was 3.48 with standard deviation of 2.5 D (from 0.63 to 14.28 D). As it is shown in table 1, the mean AA did not show a significant difference between two genders (p=0.703). Increasing age decreased AA 0.23 D for each year (p<0.001) (Table 1) in a way that mean AA in 35-40-year-olds was 7.45 D while it was 1.18 in 66-70 year-olds. Figure 1 shows the distribution of AA between two genders. The AA in age group of 35-40 was less in females than males (p=0.011), and after that, it was approximately the same in both groups.

Moreover, figure 2 shows the relationship between AA and addition. The results of this study indicated that add was needed when AA was less than 6 D.

Table 3 shows mean AA and AP in emmetropes, myopes and hyperopes. Analysis of variance showed that hyperopes needed addition significantly more than myopes and emmetropes (p<0.001). Furthermore, hyperopes had significantly lower AA than others, while myopes had significantly higher AA than the others (p<0.001).

Distributions of AA and AP for different types of refractive errors in different age groups are shown in figures 3 and 4. As it can be seen, in age group 35-40 years, hyperopes needed the highest add, while after 45 years old, there is no difference among different groups. However, changes of AA with age in different groups of refractive errors shows that in age group of 35-40 years, the highest AA belonged to myopes (9.02 D) while hyperopes had an AA of 4.99 D (p<0.001).

Table 1. Mean add power and amplitude of accommodation for age and gender

	Add power (Diopter)	Amplitude of accommodation (Diopter)
	Mean±SD	Mean±SD
35-40	0.29±0.41	7.45±2.73
41-45	1.03±0.39	4.43±1.19
46-50	1.52±0.23	3.15±0.55
51-55	1.99±0.24	2.33±0.51
56-60	2.24±0.25	1.72±0.61
61-65	2.54±0.12	1.22±0.31
66-70	2.57±0.11	1.18±0.23
Male	1.57±0.82	3.52±2.6
Female	1.56±0.83	3.43±2.42
Total	1.57±0.82	3.48±2.5

Table 2. Percentage of add power for different age groups

	Add power (Diopter)					
	<0.5	0.5 to 1	1 to 1.5	1.5 to 2	2 to 2.5	>2.5
35-40	75.3%	22.1%	0.0%	2.6%	0.0%	0.0%
41-45	6.0%	56.7%	35.8%	1.5%	0.0%	0.0%
46-50	0.0%	2.8%	68.1%	27.8%	1.4%	0.0%
51-55	0.0%	0.0%	7.7%	61.5%	30.8%	0.0%
56-60	0.0%	1.5%	0.0%	13.2%	85.3%	0.0%
61-65	0.0%	0.0%	0.0%	0.0%	78.0%	22.0%
66-70	0.0%	0.0%	0.0%	0.0%	73.7%	26.3%

Table 3. Mean and standard deviation of amplitude of accommodation, and add power for different refractive errors

	Mean±SD	Mean±SD	Mean±SD
	Emmetropia	Myopia	Hyperopia
Addition power (Diopter)	1.41±0.69	1.22±0.94	2.02±0.6
Amplitude of accommodation (Diopter)	3.5±1.75	4.82±3.41	2.27±1.28

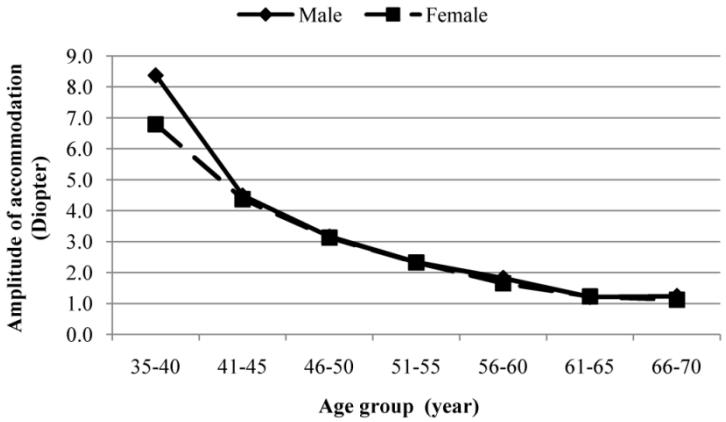

Figure 1. Distribution of amplitude of accommodation in males and females for different age groups

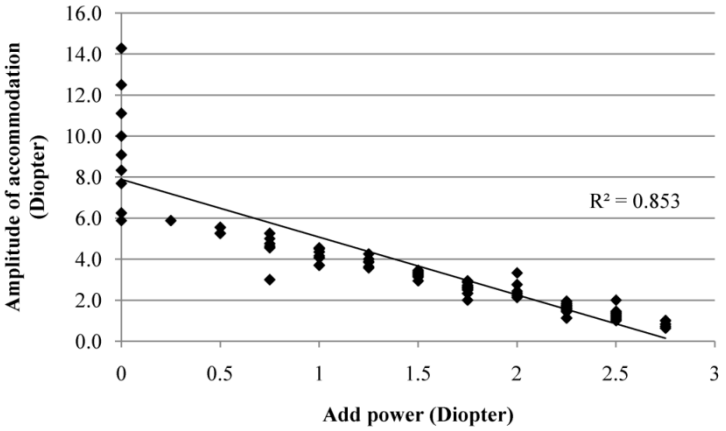

Figure 2. Correlation of add power and amplitude of accommodation

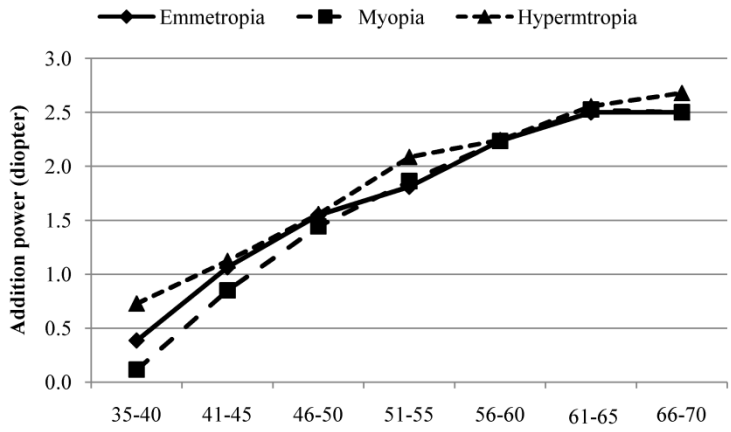

Figure 3. Add power in different age groups for different refractive errors

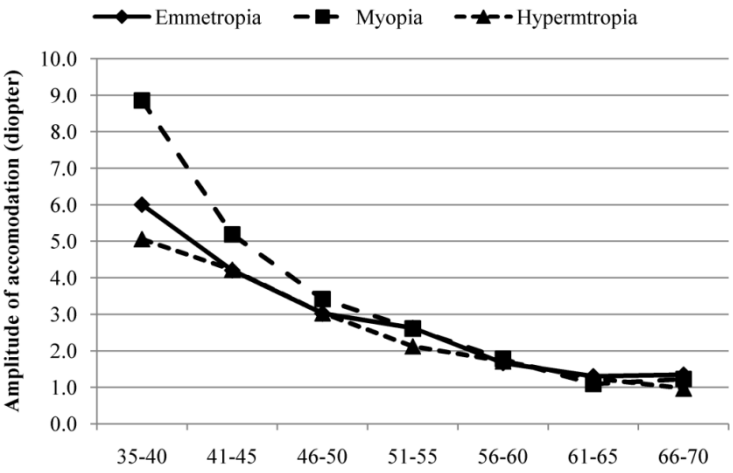

Figure 4. Amplitude of accommodation of different age groups for different refractive errors

Discussion

Based on different studies, mean age for onset of presbyopia is different in countries due to racial, environmental and genetic differences.[8,9] In Iran, epidemiological studies have shown different aspects of ophthalmic and visual impairments, but no report has been given on AP and AA of Iranian people.[4,12,13,15,16] That is why we aimed to study these indexes in a sample Iranian population without ophthalmic disorders.

The results of this study showed that mean AP ranged from 0.29 D in 35-40-year-olds to 2.57 D in 66-70 years. Table 4 shows the comparison of our findings with those of two other studies which showed AP for each gender regardless of the relationship with gender, our results also indicated that AP in different age groups was not significantly different among three studies.[8]

It is noteworthy that AP in both genders of 41-45 years old in Hofstetter's study[17] was higher than that in our study and Pointer's study.[8]

Participants in Pointer's study had the lowest AP.[8] Moreover, after 45 years old, AP in all three studies were almost similar, but after 60 years old, AP in our study was at least 0.25 D higher. The trend of AP with increasing age is because of the decrease in AA. Almost 25% of people of 35-40 years old

need addition while before 45 years old; the amount of AA is different in other studies. As can be seen in this study, the highest decrease in AA occurred after the age of 40. Figure 5 shows the comparison of AA in our study with that in Donders', Duane's, Jackson's and Tumer's studies.[7] As it can be seen, AA is over 6 D in 35-40 years, but after 40 years, it is lower than 6 D in all studies.

Based on our results, AA did not become zero even after 60 years old. The participants of the present study had the highest AA as compared with other studies. The relationship between AA and age in present and previous studies is shown in figure 5. Based on some studies,[18,19] the relationship between AA and age is due to lens crystalline and lens capsule. After 52 years old, about 1 D of AA is apparently left, which shows the person's depth of focus.

As figure 5 shows, in most studies, at least 1 D of AA remains after the age 55 years. In our study, when AA reached 6 D, addition was needed for myopia. This finding was seen in all people over 40 years, but only once in a 37-year-old. Edwards et al[14] reported that Chinese had less AA than Caucasians, and add was needed when AA was less than 5 D. Edwards et al[14] showed that the need for add is strongly related to AA, other environmental and even anthropometric conditions are involved in the onset of presbyopia. However, the present and other similar studies show that presbyopia process begins before 40, and completes after 40 years.[5,20] Kalsiet al[21] studied changes in static accommodation with increasing age. He showed that the slope of the curve is low before 40, but it rises sharply after 40 years. This change is because of the changes in accommodation, which occur with age when the maximum of AA is used and depth of focus increases.

Table 4. Female versus male add power (Diopter) in three studies

	Hofstetter8		**Pointer8**		**Current study**	
	Female	Male	Female	Male	Female	Male
41-45	1.15	1.06	0.84	0.069	0.92	0.83
46-50	1.55	1.42	1.29	1.15	1.46	1.35
51-55	1.97	1.86	1.84	1.69	1.94	1.89
56-60	2.17	2.04	2.07	1.99	2.19	2.20
61-65	2.25	2.17	2.15	2.03	*2.54	2.54
66-70	2.35	2.26	2.34	2.26		
71-75			2.5	2.5		
76-80			2.71	2.59		

*: In Iranian population this group was over 60 years old

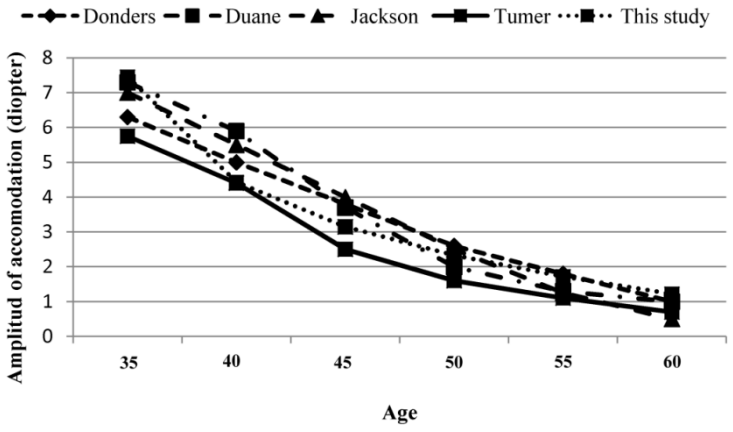

Figure 5. Amplitude of accommodation of present study compared with that of other investigations

On the basis of our findings, there was no difference between two genders with regard to AP and AA. Meanwhile, AA in females of 35-40 was significantly lower than in males. In addition to relationship with genders, these results show that although the need for addition is strongly related with AA, other factors are involved, too. AA depends on physiology, but the need for addition depends on AA and myopia. Most studies found earlier onset of presbyopia and lower accommodation in females than males.[4,8,20] Several reasons are suggested for this early onset of presbyopia in females like their short height, and hormonal changes during menopause. The next section discusses the relationship between refractive errors and presbyopia, but we believe that since hyperopia is more common in women,[15,22,23] one of the reasons for prevalence of earlier presbyopia in women is hyperopia.

Based on our results, hyperopes significantly need addition more than myopes and emetropes, and AA is less in them than in myopes and emetropes.

Attention should be paid to facultative hyperopia since we did not use cycloplegic refraction in this study.

Previous studies show that presbyopia is more prevalent in hyperopia,[10,20,24] but our interesting finding is that lower AA occurs earlier in hyperopes than in others. After 45 years, myopes, hyperopes, and emmetropes are not significantly different. Likewise, Abraham et al[25] showed that AA and refractive errors were related. He showed that myopic subjects of 35-39-year-olds had a higher AA as compared with hyepropes. In that study,[25] the same relationship was found in people of 40-44 years old, but after 44, there was no difference between myopes and hyperopes. His findings are in line with ours. Several hypotheses can be suggested in this regard. Since accommodation is needed more in hyperopes and that hyperopes do more accommodation than mypoes in their life, they suffer from accommodation anomalies and need addition earlier.

The weak points of this study are its small sample size and its non-population based design, The AA in this study was mid-range in comparison with other studies. Moreover, since we did not use cycloplegic refraction, some findings could be influenced by facultative hyperopia. Therefore, we recommend that cycloplegic refraction be used in future studies.

Conclusion

The results of this investigation showed the distribution of AA and AP in an Iranian population for the first time. AP increases linearly with the increase of age and decrease of accommodation amplitude. Females become presbyopic earlier than males, and hyperopes become presbyopic earlier than emmetropes and myopes. A decrease in AA less than 6 D requires near addition.

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