

# COMPARISON OF MEASUREMENT TECHNIQUES OF AMPLITUDE OF ACCOMMODATION IN YOUNG ADULTS

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## ABSTRACT

**OBJECTIVES:** To compare the four standard measurement techniques of the amplitude of accommodation (AA), which are pull-up (PU), pull-away (PA), minus lens (ML) method, and modified pull-up (MPU) method, in young adults.

**METHODOLOGY:** Forty young adults (students) participated in this comparative cross-sectional study. Data were entered by using Statistical Package for Social Science (SPSS version 21.0). Wilcoxon signed-rank test was applied to compare the four methods of the amplitude of accommodation measurement.  $P$ -value < 0.05 was taken as significant. Intraclass Correlation Coefficient method and Bland Altman Plot methods were applied. The amplitude of accommodation was measured with four standard methods, namely pull-up, pull-away, minus lens, and modified pull-up method.

**RESULTS:** The highest amplitude of accommodation was measured with the pull-up method (11.66D), while the minus lens method gave the lower one (9.45D). The highest and the lowest mean difference was related to pull-up with minus lens method (2.24) and pull-down with modified pull-up (0.5). There is a high correlation between the pull-up method and the pull-away method (1.00). The higher Intraclass correlation was found between pull-up and pull-away (0.93) and the lowest between pull-up and minus lens method (0.214). Thus, there is a perfect agreement between pull-up and pull-away. Bland Altman showed good agreement for pull-up and pull-away method.

**CONCLUSION:** The pull-up method gave the highest value of the amplitude of accommodation and the minus lens gave the lowest one. The pull-up and pull-away methods have comparable results. These two methods can be used interchangeably, as there is a good agreement and correlation between them.

**KEYWORDS:** Accommodation, The amplitude of accommodation, Pull-up method, pull-down method, Minus lens method, Modified pull-up method.

## INTRODUCTION

Accommodation can be defined as an increase in convexity of the lens of the eye for focusing the object at near distance in focus on the retina.<sup>1</sup> Accommodation is used to focus on an object of regard whose distance varies and this distance is different from person to person from far point to near point. Punctum remotum (Far point) is the point where accommodation is fully relaxed and conjugate with the retina. Punctum proximum (Near point) is the point conjugate with the retina when the full accommodation is used.<sup>2</sup> Ciliary muscles control the eye crystalline lens movement,

make it globular and flatten to use the near and distance vision. Flattening and rounding of lens occur during the accommodation. The ciliary body, zonule fibers and anterior lens capsule are responsible for accommodation. Ciliary body contracts when near object are comes in focus, which moves the muscle mass anteriorly towards the axis and reduce the diameter of the ciliary ring. This allows the zonules to relax and stretching force on the lens is reduced. Thus, the crystalline lens becomes more globular and power is also increased.

Amplitude of accommodation is the difference in the focusing power of the eye while fixating for near distance and fixating for far distance.<sup>3</sup> It is one of the commonly assessed visual functions during an eye examination. It is valuable when investigating the accommodative status of a patient. Clinically, it is used to diagnose accommodative anomalies, as well as estimating the additional power required to correct presbyopia.<sup>4</sup> Clinical measurement of the amplitude of accommodation (AA) provides an indication of the maximum accommodative ability. A reduced amplitude may reflect functional difficulties resulting from a failure to initiate or maintain an appropriate accommodative response, uncorrected refractive error (particularly latent hyperopia), or a wide range of systemic conditions.<sup>5</sup> Previous studies have demonstrated that the amplitude of accommodation decreases throughout life in a curvilinear manner from three to forty years of age, with the biggest change occurring between 20 and 50 years.<sup>6</sup>

AA reduces at the rate of 0.30 D per year and reduce to 0.50 D at the age of 60 reported by the Hofstetter.<sup>7</sup> Hofstetter measured the average amplitude of accommodation in diopters in 1950 to be  $18.5 - (0.30 \times \text{patient age in years})$  with the minimum amplitude of accommodation as  $15 - (0.25 \times \text{age in years})$ , and the maximum as  $25 - (0.40 \times \text{age in years})$ . However, Hofstetter's work was based on data from two early surveys of Duane and Donders.<sup>8</sup> The aim of measuring amplitude of accommodation is to detect the anomalies of accommodation that producing the symptoms in prepresbyopes and presbyopes. RAF (Royal Air Force) Rule is the most common subjective method used in orthoptics and optometry clinical practice for measuring the near point of accommodation. Other subjective methods use phoropter or focometer.<sup>9</sup>

A number of methods have been described for measuring the accommodative amplitude. Objective procedures include dynamic retinoscopy (DR), Hartinger coincidence refractometer, or a remote Haploscopic videorefractor incorporating plusoptix So4<sup>10</sup> and the use of an open-field autorefractor, to assess the maximum accommodative response.<sup>1</sup> clinical practice, subjective techniques are used most commonly to measure the amplitude of accommodation. The subjective techniques include Donders's push-up (PU), push-down (PD) (also termed

push-away), and Sheard's minus lens (ML) methods.<sup>11</sup>

The push-up method is performed to measure the near point of accommodation. The target is pushed towards the subject and the first sustained blur point is noted where the target become blur and remained blur. Push-up method is the simplest and common method of clinically measuring amplitude of accommodation in which a reading material is used and subject is asked to report where the reading print gets blur while moving the print towards the subject. This method may be done with or without subject own prescription of glasses.

In younger subjects it is difficult to accurately measure the AA in diopters, because slight changes in distances results in large changes in dioptric values.

The push-down method is also performed with RAF rule, in push-down the target is kept close to the subject and then pulled away from the subject until it gets clear and remained clear the reading is noted from the ruler.

Minus lens method is another subjective method of amplitude of accommodation measurement. The subject is asked to sit 33cm away from log MAR test type chart wearing his own prescription and one eye is occluded. Viewing the smallest print that can be seen clearly, minus lenses are added in the interval of 0.5-1 diopters until the clear print gets blurred. The addition of all lenses through which subject can no longer see the print clearly, plus the working distance equivalent diopters is the value of amplitude of accommodation.<sup>2</sup>

Modified push-up method is an alternative subjective technique, where the maximum amount of accommodation is measured by using the minus lens along with the distance prescription. Then the pull-up procedure is done. The benefit of the modified pull-up over the pull-up procedure is, the letters look reduced in size when looked through the concave lens, and this is the reason, why people will perceive the unclear point earlier.<sup>13</sup>

## MATERIALS AND METHODS

### STUDY DESIGN

Comparative Cross-sectional study

### SETTING

The Institute for the study was College of Ophthalmology and Allied Vision Sciences, King Edward

Medical University Lahore.

**SAMPLING TECHNIQUE**

Random sampling technique.

**MATERIALS AND INSTRUMENTS**

- VA charts of near
- Trial box
- Occluder
- Millimeter ruler

**DATA COLLECTION METHOD**

Visual Acuity <6/6 in each eye at 6m and at 40cm either with or without routine prescription of spectacles, no history of squint at 6m or 40cm, lag of accommodation binocularly with bell's retinoscopy within 0.25-0.75D, no history of ocular trauma, no eye disease, no history of amblyopia, aphakia or pseudophakia. All the demographic data & the previous history were collected. A complete refraction procedure was performed & after refraction all the patients underwent four standard measurement techniques of the amplitude of accommodation. AA was measured with pull-up, pull-away, modified pull-up method, and minus lens to blur method. All the four procedures were done with the correction in the trial frame and room illumination was normal.

Each test was performed monocularly first on the right eye and then on the left eye. Four techniques were randomly carried.

**DATA ANALYSIS METHOD**

Data were entered by using Statistical Package for Social Science (SPSS version 21.0). Qualitative variables like gender were presented as frequency & percentages. Wilcoxon signed-rank test was applied to compare the four methods of the amplitude of accommodation measurement. p-value < 0.05 was taken as significant. Intraclass Correlation Coefficient method and Bland Altman plot methods were applied.

**RESULTS**

The highest amplitude of accommodation was obtained with the pull-up method (RE=11.66+2.38D) (LE=11.90+2.55D) while the minus lens to blur method gave the lowest value of accommodative amplitude (RE=9.45+1.09D) (LE=9.44+1.10D). Wilcoxon signed-

rank test showed, p value is significant for PU-PA pair (RE/LE p<0.05), PU-MPU (RE/LE p<0.05), PU-ML (RE/LE p<0.05), PD-MPU (RE/LE p<0.05), PD-ML (RE/LE p<0.05), MPU-ML (RE/LE p<0.05).

There was a poor correlation between the minus lenses to blur method with the other three methods. The highest and the lowest mean difference was related to a push-up with the minus lens method (RE=2.24, LE=2.45) and push-down with modified push-up (RE=0.5, LE=0.5). There is a high correlation between the push-up method and the push-down method (RE/LE=1.00). The higher Intraclass correlation found between a push-up and push-down (RE=0.93, LE=0.942) and the lowest between push-up and minus lens method (RE=0.214, LE=0.179).

Thus, there is a perfect agreement between pull-up and pull-down. But there was a poor agreement between the pull-up and minus lens to blur method.

**Table- 1:Mean, SD, and 95% confidence interval of accommodative amplitude with different measuring procedures.**

| Techniques | PU          | PD          | MPU        | ML         |
|------------|-------------|-------------|------------|------------|
| Mean+ SD   | 11.78+2.47  | 11.21+2.33  | 10.77+1.79 | 9.44+1.09  |
| 95% CI     | 10.64-12.91 | 10.75-12.29 | 10.29-11.5 | 9.11-10.06 |

PU: Pull-up, PD: pull-away, MPU: Modified pull-up, ML: Minus lens to blur method, SD: Standard deviation, CI: Confidence intervals

**Table -2:Intraclass Correlation Coefficient found in all four methods of Amplitude of Accommodation measurement**

| Intraclass Correlation Coefficient Values |       |       |       |
|---|-------|-------|-------|
|   | MLM   | MPU   | PD    |
| PU  | 0.197 | 0.742 | 0.952 |
| PD  | 0.355 | 0.828 |       |
| MPU                                       | 0.463 |       |       |

PU: Pull-up, PD: pull-away, MPU: Modified pull-up, ML: Minus lens method.

**DISCUSSION**

Push-up method showed high value of amplitude of accommodation according to the results of this study as compared to the other three methods. And the minus

lens method showed the lowest amplitude value in the comparison of other techniques.

According to the type of accommodative system that stimulates, the difference between the techniques is predictable. As the distance decreases in the push-up method, the angular size of the retinal image increases. And also increases the proximal stimulation to the accommodation which is inversely proportional to the target distance. Hence, the higher value is obtained with the push-up method, compared to other three methods.<sup>14</sup>

In the minus lens method, there is the minification of the retinal image due to the concave lens optical properties. The proximal stimulation of accommodation remains constant because the relative distance magnification is absent, unlike the push-up method where the relative distance magnification increase.<sup>15</sup> Due to these reasons the minus lens method gives the lower value of the amplitude of accommodation but on other hand, this method thought to be more accurate than the push-up method.

According to this study, the descending order of values is  $PU > PD > MPU > ML$ , the trend is same for both the left and right eye, this is the same as found in Antona's study with the exception of modified push-up method which was not included in his study.<sup>16</sup> When we examine the subjects of same age group those in our study, Leon reported the mean of 9.43 (SD+1.66) with the minus lens method, which was very similar to the mean of 9.45 (SD+1.09) RE, 9.44 (SD+1.10) found here.<sup>17</sup>

The highest mean difference between two methods, found in push-up method and minus lens method, and the lowest is between push-down and modified push-up method, then comes the pair push-up and push down mean difference in ascending order.

By constructing the Bland-Altman technique, the agreement relation is found between all methods. There was a good agreement in pull-up and pull-down method. This finding was related to the results of Woehrle, who suggested that the pull-away and pull-up method results were comparable. It also showed that the agreement was a poor agreement in pull-up and minus lens to blur method, and so good between pull-away and modified pull-up method. Modified pull-up with minus lens and pull-away with minus lens showed

a poor agreement though.

According to ICC, in our results there is a good agreement relation ( $RE=1.00$ ,  $LE=0.9$ ) between the push-up method and push-down method, similar to the results of Atchison. Also found a higher correlation between push-up and push-down ( $RE=1.00$ ,  $LE=1.00$ ). Thus, it is suggested that these two methods can be used interchangeably. But there is a poor agreement between the push-up method and minus lens method, as Antona found poor agreement between three methods, push-up, push-down and minus lens methods.

Comparing the amplitude values of push-up method and modified push method, the modified push-up gives the lower value of amplitude. There is a high correlation between the push-up and modified push-up method, ( $RE=0.9$ ,  $LE=0.9$ ) which is 0.1 times less than the correlation found between push-up and push-down.

## CONCLUSION

Pull-up and pull-away method are quick and easy methods of amplitude of accommodation measurement, and are favorably compared with other methods. The perfect agreement between these two methods can facilitate the clinicians to use these two methods in routine clinical examination, especially in the absence of Phoropter. There is another suggestion, combination of these two methods can further make the results more accurate. This combination will eliminate slight over and underestimation of the values.

The value of amplitude of accommodation measured with modified pull-up method is more similar to the pull-away method, than that of the pull-up method. The pull-up method gives the highest value, minus lens method gives the lowest value of AA and the pull-away and modified pull-up gives in between them.

## RECOMMENDATION

The study on the topic, "Comparison of measurement techniques of amplitude of accommodation young adults" reveals that clinically amplitude of accommodation measurement should be included in the routine eye examination. It should also be assessed in normal individuals to check the occurrence of presbyopia.

- The method of measurement must be referred

through which the accommodative amplitude is measured.

- The use of minus lens to blur method should be discontinued clinically as it gives under estimation of the accommodative amplitude.
- Clinically pull-up and pull-away methods should be used in combination to avoid the slight under and over estimation.

This study was conducted on the individuals with no ocular alignment abnormalities. They had neither ocular motility disorders nor they had any accommodation defects. Still there were differences between the results of four of these methods.

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