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Research Article

# Comparative Study between Mohindra Retinoscopy and Subjective Refraction, in Young Adults with Accommodative Excess

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## Abstract

**Purpose:** The aim of this study was to compare the results of three refractive techniques: Autorefractor (AR), Mohindra Retinoscopy (MR) and Monocular Subjective (MS) and study the differences between the results of Mohindra Retinoscopy and Monocular Subjective test, in subjects with accommodative excess.

**Methods:** The refractive measurements were taken with the open field AR (Grand Seiko WAM-5500), the monocular subjective refraction and MR, and measures of accommodative flexibility and Monocular Estimated Method (MEM) were also taken, in 85 right eyes of 85 healthy university students. (22.3±2.4 years).

**Results:** Statistically significant differences were found on the spherical equivalent for the three techniques, with the Friedman statistical test (N=85; χ_F^2=42.771; p<0.0001). The MR is the technique that provide more positive results and the AR the most negative. Regarding astigmatic components there was no statistically significant differences found between the techniques, with de Friedman statistical test. Data were also analyzed based on accommodation function and there were no statistically significant differences found between subjects with accommodative excess and subjects with normal accommodation, for the spherical equivalent (N=74; H=1.785; p=0.410), and for J0 component (N=74; F=0.948; p=0.392), with the Kruskal-Wallis statistical test.

**Conclusion:** These results revealed significant differences between the three refractive techniques in young adults, independently of accommodative state. The open field AR overestimated some degree of accommodation during the refractive measurements and the MR was the technique that presented more positive results, even in subjects with normal accommodative function. Regarding astigmatic components, all the techniques provide similar results.

**Keywords:** Mohindra retinoscopy; accommodative excess; monocular subjective refraction; refractive state; university students

**Abbreviations:** Accommodative Excess (AE); Visual Acuity (VA); diopters (D); Monocular Estimation Method retinoscopy (MEM); Autorefractor (AR); Mohindra Retinoscopy (MR); Monocular Subjective (MS); Monocular Accommodative Facility (MAF); Early Treatment Diabetic Retinopathy Study (ETDRS); Minnesota Low Vision Reading Test (MNREAD); spherical equivalent (SE)

## Introduction

The accommodative excess (AE) is the most prevalent dysfunction among the university students [1]. In this dysfunction, the patient hyper-accommodates, which implies an excessive accommodative convergence [2]. The excessive use of accommodative convergence will result in a pseudomyopia, what means a temporary transition from refraction towards myopia [3-7]. As such, in individuals with accommodative excess, due to hyper-accommodation, there is a tendency to obtain more myopic results in the techniques of subjective refraction, which are the techniques usually used in clinic [2,8]. Other clinical signs found in subjects with AE are low astigmatisms against the rule, variable visual acuity (VA), failure or difficulty in relaxation of accommodation and low values on Monocular Estimation Method retinoscopy (MEM) (accommodative response without delay or with advance) [2,8]. In order to obtain a correct ocular refraction without the influence of

accommodation, cycloplegic refraction should be used. The active principle of the drugs used is to relax and paralyze accommodation [2,3]. Cycloplegic retinoscopy, in addition to Subjective refraction, is a technique considered standard in the measurement of the refractive state [9]. However, it is associated with temporary symptoms of blurred vision, photophobia and discomfort due to paralysis of the accommodation. In addition, Cycloplegic Retinoscopy is contraindicated in people with heart problems, primary glaucoma, people prone to glaucoma (narrow anterior chamber angle), and hypersensitivity to any of the excipients of the drug [9-11].

According to Mohindra, the Mohindra Retinoscopy is a good substitute technique for Cycloplegic Retinoscopy and provides similar results when used the correct correction factor, without the disadvantages indicated, a fact supported by other authors [9,12,13]. Recently, the use of open field autorefractor has become a widely used technique for measuring refractive state [9]. There is scientific evidence showing that the use of the autorefractor, without cycloplegics, has a reasonable precision when compared to the values obtained by Cycloplegic Retinoscopy and Subjective Refraction [9,14-17]. However, there are also studies that show that the autorefractors without cycloplegics, fails to completely neutralize patients accommodation. In these studies, the results obtained by open field autorefractor leaded to a reduction in the accuracy of measurements between 0.01 and 0.38 diopters (D) towards myopia. This fact is especially relevant in people with large accommodative reserves [9,17-19]. The aim of this study was to compare the results of three non-cycloplegics refractive techniques: Autorefractor (AR), Mohindra Retinoscopy (MR) and Monocular Subjective refraction (MS), in university students. The purpose of this study was to evaluate the results of MR and the results of MS technique, to understand if the accommodation is being compensated, in addition to patients ametropia.

## Methods

The data acquisition was performed between October 2017 and January 2018, at the Optometry Laboratory and the Clinical and Experimental Center of Vision Sciences. The project complied with the directives of the Helsinki Declaration and was approved by the Ethics Committee (CE-UBI-Pj-2018-002). Participants signed a free and informed consent, after knowing the nature of the study. A total of 85 university students' volunteers (37 women and 48 men), aged between 18 and 30 years (mean age of 22.3±2.4 years), were evaluated. None of the subjects had strabismus, amblyopia, previous history of refractive surgery or pregnancy. Participants were also excluded from taking medication that would interfere with accommodative function. Inclusion factors were the achievement of usual visual acuity better or equal to 0.1 logMAR and presentation for optometric evaluation without contact lenses. Refractive and accommodative measures were taken. In order to study the refractive function.

### The following acquisitions were made:

**a)** Refractive and accommodative measures were taken. In order to study the refractive function, the following acquisitions were made: Monocular habitual VA at 4 meters, using well-contrasted ETDRS charts for far vision.

**b)** Mohindra Retinoscopy (MR), using test glasses, loose lenses, and esquiascopia rules.

**c)** Monocular Subjective Refraction (MS), using a CSO LCD monitor, in logMAR scale, test glasses and loose lenses. and

**d)** Autorefractor (AR), using the Grand Seiko WAM-5500 open-field autorefractor (Japan) with visual stimulus at far of 1.0 logMAR.

### The following clinical tests were performed for the study of the accommodative function:

**a)** Monocular Accommodative Facility (MAF), performed on the habitual compensation of the subjects, using lens flippers of ±2.00 D and MNREAD chart with a stimulus of 0.2 logMAR; and

**b)** MEM, using an accommodative stimulus of 0.2 logMAR and spherical lenses.

The MR and the MS were performed by different researchers, to guarantee a greater veracity of the results, since the researchers didn't know the value of one of the refractive techniques. MR was performed in a completely dark room after the volunteer had his eyes closed for five minutes to allow relaxation of accommodation. The measurement was taken in the right eye over the test glasses and it was used a combination of spherical and cylindrical loose lenses, with the left eye occluded. The volunteers were instructed to look right into the light of retinoscope, that was 50 centimeters away. After de procedure of retinoscopy, a value of +1.25 D was withdrawn from the final result.

## Results

Considering the usual refraction of the volunteers who participated in this study, 44.7% had myopia, 52.9% were emmetropic, and 2.4% had hyperopia. The spherical equivalent of the usual refraction was divided according to criteria provided by the American Academy of Optometry [20,21]. The usual refractive error of the sample ranged from -7.75 to +2.25 spherical diopters. The maximum magnitude of astigmatism was -3.75 cylindrical diopters. For the comparative study between the results of the different refractive techniques used in this work, the powers obtained in sphero-cylindrical form were converted to their vector components according to Thibos [22]. The spherical equivalent (SE) and the astigmatic components in horizontal/vertical ($J_0$) and oblique ($J_{45}$) directions were calculated according to the expressions:

$$SE = S + C/2$$

$$J_0 = -\frac{c}{2} \times \cos(2 \times axis)$$

$$J_{45} = -\frac{C}{2} \times \sin(2 \times axis)$$

The graphs of (Figure 1) show the distribution of the values for the SE (part A), $J_0$ (part B) and $J_{45}$ (part C) components, obtained by each of the refractive techniques: AR, MS and MR. With respect to the SE component, it can be observed that of the three refractive techniques used, the open field AR was the method that presented more myopic values. The MR presented median results very similar to those of MS, although with slightly more positive values. Regarding the $J_0$ component, it is observed that the median is slightly more positive in MR. The MS test presented median values very similar to the open field AR, for the $J_0$ component. With respect to $J_{45}$ component, the results are similar in all three refractive techniques. (Table 1) reports the mean and standard deviation of the SE, $J_0$ and $J_{45}$ components of the three refractive techniques. It is possible to observe that the mean differences between the techniques are around ±0.25 D, and MR presents slightly more positive values and the AR the more negative for the SE component. The comparison of the results of the three refractive techniques shows that for the SE component, the AR provides more myopic values, whereas the MR gives more hypermetropy values, and for the $J_0$ and $J_{45}$ components the techniques provide similar results. The differences found through the Friedman test, for the SE component are statistically significant, ($_{2,85}$=42.771, p<0.0001) and the multiple mean comparisons reveals that there are statistically significant differences between all pairs of techniques. For the $J_0$ component, the interpretation of the statistically test result ($_{2,85}$=6.607, p=0.037) indicates that this component also presents significant differences, however through the multiple mean comparison test it is verified that there is no statistical evidence to state that there are differences between any pair of techniques. For the $J_{45}$ component the differences between the techniques are not significant ($_{2,85}$=5.801, p=0.055).

**Table 1:** Descriptive statistics (mean±SD) for the SE, $J_0$ and $J_{45}$ components, of the three refractive techniques.

| | AR Mean±1 SD | Sub Mean±1 SD | MR Mean±1 SD |
|---|---|---|---|
| SE (D) | -1.02±1.65 | -0.91±1.71 | -0.73±1.64 |
| $J_0$ (D) | 0.21±0.47 | 0.19±0.45 | 0.23±0.50 |
| $J_{45}$ (D) | 0.04±0.29 | 0.02±0.29 | 0.01±0.34 |

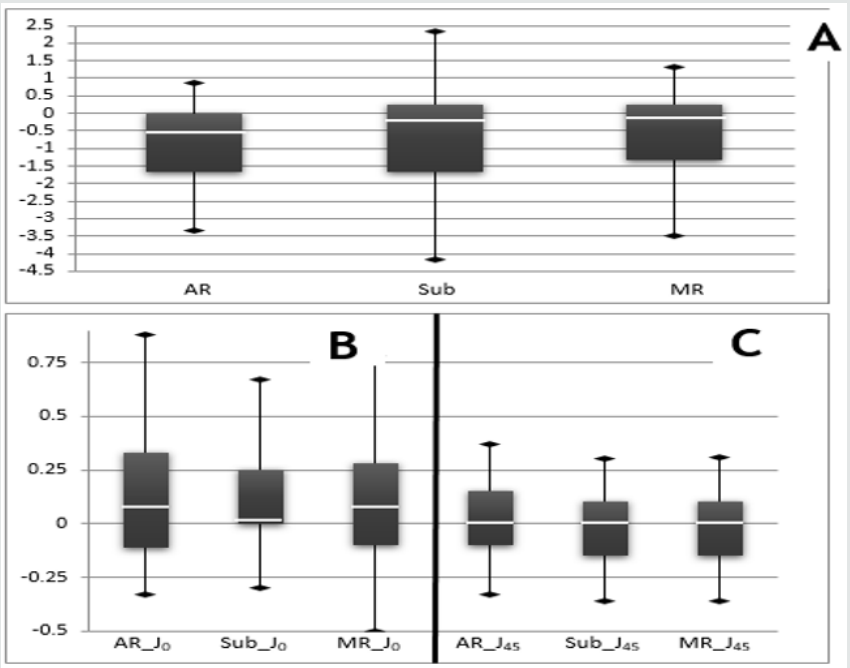


**Figure 1:** Distribution of the values related to SE (part A), $J_0$ (part B) and $J_{45}$ (part C) components.

In order to analyze the relationship between the accommodative state and refraction, the sample was stratified according to the accommodative state in the following categories: normal accommodation, definite accommodative excess, suspected accommodative excess, and other types of accommodative alterations. To carry out this division, the MAF and MEM test standards were used and are summarized in (Table 2). In this analysis, only the categories of normal accommodation, suspected accommodative excess and definite accommodative excess were considered, excluding subjects who presented other types of accommodative alterations. In order to compare the results of the refractive techniques, as a function of the accommodative state, two new variables, ΔSE and $\Delta J_0$, were created, characterized by the difference between MR results and the MS results, for the SE component and for the $J_0$ component, respectively. Only the SE and $J_0$ components were studied since they are the parameters mentioned in the literature as those that can be associated with the accommodative excess that is, pseudomyopia and low astigmatism against the rule. (Table 3) shows the mean difference and the level of statistical significance among refractive techniques.

**Table 2:** Division of the sample by type of accommodation and its frequency.

| Type of accommodation | Criteria | Frequency of occurrence (%) |
|---|---|---|
| Normal accommodation | FAM ≥6cpm and 0.00≤MEM≤+0.75 | 47.1 |
| Suspected accommodative excess | FAM <6 cpm (difficulty/failure with positive lenses) or MEM ≤ -0.25 | 28.2 |
| Definite accommodative excess | FAM < 6cpm (difficulty/failure with positive lenses) and MEM ≤ 0.00 D | 11.8 |
| Other accommodative alterations | None of the above | 12.9 |

**Table 3:** Mean difference and the level of statistical significance for the ΔSE and $\Delta J_0$, of the three refractive techniques.

| MR - Sub | | | |
|---|---|---|---|
| | Mean±SD (D) | p-value | Statistical test |
| ΔSE | 0.19±0.44 | 0.410 | Kruskal-Wallis |
| $\Delta J_0$ | 0.04±0.24 | 0.392 | One-Way ANOVA |

In order to graphically analyze these small differences between accommodative groups, the box plots of the SE and $J_0$ components are shown in (Figures 2 & 3), respectively. The comparison of the results of the MR and MS techniques, as a function of the accommodative state, shows that for the SE component (ΔSE = MR-MS) the subjects with definite AE are those with higher mean values, meaning that the value obtained by the MS tends to be more myopic than the one obtained by MR. for the component $J_0$ ($\Delta J_0$ = MR-MS), the subjects with definite AE present lower average values, meaning that the results obtained by the MS tend to be more positive (presence of astigmatism against the rule) than those obtained by MR. Despite the differences observed graphically, there was no statistical evidence that those differences were statistically significant, for none of the components, SE ($H_{2,74}$=1.785, p=0.410) and $J_0$ ($F_{2,74}$=0.948, p=0.392).

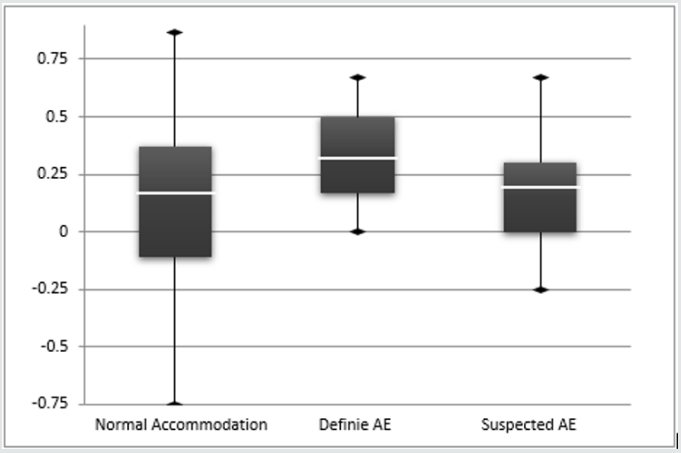


**Figure 2:** Box plots of SE component, depending on the accommodative state.

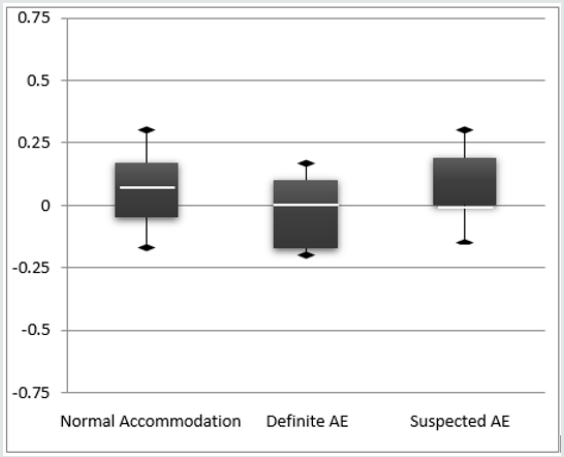


**Figure 3:** Box plots of J0 component, depending on the accommodative state.

## Discussion

The most prevalent spherical ametropia found in this study was myopia, with the low magnitude being the most frequent, which agrees with what is reported in the literature, for the same classification criteria for ametropia [23,24]. In relation to astigmatism, there was a greater predominance of astigmatism with the rule, a fact that has also been announced by other authors in young populations [25-28]. Regarding the accommodative state, the sample was divided according to the accommodative state in normal accommodation, definite accommodative excess, suspected accommodative excess and other accommodative alterations. Of the 85 volunteers, 11.8% were classified as having definite accommodative excess, 28.2% with suspected accommodative excess, 47.1% with normal accommodation and 12.9% with other accommodative alterations. The frequency rate found has a value within the same order of magnitude as those indicated by Porker et al, although slightly higher, a situation that is expected, as reported in the literature, due to the change in visual habits derived from the increasing use of new technologies and the increase of hours of intensive study that a higher education requires [1,29]. The main objective of this study was to determine if subjects with an accommodative excess presented differences between the refractive results obtained by an objective technique and a subjective one, performed routinely in clinical practice. As a subjective technique, we used the subjective test because it was considered the standard refractive examination and as objective technique, we used the MR because it is considered the objective refractive technique that presents values closer to those of the Cycloplegic Retinoscopy [9,15,30]. The identification of subjects with accommodative excess was based on the interpretation of the results of the MEM test and the MAF test, following the criteria suggested by other authors [31-33].

The results revealed significant differences in SE component between three refractive techniques, and these differences were found to be identical in all groups, regardless of the accommodative state of the volunteers. The open-field AR tends to overestimate some degree of accommodation during refractive measurements, in university students, providing slightly more myopic values than the other techniques, which is also found by other authors and is well documented in the scientific literature [9,17,34,35]. Comparing the open field AR and MS techniques, although statistically significant differences were found through the Friedman test and the multiple mean comparison, these differences present a mean variation of ±0.11 D. These results are in line with those reported by Sheppard and others, who found differences between these two techniques ranging from 0.01 to 0.38 D, with the open field AR presenting the most negative values [35]. The results of this work showed that MR was the technique that provided less myopic results. Even in subjects with normal accommodation, the differences between MR and MS were around ±0.18 D. MR provided less myopic values than the MS, which coincides with the mentioned by Natarajan et al. This author concludes that although the values are similar, MR provides slightly higher values, possibly due to the accommodative tone of +0.75 D [36]. A single accommodative tonus value may not be advisable for all age groups and further studies should be conducted in relation to this. The results of this present study showed that for the age group of university students, the accommodative tone value of +0.75 D may not be the most adequate, since more hypermetropic values were obtained with the MR, compared to MS. Regarding the astigmatic components, no statistically significant differences were found between the refractive techniques. This means that all the techniques used provided similar results in relation to astigmatism, which is in line with found by Mohindra [37].

These results show that there are statistically significant differences for the SE component throughout the sample, with MR providing more positive results for all individuals, around ±0.25 D, regardless of the accommodative state. Although the findings are statistically significant, clinical routine may be interpreted as having little significance. However, the results of this study showed that the prescription of university students may be overvaluing myopia. Since myopia is the refractive error most prevalent globally, it is strongly related to the excessive use of the near vision [24,38,39]. University students make use of near vision because of the intensive study hours a high education requires. As such, this greater accommodative effort may influence refractive outcomes. The accommodation factor is quite controlled in children, however, there doesn't seem to be much interest in being controlled in older age groups. Given the changes in lifestyles, increased use of near vision, and increased rates of myopia, university students are expected to present accommodative reserves that may interfere with manual refraction, if they are not controlled. More studies within this area are needed to study the effect of accommodation on refraction in young adults using cycloplegic refraction. As future work, one aspect that deserves attention is to verify if the correction factor of +1.25 D proposed by Mohindra, in this age group, is updated, considering that this study happened in the year of 1977, and until the date there are not studies that verify if it is a good correction factor, in order to minimize the influence of working distance and tonic accommodation. Another aspect that should by studied is the effect of accommodation on refraction in young adults and students, because of the great use of the near work.

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