The influence of cycloplegic in objective refraction

J Jorge[1], A Queiros[1], J González-Méijome[1], P Fernandes[1], JB Almeida[1], and MA Parafita[2]

1 Department of Physics (Optometry), School of Sciences. University of Minho. Braga. Portugal.

2 Department of Surgery (Ophthalmology), School of Optics and Optometry. University of Santiago de Compostela. Spain

Author Address:

Jorge Jorge
Departamento de Física
Universidade do Minho
Campus de Gualtar
4710-057 Braga
Portugal

Telf: +351 253 604333
Fax: +351 253 604061

e-mail: jorge@fisica.uminho.pt

SUMMARY.

The purpose of this study was to compare refractions measured with an autorefractor and retinoscopy in cycloplegic and non-cycloplegic eyes.

The objective refractions were performed in 199 right eyes from 199 healthy young adults with a mean age of 21.6 ±2.66 years. The measurements were performed first without cycloplegia and repeated 30 minutes later with cycloplegia.

Data were analyzed using Fourier decomposition of the power profile.

More negative values of component M and J_0 were give by non-cycloplegic autorefraction compared to cycloplegic autorefraction ($p<0.001$). However more positive values were given by non-cycloplegic autorefraciton regarding to the J_{45} vector, althought this differences were not statistically significant ($p=0.233$).

Regarding retinoscopy, more negative values of component M where obtained with non-cycloplegic retinoscopy ($p<0.001$); for the cylindrical vectors J_0 and J_{45} the retinoscopy without cycloplegic yields more negative values ($p= 0.234$; $p= 0.112$, respectively).

Accepting that differences between cycloplegic and non-cycloplegic retinoscopy are only due to accommodative response, present results confirm that when performed by an experienced clinician, retinoscopy is a more reliable method to obtain objective start point for refraction under non-cycloplegic conditions.

Key Words: astigmatism, autorefractor, retinoscopy, refractive errors, cycloplegic and non-cycloplegic refraction.

INTRODUCTION

Automatic objective refractors, which estimate the refractive error without requiring either operator or patient judgment, have been available since 1969. These instruments are easy to operate, quicker than other techniques of objective refraction such as retinoscopy and are better appreciated by patients (Wood *et al.* 1998).

For these reasons autorefractors are enjoying an increased popularity in ophthalmologic and optometric practice for objectively assessing the refractive error of patients, and in some situations completely dispensing with retinoscopy.

Although autorefraction provides a fast, repeatable measure of refractive error, its validity is as important as its efficiency. For example, fortunately, most clinicians do not prescribe spectacles based exclusively on results from autorefraction or retinoscopy. (Strang *et al.* 1998;Walline *et al.* 1999;Zadnik *et al.* 1992).

As well as in clinical practice, autorefractors are also widely used in optometric and ophthalmic research, for example to examine refractive error development, accommodative responses and the correlation before and after refractive surgery (Allen *et al.* 2003;Mallen *et al.* 2001;McBrien and Millodot 1985;Salchow *et al.* 1999).

For research purposes and clinical practice, the ideal autorefractor should provide valid and repeatable measurement of refractive error; be rapid and easy to use and absolutely objective. Previous studies have found most models to be valid/accurate and reliable when compared with subjective refraction. Nevertheless, for some instruments, pseudo-myopia due to accommodation and an inadequate auto fogging mechanism has been revealed. (Bullimore *et al.* 1998;Davies *et al.* 2003;Kinge *et al.* 1996;Mallen *et al.* 2001;McCaghrey and Matthews 1993).

The Nidek ARK 700A was chosen because it provides a confidence value for each reading and because it has been used in some clinical studies with refractive error as the primary outcome measure (e.g., Correction of Myopia Evaluation Trial) (Gwiazda *et al.* 2003;Gwiazda and Weber 2004;Hyman *et al.* 2001)

Objective refractive values can be badly affected by the accommodative activity under non-cycloplegic conditions. This factor could be more significant with autorefraction due to instrument accommodation (Nayak *et al.* 1987a), so retinoscopy could be a more reliable method of non-cycloplegic refraction. In order to elucidate this question, the purpose of the present study was to estimate the role of accommodative response (non-cycloplegic against cycloplegic) on objective refraction (autorefraction and retinoscopy) by studying a large group of young adults.

MATERIALS AND METHODS

The right eye of one hundred and ninety nine healthy sciences students (66 males and 133 females) where analyzed. The mean age was 21.6 ± 2.66 years (range 18 to 34 years). Exclusion criteria were systemic disease or previous or present eye disease or injury.

After the nature of the study was explained, a consent form was signed by the patient before being enrolled in the study. The research followed the Declaration of Helsinki rules and was reviewed and approved by the Scientific Committee of the School of Sciences of Minho University (Portugal).

The eye examinations took place at the Laboratory of Clinic Optometry, School of Sciences of the University of Minho and all measurements were performed by the first author using in all exams the same equipment and method as described below.

The Nidek ARK 700A, an autorefractor with a closed field of view first manufactured in 1997, takes readings every 0.3 sec. The measurement technique is based on the Scheiner disc principle, with the disc formed by two small LED's mounted in a rotating tube such that all meridians of an eye are scanned. The Nidek ARK 700A determines astigmatism from 180 separate readings taken at each 1° of axis. For the Nidek ARK 700A, subjects viewed a picture of a hot air balloon enclosed in the instrument. The target was fogged by 1.5 D in an attempt to minimize accommodation.

The display was masked for the first author, the readings being made by the second author. Three readings were taken for each eye, and the final autorefractor prescription calculated from the average result. The results were recorded via attached printer.

Retinoscopy was performed in each eye over the phoropter lenses, attempting to refine the retinoscopy to be within a ±0.25 D range over the real power for both the spherical and the cylindrical components and the axis to ±5 degrees maximum error. The spherical power, cylindrical power and cylinder axis display on the phoropter were covered so the examiner could not see them, as was proposed by Rosenfield and Chiu (Rosenfield and Chiu 1995), for the spherical power display. Under these conditions, the first author acted as retinoscopist in each case, while the second author recorded the results. The phoropter was reset to zero before each use by the second author.

These measurements were performed first without cycloplegic and repeated 30 min later with cycloplegia. This was performed by instillation of one eyedrop 1%, cyclopentolate (Colircusi Cyclopegic) in each eye twice with a 5-minute interval.

The most investigators (Bullimore *et al.* 1998;Harris 2001) recognized that traditional clinical representations of refraction, including sphere, cylinder, and axis, are not adequate for quantitative analysis. For this reason, sphero-cylindrical refractive results were converted into vector representations by Fourier analysis as recommended by Thibos (Thibos *et al.* 1997).

i. A spherical component of power M

$$M = Sphere + \frac{cylinder}{2}$$

ii. Jackson cross-cylinder at axis 0º with power J_0

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

iii. Jackson cross-cylinder at axis 45º with power J_{45}

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

The data obtained from both eyes were previously analysed and no significant differences were found between the left and the right eye. However, only right eye measurements were submitted to analysis.

Bland and Altman (Bland and Altman 1986) described a method of measuring test agreement by calculating the mean difference between measurements. Moreover, this statistical method can be used in comparisons among different tests. Since then, plots of differences against means were recommended as the best method to compare measurements obtained with different instruments or techniques, when the actual measurement is unknown (Bland and Altman 1995;Shakespeare *et al.* 2001;Zadnik *et al.* 1994). In this study, data was analysed using the statistical package SPSS v.11.5. The bias was assessed statistically as the mean of the differences compared to zero. The hypothesis of zero bias was examined by a paired t-test. The 95% limits of agreement (mean of the difference ± 1.96 x SD of the differences) were also calculated. This type of analysis makes it easier to assess the level of agreement between techniques, spot outliers and see whether there is any trend.

RESULTS

The refractive error of the sample, as represented by retinoscopy with cycloplegic, ranged from –9.00 to +3.75 D. Mean spherical equivalent was + 0.28 ± 1.48D (Mean ± SD.). The maximum amount of astigmatism was –2.50 D. The distribution of refractive errors was: 22.1% of the sample had myopia, 24.1% had emmetropia and 53.8% had hyperopia.

Table 1 displays the mean and standard deviation of M, J_0, and J_{45} components of the orthogonal functions obtained with the autorefractor and retinoscopy with and without cycloplegia. These values show that in both techniques the measures obtained without cycloplegic are more negative or less positive when compared to measures obtained under cycloplegic conditions.

Table 2 presents mean difference, level of statistical significance as well as the limits of agreement between autorefractor, and retinoscopy with and without cycloplegic.

The comparison of the autorefractor values without and with cycloplegic shows that, for the components M and J_0, the autorefractor without cycloplegic yields more negative values (M –0.86 ± 0.79 D, $p < 0.0001$; J_0 –0.05 ± 0.11 D, $p < 0.0001$), and for the J_{45} vector, the autorefractor without cycloplegic yields more positive values (0.01 ± 0.08 D, $p = 0.233$). The differences found for the M, J_0 components are statistically significant.

The comparison of the retinoscopy values without and with cycloplegic verifies that, for all components, the retinoscopy without cycloplegic yields more negative values (M –0.37 ± 0.45 D, $p < 0.0001$; J_0 –0.01 ± 0.11 D, $p = 0.234$; J_{45} -0.01 ± 0.07 D, $p = 0.112$). Only for the M component the differences found are statistically significant.

In order to graphically analyze the agreement between measurements obtained with and without cycloplegic, plots of differences as a function of the mean for each component are displayed in *figure 1 (a to f)*.

The confidence interval for components, M and J_{45}, follow the same tendency, i.e. the confidence interval is narrower when comparing retinoscopy without cycloplegic with retinoscopy with cycloplegic (limits of agreement, M = $\pm$ 0.88; J_{45} = $\pm$ 0.15) than when autorefraction without cycloplegic against autorefraction with cycloplegic are considered (limits of agreement, M = $\pm$ 1.54; J_{45} = $\pm$ 0.16). For the J_0 components the confidence interval is the same.

Analysing the results obtained with autorefractor with and without cycloplegic, it can be concluded that: for M component, the autorefractor without cycloplegic read 0.86 D more negative or less positive than when cycloplegic is present. For the retinoscopy the difference was 0.37 D.

DISCUSSION

One of the most important concerns for clinicians when perform refraction to children and young adults is the control of the accommodative response. Standards of optometric practice suggest that a reliable objective start point is fundamental to reach a satisfactory subjective result. The most currently used methods of objective refraction include retinoscopy and autorefraction. However, both approaches can be badly affected by accommodative response in young phakic patients (Nayak *et al.* 1987a), which frequently results in overestimation of myopia, and consequently in wrong prescriptions. This circumstance could be one of the potential factors influencing myopic shifts and binocular disorders in children and young adults exposed to prolonged near work activities (Ciuffreda *et al.* 1999;Goss and Rainey 1999;Hung and Ciuffreda 1999).

To minimize the effects of accommodation during refraction, non-cycloplegic fogging and drug assisted cycloplegia are the most commonly used procedures. The second one warrants the pharmacological inactivity of accommodation for a period of time; however, many optometric practitioners around the world are not allowed to use diagnostic drugs. Fogging procedures under non-cycloplegic conditions involve sophisticated systems introduced in new autorefractors or require the expertise of the practitioner who performs retinoscopy to be effective.

The limit for clinical significance was adopted to meet the criterion suggested by Goss and Grosvenor (1996). In their work, which consisted of a review of literature on the repeatability of different methods of refraction, they consider that whatever difference higher than ± 0.25 D should be considered as being clinically significant.

The differences between cycloplegic and non-cycloplegic autorefraction clearly indicates that autorefractor's auto-fogging system does not seem to adequately neutralise patient's accommodative activity, as the fixation target probably induces instrument myopia. Previous studies (Gwiazda and Weber 2004), in which ARK700A was compared with current open-field autorefractors models, show the same trend of the equipment to measure more negative or less positive values than others, suggesting some weakness in auto-fogging system. Our results are also in agreement with those obtained in older autorefractors models (Ghose *et al.* 1986;Nayak *et al.* 1987a;Nayak *et al.* 1987b)

The absence of significant differences between cycloplegic and non-cycloplegica autorefraction for components J_0 and J_{45} are in agreement with the results of Gwiazda and Weber (2004). In their study, Nidek ARK700A showed excellent agreement with other autorefractors for low astigmatic eyes.

The comparision between cycloplegic and non-cycloplegic retinoscopy also evidences that even on the hands of an experienced clinician, the fogging system does not adequately neutralise patient accommodation, leading to more negative values in the absence of cycloplegia.

In summary, both, autorefraction and retinoscopy, give more negative or less positive values as a start point to subjective refraction. Considering Goss and Grosvenor criterior, the myopic shift induced by non-cycloplegic objective refraction is clinically significant.

In 1994 Chan and Edwards (Chan and Edwards 1994) presented the results of a research done on Asian children and verified the existence of a more myopic values opr less positive of refractive error value using retinoscopy without cycloplegic. Their values found were higher than ours, which was to be expected due to the age difference between the populations

Our results show that the spherical part of refraction, here represented by M component, could be more affected by accommodative activity when obtained by autorefraction in young adults given more negative results when performed under non-cycloplegic conditions. Similar results were also found by Bullimore and Zadnik for the autorefractor and retinoscopy values (Bullimore *et al.* 1998;Zadnik *et al.* 1992). Other studies, considering different models of autorefractor, show the same tendency of the autorefractor to yield more negative or less positive values of the refractive error (Cordonnier and Dramaix 1999;Cordonnier and Kallay 2001;Harvey *et al.* 1997;Isenberg *et al.* 2001;Kinge *et al.* 1996;Salchow *et al.* 1999).

In the view of this work, practitioners must be aware of the myopic shift expected with current objective refractive methods, especially those prohibited of the use of cycloplegic drugs. However, our results demonstrate that when performed under standard procedures to minimize acccomodation, non-cycloplegic retinoscopy should give a valuable objective start point to perform subjective refraction in young adults. Despite the proliferation of autorefractors in optometric and ophthalmology clinics, the use of retinoscopy should not be underestimated, mainly by the new generations of optometrists and ophthalmologists. If so, we cannot warrant a reliable start point for subjective refraction free from the influence of accommodation under non-cycloplegic conditions.

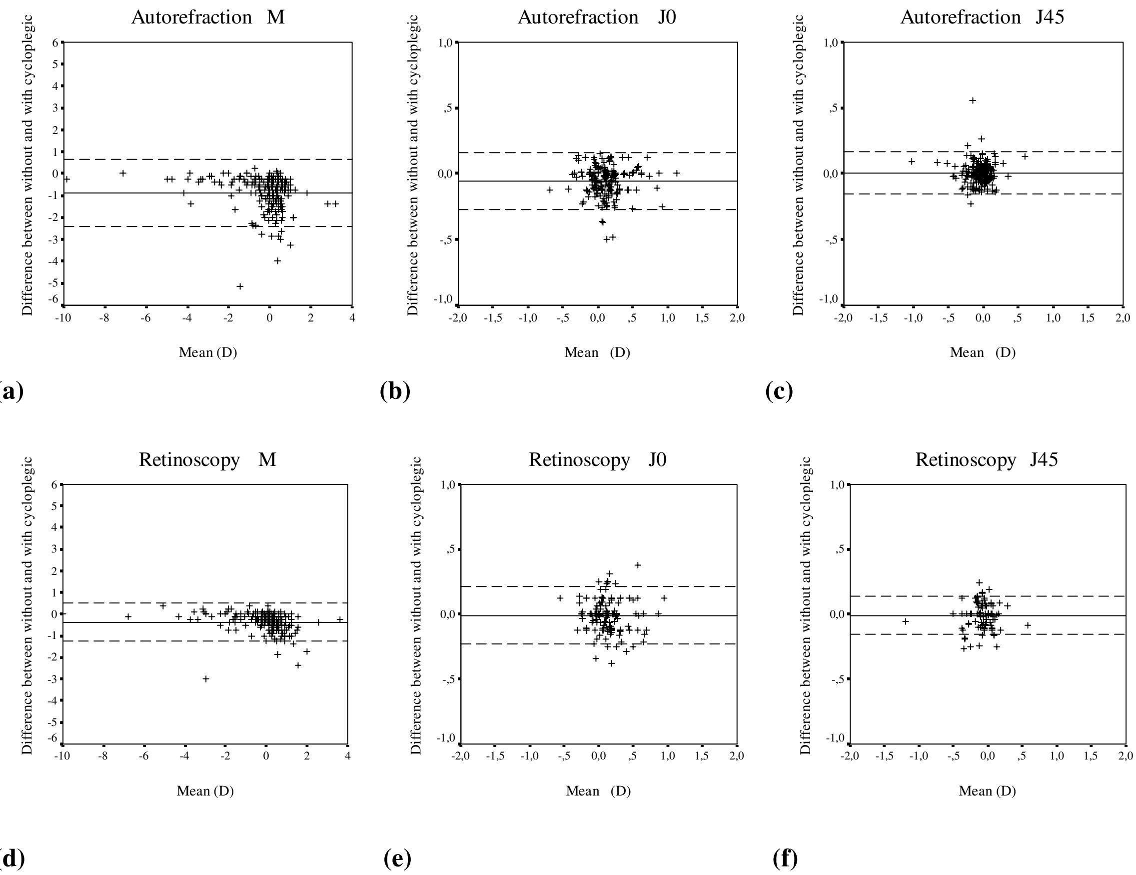
Table 1. - Descriptive statistics (mean, S.D) for M, J_0 and J_{45} components of refractive error obtained with ARK700A and retinoscopy under cycloplegic and non-cycloplegic conditions. Values are expressed in dioptres.

	AUTOREFRACTION		RETINOSCOPY	
	Non-cycloplegic	Cycloplegic	Non-cycloplegic	Cycloplegic
M	-0.73 ± 1.41	0.13 ± 1.58	-0.30 ± 1.41	0.07 ± 1.53
J_0	0.10 ± 0.24	0.15 ± 0.24	0.12 ± 0.21	0.13 ± 0.22
J_{45}	-0.04 ± 0.17	-0.05 ± 0.17	-0.04 ± 0.15	-0.03 ± 0.14

Table 2. - Mean difference, significance level and 95% limits of agreement for the components M, J_0 and J_{45} for the autorefraction and retinoscopy under cycloplegic and non-cycloplegic conditions.

				Limits of agreement	
		Mean ± SD	*p*	Mean – 1.96*SD	Mean + 1.96*SD
Autorefraction cycloplegic vs. non-cycloplegic	M	-0.86 ± 0.79	<0.0001	-2.40	0.67
	J_0	-0.05 ± 0.11	<0.0001	-0.27	0.16
	J_{45}	0.01 ± 0.08	0.233	-0.15	0.17
Retinoscopy cycloplegic vs. non-cycloplegic	M	-0.37 ± 0.45	<0.0001	-1.25	0.51
	J_0	-0.01 ± 0.11	0.234	-0.23	0.21
	J_{45}	-0.01 ± 0.07	0.112	-0.15	0.14

Figure 1. Plots of difference versus mean of refractive errors values obtained with autorefraction and retinoscopy without and with cycloplegic.



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