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Abstract
Non-cycloplegic autorefraction or retinoscopy are often performed during vision screenings and eye care missions to obtain a quick refraction for all age groups. In an attempt to compare the accuracy of autorefraction and retinoscopy, under noncycloplegic conditions, the results of five papers examining non-cycloplegic and cycloplegic autorefraction and four papers examining non-cycloplegic and cycloplegic retinoscopy are analyzed. It was found that non-cycloplegic autorefraction can underestimate hyperopia by up to 8.00 D, and non-cycloplegic retinoscopy usually underestimates hyperopia by no more than 2.00 D in children due to poorly controlled accommodative response. Autorefraction results, especially those obtained without the use of a cycloplegic, should not be used for prescriptive purposes with children. Autorefraction without cycloplegia has been shown to be reasonably accurate for determination of astigmatic power and axis in all age groups.

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THE USE OF NON-CYCLOPLEGIC AUTOREFRACTION
VS.
NON-CYCLOPLEGIC RETINOSCOPY IN CHILDREN
DURING EYECARE MISSIONS:
A LITERATURE REVIEW

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Abstract

Non-cycloplegic autorefraction or retinoscopy are often performed during vision screenings and eye care missions to obtain a quick refraction for all age groups. In an attempt to compare the accuracy of autorefraction and retinoscopy, under non-cycloplegic conditions, the results of five papers examining non-cycloplegic and cycloplegic autorefration and four papers examining non-cycloplegic and cycloplegic retinoscopy are analyzed. It was found that non-cycloplegic autorefraction can underestimate hyperopia by up to 8.00 D, and non-cycloplegic retinoscopy usually underestimates hyperopia by no more than 2.00 D in children due to poorly controlled accommodative response. Autorefraction results, especially those obtained without the use of a cycloplegic, should not be used for prescriptive purposes with children. Autorefraction without cycloplegia has been shown to be reasonably accurate for determination of astigmatic power and axis in all age groups.
Optometrists, optometry students and other volunteers perform eye care missions around the world every year. On these mission trips thorough vision screenings include assessment of binocular health, anterior and posterior segment health, and refractive error. Donated eyeglasses are collected, organized, and sent to the mission site so that they may be distributed to those in need of vision correction. Many children are seen during these missions, and not unlike pediatric vision screenings elsewhere, a primary goal is to detect any uncorrected refractive error that could lead to amblyopia. Accurate determination of the true refractive error in children is most often accomplished with the use of cycloplegic pharmaceutical agents. This prevents the child from being able to accommodate, therefore preventing gross underestimation of hyperopia. This is critical considering that hyperopia is the most prevalent refractive condition in the pediatric population, especially below age 6. Unfortunately, due to time and legal constraints, it is not possible to cycloplege children during eye care missions. Autorefraction (AR) is often chosen, over retinoscopy (RNS), to determine refractive error in a screening setting such as the eye care mission, due to its speed and minimal difficulty. However, clinical research has demonstrated limited reliability in the pediatric population for AR under non-cycloplegic conditions. This paper looks at various AR and RNS studies to determine which method is more reliable in quantifying refractive error in a non-cyclopleged pediatric population.

Five papers examining AR findings were reviewed. The studies were chosen based on the fact that subjects between the ages of 0 and 18.0 were included and that cycloplegic and non-cycloplegic data was provided. It was important that the pediatric autorefractor findings be differentiated from those of the adult subjects due to the
difference in accommodative ability between these two populations. It was also necessary to compare the results obtained with and without cycloplegia to determine what effect accommodation had on the resultant autorefractor reading.

Thirty-six preschool children enrolled in the Tohono O'Odham Early Childhood Head Start Program, aged 3.6 to 5.6 years, underwent NC-AR with the Nikon Retinomax K+ and non-cycloplegic and cycloplegic retinoscopy (NC-RNS and C-RNS). Harvey, et al. wanted to determine the reproducibility and validity of the Retinomax autorefractor when used with a population of preschoolers with a high prevalence of astigmatism. Autorefraction was compared with optimal C-RNS, and the mean difference in spherical equivalent values (AR – optimal C-RNS) was -1.15 D for NC-AR and 0.02 D for C-AR. The results indicate that although NC-AR provides reliable measurements within subjects, comparisons with optimal C-RNS findings show that the Retinomax overestimates myopia and that measurement validity varies significantly between subjects. The mean difference in refractive cylinder values was -0.21 D for NC-AR and -0.02 D for C-AR. Findings suggested that there was little bias in measurements of cylinder with NC-AR. It was concluded that the large variability in validity between subjects should be examined further to evaluate the efficacy of the Retinomax K+ in the screening of spherical refractive error in young children.

Elizabeth Evans, D.B.O. performed a study that included out-patients, ages 5.5 to 12.5, of the Orthoptic Department in Derby, UK. Three measurements of each eye (100 eyes) were taken with the R x 1 autorefractor before a cycloplegic was instilled in each eye. Retinoscopy and AR were then repeated. The equivalent sphere of C-AR was, on average, 1.15 D more plus than that of AR without cycloplegia. It was also found that the
C-AR findings were more consistent. Without cycloplegia, 26% of the AR findings showed a difference of more than 1.00 D sphere from the equivalent sphere obtained with C-RNS. With cycloplegia only 11.5% of the findings showed the same discrepancy between AR and RNS. A comparison was also made of the cylinder power and axis given by each type of refraction. The autorefractor measurements for cylinder power taken with and without cycloplegia instilled were not significantly different, and the same findings showed clinically acceptable accuracy when compared to C-RNS. The autorefractor readings for cylinder axis with and without cycloplegia were fairly consistent. When compared to C-RNS, NC-AR showed an axis difference of more than 20 degrees on 6 occasions for cylinders of more than 1.00 D, as opposed to only 2 times with C-AR readings. It was concluded that the R x 1 autorefractor gave clinically acceptable readings of cylinder power and axis whether or not cycloplegia was used.

When using the R x 1 autorefractor to measure the spherical refractive error in children the results were more consistent with cycloplegia but were still sometimes substantially different from C-RNS.

A study conducted by Silverberg, et al.\textsuperscript{9} consisted of 89 patients (178 eyes), seen at a pediatric ophthalmology clinic. The age range was 2 to 16 years. Each patient underwent C-RNS, as well as NC-AR and C-AR, with the Nidek 1600. Compared to RNS, the AR was considered accurate if within 0.50 D of sphere, 0.50 D of cylinder and 15 degrees of axis. The NC-AR findings were found to be accurate for sphere in 25 eyes (14%), cylinder in 124 eyes (69.6%), and axis in 91 eyes (51.1%). Agreement between NC-AR and C-RNS was particularly low for ages 2.0-4.5 and 5.0-8.0, with 4.1% and 9.0% respectively. Cycloplegic AR agreed with C-RNS for sphere in 100 eyes (56.2%),
cylinder in 143 eyes (80.3%), and axis in 91 eyes (51.1%). There was not a statistically significant difference between age groups when comparing C-AR sphere to C-RNS sphere results, and cylinder and axis agreement (with or without cycloplegia) was also not age dependent when comparing methods. The number of myopes and hyperopes was determined by each method. Non-cycloplegic AR, C-AR and C-RNS showed that 75.2%, 60% and 48% of the subjects were myopes, respectively. The authors found that it would be inappropriate to prescribe spherical correction for young children, especially those under age 8.0, based solely on the NC-AR results. When compared to RNS, cylinder determination appeared to be the most accurate component of AR, with increasing accuracy under cycloplegia, and AR was most effective at determining axis when cylinder power was greater than 2.00 D. Autorefraction was concluded to be a useful adjunct to retinoscopy in children.

El-Defrawy, et al.\(^2\) included 102 children, aged 5 months to 6.0 years in their study. Non-cycloplegic AR and C-AR, with the Nikon Retinomax, as well as C-RNS, was performed. Results obtained by C-AR and C-RNS for both sphere and cylinder were not significantly different in the age range examined. The results of AR without cycloplegia were extremely inaccurate and overestimated myopia by up to 8.00 D. It was concluded that the Nikon Retinomax did not show any tendency to consistently over or under-estimate the refractive error in patients who had received cycloplegic drops.

Helveston, et al.\(^5\) examined patients in the Pediatric Ophthalmology and Ocular Motility Clinic at the Indiana University School of Medicine, Department of Ophthalmology. Ninety-six individuals, aged 2.0 to 60 years, were included. A total of 185 eyes were examined, and 99 of the eyes were in children seven years old or younger.
The Nidek 3000 refractor was used for AR, and both AR and standard RNS were done before and after cycloplegic drops were used. This study only compared NC-AR to C-AR and NC-RNS to C-RNS. The data was not used to directly compare NC-AR and C-RNS. However, the results did show that the AR reliability improved significantly when accommodation was eliminated with cycloplegia. Without cycloplegia the Nidek tended to find the maximum amount of minus due to instrument-induced accommodation.

Although children over 3 years of age were suitable for AR in that minimal cooperation and no subjective response was necessary, NC-AR was found to show 8.00 D of induced myopia in some young children due to their extensive range of accommodation. Non-cycloplegic refraction in children using the Nidek 3000 refractor was therefore found to be unreliable.

A number of studies addressing the use of RNS in a pediatric population were also reviewed. Each study compares results obtained with and without cycloplegia and examines how age and the degree of refractive error effect the variation between the cycloplegic and NC-RNS findings. Comparison of these findings with those from the autorefractor studies reveals which method shows more variability without cycloplegia, autorefraction or retinoscopy.

Chan compared the RNS results of 27 Hong Kong children, aged 3.0 to 5.5 years. The subjects were divided into three groups based on their C-RNS findings. The first group had a spherical equivalent of myopia or plano, the second group had up to 2.00 D of hyperopia, and the third group had greater than 2.00 D of hyperopia. The C-RNS and NC-RNS findings for each group were compared by subtracting the spherical equivalent of the NC-RNS from the spherical equivalent of the C-RNS. The mean difference for the
first, second and third groups were 0.06 D, 0.61 D and 1.42 D, respectively. This study concluded that the difference between the C-RNS and NC-RNS is dependent on the amount of hyperopia but independent of age in the limited age range of 3.0 to 5.5.

Young, et al.\textsuperscript{10} included in their study 328 Eskimo subjects aged 6.0 to 15.0 years, as well as individuals up to age 88. Non-cycloplegic RNS and C-RNS were performed on each. Ninety-one of the eyes were myopic, 206 eyes had refractive error of plano to 3.00 D of hyperopia, and 31 eyes had hyperopia greater than 3.00 D. The mean difference between C-RNS and NC-RNS was from +0.38 D to −0.13 D for the myopic eyes, +0.67 D for the low hyperopes, and +2.06 D for the moderate to high hyperopes. From this study it was concluded that it is unlikely for the difference between C-RNS and NC-RNS to exceed +2.00 D. However, this finding applied to all age groups included in the study, which was 6.0 to 88 years. It was also found that there was an age effect in the group with high levels of hyperopia. Of the 237 hyperopic eyes aged 6.0 to 15.0, 10.9% had a difference of +2.00 D or more when comparing C-RNS and NC-RNS, as opposed to only 2.6% of the 178 hyperopic eyes aged 46 and up.

Schultz\textsuperscript{8} looked at individuals between the ages of 7.0 and 18.0 who were patients at the Department of Optometry Kaiser Foundation Hospital in Fontana, CA. Retinoscopy was performed on each individual before and after cycloplegia. The results consisted of 82 myopic eyes, 5 emmetropic eyes, 65 eyes with 0.25 D to 2.00 D of hyperopia, and 18 eyes with greater than 2.00 D of hyperopia. The mean difference found with cycloplegia was 0 D for the myopic and emmetropic eyes, +0.75 D for the low hyperopes and +2.00 D for those with more than 2.00 D of hyperopia. It was
concluded that when performing C-RNS additional plus acceptance of +0.75 D to over +2.00 D can be expected, depending on the degree of hyperopia.

Hiatt selected patients at random from both clinic and private practice populations. Retinoscopy, before and after cycloplegia, was performed on 149 hyperopic eyes of patients aged 6.0 to 10.0 years. It was concluded that from 25% to 33% more hyperopia is measured after cycloplegia, with a more pronounced difference in the younger patient. It can be assumed that if the NC-RNS result is around +0.50 D it will measure approximately +1.00 D after cycloplegia, and if an eye measures +6.00 D before cycloplegia it will measure +8.25 D after the use of a cycloplegic.

Although both methods tend to underestimate hyperopia in the pediatric population, studies have shown a much greater variance in the “accommodative effect” in NC-AR vs. NC-RNS. There are two major problems with NC-AR. The autorefractor target is designed to simulate infinity, but it is impossible for the examiner to know if the child has truly relaxed her accommodative system. Also, when looking into the autorefractor accommodation is induced due to nearness of the instrument to the patient’s eyes. It is possible for hyperopia to be underestimated by up to 8.00 D due to this induced accommodation. There are two significant differences between NC-AR and NC-RNS. During retinoscopy the examiner is able to detect if the patient is accommodating by observing change in the retinoscopic reflex and pupil size. Also, accommodation induced by the proximal effect can be eliminated by using a target at distance and by performing retinoscopy with appropriate fogging lenses. Hyperopia is much less likely to be underestimated with NC-RNS due to the examiner’s ability to control the patient’s accommodation. The studies that compared cycloplegic and NC-RNS found that the
most additional plus expected to be found with C-RNS is around 2.00 D. There is a trend for the discrepancy of the NC-RNS and C-RNS to increase with decreasing age and increasing degree of hyperopia. The AR data reports that myopia may be overestimated, but the studies do not address the effects of age and amount of hyperopia on the resultant refractive error estimation. This is a possible topic of research for a future study.

The standard of care for obtaining an accurate refraction in almost all children is to do so while they are cyclopleged. Unfortunately, due to time and legal constraints, it is not always possible to cycloplege children during eye care missions. The autorefractor is commonly used during eye care missions, but it is imperative that its limitations with children are understood so that inaccurate spectacle prescriptions are not given. The importance of an accurate prescription cannot be underestimated since the mission team may be the only access the people of that area have to vision care.

The autorefractor is very useful for measuring the refractive error of adult patients. It is quite accurate in predicting the cylinder power and axis and therefore may speed up retinoscopy in individuals with high astigmatism. The autorefractor is able to report a high refractive error in the same amount of time as a low one, while a retinoscopist most often gradually works toward neutralizing a high refractive error. Autorefraction provides a starting point for the cylinder correction, and the retinoscopist can refine it from there. Although the autorefractor is fast and easy to operate, these attributes are meaningless without reliability, and NC-RNS clearly has a greater predictive value of the absolute refractive error in children. Retinoscopy, performed by an experienced retinoscopist, should be the method of choice for the refraction of young
children, especially in non-cycloplegic conditions such as eye care missions, and AR should be used only as an adjunct to the RNS.
References


