A comparison of non-cyclopegic and cyclopegic autorefraction of African children aged 5-15 years in Kwazulu-Natal

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Abstract

Anecdotal evidence has revealed much debate about the use of cycloplegia when screening children. The issue of precision versus practicality remains an unresolved debate. In the developing world, with huge disparities in eye care resources and services, there is a need to address this issue so as to ensure that access is not compromised in the search for precision and vice versa. This study therefore compared autorefraction measurements with and without cycloplegia.

Methods: One hundred and fifty children of 5 to 15 years of age were randomly selected from a study population of 4890. Autorefraction was conducted on the sample using the hand-held Nikon Retinomax autorefractor and these readings are referred to as the *dry* autorefraction readings. Thereafter, readings were repeated once cycloplegia was reached following the instillation of cyclopentolate and these are referred to as the *wet* autorefraction readings. Of the 150 children, only 118 eyes met the full cycloplegic criteria, that is, pupil diameter greater than 6 mm and absent light reflex.

Results: Data analysis revealed a clinically significant difference of 0.97 D between the mean nearest equivalent sphere of the dry and wet readings with the majority of wet readings tending towards more positive values. This difference was statistically significant to the 99% confidence interval ($p = 0.00$).

Conclusions: Autorefraction with cycloplegia is the more reliable methodology of detecting refractive error in screening or pre-exam application. The difference is significant enough to warrant the use of cycloplegics in children, given the minimal side-effects and despite the extra time and effort.

Keywords: Cycloplegia, refractive error in children, autorefraction.

Introduction

The introduction of automated refraction has created a new dynamic in the vision care industry. It is fast becoming a preferred method of both preliminary testing and screening in various eye care settings. The growing use of autorefraction has stemmed from the numerous studies conducted on its reliability and accuracy[1-3]. In many cases, even though autorefraction is not selected as the only refractive technique in the patient examination, it is a useful adjunct. In the management of large numbers of patients, it is essential to employ methods of examination that are more objective and less time consuming, thus making autorefraction one of the principal tests used in vision screening.

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The goal of vision screening is to detect poor vision or risk factors that disrupt normal vision and its development. Studies[4, 5] have shown that uncorrected refractive error in early childhood can lead to amblyopia. Vision screening is therefore vital since the early detection of visual anomalies allows timely intervention that promotes better visual outcomes. In addition to vision screening, autorefraction is also favoured in the management of patients where objective tests are preferred, for example, in infants and young preverbal children, as well as, older patients who are nonverbal or patients who have developmental delays. A recent refractive error study[6] of children in Durban, South Africa showed that the younger cohorts of children represent a challenging group for examination with respect to cooperation and reliability. It is thus essential that more objective means of refraction be used to determine refractive status in the paediatric population[7]. Studies using objective testing[8-11] have been very successful in addressing some of the issues of the younger paediatric population.

Literature Review

Accommodation is the facility by which the eye is able to change its refractive power to focus on near objects[12]. Even though research[13] has shown that conventional methods of relaxing accommodation are not as effective, various methods are employed clinically to ensure that accommodation remains at rest[14]. The amount of accommodation that a patient is able to exert is dependent on the amplitude of accommodation, which is greatest in younger patients[15]. Young patients generally have sufficient accommodative reserves to maintain clear vision without asthenopic symptoms, however, symptoms may develop under conditions of visual stress[16]. The 'true' refractive error in these children can often only be determined if accommodation is fully relaxed[16]. Considering that the role of cycloplegic agents is to paralyze the accommodative mechanism, it is not surprising that cycloplegic refraction is fast becoming essential in the evaluation of paediatric patients[17] and is now recognized as a time-tested and reliable method of refractive error measurement[18].

A cycloplegic refraction is one that employs the use of parasympatholytic drugs to paralyze the accommodative system. Cycloplegic agents are parasympatholytic drugs that are competitive antagonists of acetylcholine, which is the neurotransmitter that mediates the accommodative response. There is no reduction in the liberation of acetylcholine in the action of parasympatholytic drugs but rather the tissues are rendered insensitive to the action of acetylcholine[19]. The subsequent relaxation of the ciliary muscle and increase in the suspensory ligament tension of the lens results in the lens becoming less convex and consequently accommodation is relaxed. One of the contraindications of conducting dry refractions (a refraction without the use of cycloplegic drugs) is the possible inaccuracy of refractive error data due to accommodation for example as often is the case of latent hyperopia.

Cycloplegic refraction is critical in the diagnosis of various refractive and visual problems like latent hyperopia, accommodative esotropia or high esophoria and pseudomyopia[18]. It is also essential in the examination of patients with high amplitudes of accommodation who are not reliable in subjective tests and, in the management of non-communicative patients.

Cordonier and Dramaix[20, 21] have conducted numerous studies on the accuracy and reliability of autorefraction. Subsequent to these, they have suggested that refractive screening should be sensitive and specific enough to detect refractive error problems and preferably without cycloplegia[20, 21]. Despite the assertion by Cordonier and Dramaix[20] that cycloplegia is invasive and time and energy consuming and should therefore not be employed in screening procedures, it may provide better accuracy and its value therefore lies in its ability to cut out over and under-referrals which also tend to be time and energy consuming. The longstanding paucity of public sector eye care services has left a large backlog in provision of refractive services. To minimize delays in patient management, it is important that the health system is not overcrowded with children incorrectly identified as having eye defects. Thus, the public sector, children and their families are spared the unnecessary costs and long waiting periods for examination and treatment. The implications are that more reliable and effective forms of screening devices and methods need to be employed to elicit the true refractive status of the patient. The role of the autorefractor thus becomes vital in ensuring that this process of patient care is maintained by providing an appropriate, accurate and effective tool for mass screening.

The aim of the study was to compare the refractive error results of autorefraction under cycloplegic and non-cycloplegic conditions in an African population of school children.

Materials and method

Subjects and methods

The experiment in South Africa was conducted as part of a multi-country survey to determine the prevalence of refractive error in children between 5 to 15 years of age in South Africa. This refractive error study was conducted in various parts of the Durban metropolitan area of Kwazulu Natal, encompassing regions of both developed and underdeveloped urban areas and semi-rural to rural areas. The random sample of 150 children were selected from the total multi-country sample of 4890 children. Parental consent was obtained in writing prior to patient examination.

The clinical examination of the study comprised a battery of tests which included unaided and aided (if applicable) visual acuity measurements using the LogMAR chart, binocular assessment using the cover test, anterior segment evaluation using the Nikon slit-lamp, cycloplegic drop instillation, cycloplegic retinoscopy, cycloplegic autorefraction using the handheld Nikon Retinomax autorefractor, cycloplegic subjective refraction (where applicable) and finally media and fundus examinations were performed by an ophthalmologist using a 90-Dioptre lens and binocular indirect ophthalmoscope. Pre-study training sessions were conducted by practitioners prior to a pilot study which was followed by the actual study. These processes ensured that all practitioners were competent in performing their required tasks and that each clinician was familiar with their data gathering tools. With respect to autorefraction, clinicians were cautioned about the effects of too much head movement by the patient and how it affected the results. Clinicians were also informed about the accuracy levels of readings. Inaccuracy was indicated by a "reliability" value less than or equal to 7 on the autorefraction printout. If unreliable readings were obtained, the procedure was repeated until a more reliable indicator was found. If this was not achieved, then the subject was removed from the autorefraction sample for analysis. The instrument was set to take eight readings which it then converted to an average reading.

The non-cycloplegic autorefraction was conducted prior to anterior segment evaluation. A slit lamp was used to evaluate the anterior segment and ensure that the eye was safe for dilation before beginning with the cycloplegic drug regimen. The regimen consisted of one drop of anesthetic (Novesin®) to minimize the stinging sensation of the cycloplegic agent. A secondary effect of the anesthetic drop was to soften the corneal epithelium thereby enhancing cyclopentolate absorption and potentiating its effects[22]. The anesthetic instillation was followed approximately one minute later by the cycloplegic regimen which consisted of a one drop of 1% cyclopentolate followed by a second drop five minutes later and finally a third drop fifteen minutes later.

The Nikon Retinomax autorefractor is described as a monocular refractor which uses a fogging technique[23]. Studies [2, 3, 6] have shown that it is a reliable instrument when compared with other autorefractors and retinoscopy. It is also a convenient tool when conducting early screening of infants and preschoolers. While some authors in one study[24] found that the instrument was especially useful in refractive error screening under non-cycloplegic conditions, researchers in another study[25] did not agree and suggested that the instrument myopia frequently seen in young children is responsible for inaccuracies. The measurement range lies within –18 and 22 diopters (D) sphere and – 8D cylinder. The minimum required pupil diameter is 2.7 mm. Unlike retinoscopy where the reflex is neutralized, in the autorefractor, the speed of the reflex is determined in each meridian as the instrument rapidly sweeps through 360 degrees[26]. The operator of the autorefractor is able to visualize the eye being measured on a screen with the aid of the infrared light sensitive camera. Instrument alignment is aided by reflected light from the child's cornea while the child is viewing the target within the autorefractor. The target of 2 cm in width comprises a Christmas tree on a green grass and blue sky background. This target is located 6 cm away from the subject's eye. Research[27] has shown that when a patient's fixation is not directed at the tree directly but is directed on either side of it, a 10 degree disparity between fixation axis and axis of autorefraction is induced. This induces astigmatism of 0.75 D to 1.50 D in children. In this study, fixation was ensured through observation of eye position and constant coaxing of the patient to maintain fixation on the target.

Cycloplegic refraction was conducted within an hour of the drop instillation. This time delay was adopted due to the delay in onset of dilation among the study population[8-11]. Although other sample populations in the various multi-country surveys were assessed much sooner after cycloplegic instillation it was observed that cycloplegia occurred much later than expected in the South African sample. This was attributed to the greater amount of pigment in the iris of the African eye. Indicators of cycloplegic effect were pupil dilation of greater than or equal to 6 mm and the absence of a light reflex.

Results

Autorefraction measurements were obtained for both eyes from 150 subjects, however, numerous readings were excluded due to non-compliance of children during drop instillation and an incomplete cycloplegic response. Data was analyzed per eye as autorefraction was obtained for each eye individually. From the 150 subjects, three children, that is, 1% of eyes, were uncooperative (See Figure 1) and autorefraction readings were not obtained resulting in an undetermined response to cycloplegia. The response to the cycloplegic drug was noted in the remaining 294 eyes (Figure 1), of which, 13% of eyes showed a light reflex and dilation less than 6 mm, 45% of eyes had a dilation of greater than or equal to 6 mm but a light reflex present, approximately 1% of eyes had a dilation of less than 6 mm but no light reflex and 39% of eyes presented with a dilation of greater than or equal to 6 mm and an absent light reflex. Analysis was therefore only conducted on the 118 eyes that satisfied the full cycloplegic criteria. Results were converted to nearest equivalent sphere (NES) before being analyzed further.

Thirteen percent of the sample exhibited no cycloplegic response, 39% exhibited a full cycloplegic response, 1% exhibited an absent light reflex, but incomplete dilation, 45% exhibited a full dilation, but present light reflex, and 2% had an undetermined cycloplegic response due to non-cooperation or ocular disease.

The difference between the NES under cycloplegic and non-cycloplegic conditions was investigated statistically using a Student's *t*-test. This test revealed a p-value of 0.00065×10^{-28} which indicated that autorefraction readings varied significantly from non-cycloplegic to cycloplegic conditions. In addition, a clinically significant difference of 0.97 D was observed in the mean data under non-cycloplegic and cycloplegic conditions, with the majority of the findings tending toward more positive values after cycloplegia.

Discussion

This study attempted to compare the difference (if any) in autorefraction findings when conducted under cycloplegic conditions versus non-cycloplegic conditions. The 0.97 D mean

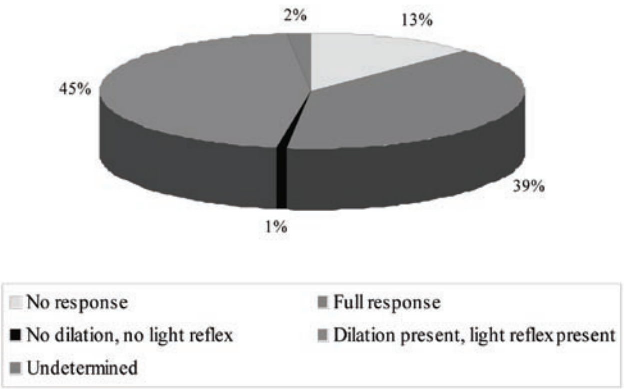

Figure 1: Distribution of cycloplegic response in sample

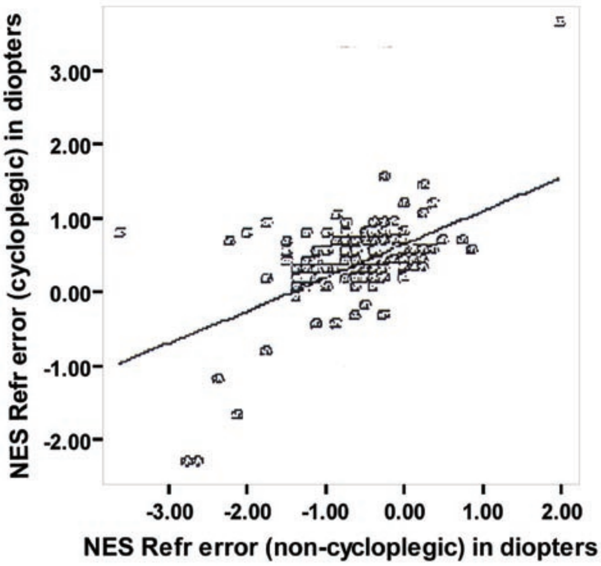

Figure 2: Comparison of nearest equivalent sphere of the refractive error in children when measured under non-cycloplegic and cycloplegic conditions.

spherical difference in refractive error could be attributed to the tonus of accommodation, that is, the resting tonus of the ciliary muscle[15]. This value is the factor that is usually adjusted in a prescription since the resting tonus of accommodation is resumed after the cycloplegic effect has worn off[15].

The marked percentage of myopes found under non-cycloplegic conditions questions the reliability of autorefraction under these conditions for screening purposes. Even though the target is set for infinity the accommodative system does not remain at rest as was previously assumed by the researchers. It is possible that the nearness of the instrument target induces the proximal accommodative response and instrument myopia. This finding thus questions the reliability of the use of autorefraction under non-cycloplegic conditions, especially in mass screening for children between 5 and 15 years of age.

Given the time consuming process of cycloplegic screening procedures and potential side-effects or risk of systemic reactions, one needs to consider what aspects of screening are essential and thereafter choose the procedure that would most accurately and reliably produce those results. One also needs to take cognizance of the target population that is being examined in order to determine the most appropriate procedures.

Conclusion and recommendations

Non-cycloplegic autorefraction has a limited role in vision screening in the paediatric population in keeping with various researchers[3, 28] who have conducted studies and have shown that autorefraction is more accurate under cycloplegic conditions as opposed to non-cycloplegic conditions.

Based on the findings of our study, it would seem inappropriate to prescribe a correction for children based upon non-cycloplegic autorefraction findings. Furthermore when taking readings, it was observed that the first few readings varied significantly from the rest. It would therefore seem that taking more than eight autorefraction values would be advisable. There is probably some stabilization of accommodation occurring after the initial readings. However, in order to confirm this, further studies are needed.

Furthermore, studies should be conducted on a broader target population in order to critically compare the reliability of autorefraction under cycloplegic and non-cycloplegic conditions and in comparison with other screening methods, for example, retinoscopy.

One should remember that even though non-cycloplegic screening offers increased patient compliance, participation, is more rapid and avoids the side effects of cycloplegia, the use of this type of examination as a method of screening remains controversial.

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