Accuracy of Noncycloplegic Refraction in Primary School Children in Southern Thailand

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Objective: *To evaluate the accuracy of noncycloplegic refraction compared with cycloplegic refraction in diagnosing refractive error in primary school children in southern Thailand.*
Material and Method: *This is a cross-sectional study. One hundred twenty children aged from 6-13 years who had visual acuity of 20/40 or worse in at least one eye were included. All the children underwent autorefraction using a Nikon model NRK-8000, retinoscopy and subjective refraction without cycloplegia followed by cycloplegic refraction. The spherical power (SP), cylindrical power (CP), cylindrical axis (CA), and spherical equivalence (SE) from each noncycloplegic technique were compared to cycloplegic refraction using the mean difference. The authors also showed the percentage agreement between the data obtained from the three noncycloplegic techniques with those from cycloplegic refraction.*
Results: *The SE mean difference of noncycloplegic autorefraction, retinoscopy and subjective refraction with cycloplegic refraction were -0.85, -0.19, and -0.26, respectively ($p < 0.0001$). The data for the SP was similar. The cylindrical power mean differences were -0.18, -0.13, and -0.02, respectively. The percentage agreements of SE between noncycloplegic autorefraction, retinoscopy, and subjective refraction with cycloplegic refraction within $\pm$ 0.5 diopter (D) were 31.25%, 80.84%, and 81.66%, respectively. For the cylindrical power, the percentages of patients who were within $\pm$ 0.5 D were 87.50%, 94.58%, and 97.50%. The percentages of patients who were within 10 degrees of the cylindrical axis were 73.46%, 96.91%, and 97.53%.*
Conclusion: *Noncycloplegic retinoscopy and subjective refraction are clinically accurate and can be applied for refractive error screening in primary school children. Noncycloplegic autorefraction has a tendency towards minus over-correction.*

Keywords: *Child, Refraction, Ocular, Refractive errors, Refractometry, Retinoscopy, Vision screening*

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Refractive error is a common worldwide preventable cause of visual disability and amblyopia in children[1,2]. Cycloplegic refraction is the gold standard measurement used in children because of its capacity to avoid accommodation that produce minus over-correction. This technique has, however, time consuming limitations, additional costs, patient discomfort, inconvenience, and needs to be performed by an optometrist[3,4]. More recently, noncycloplegic refraction techniques such as autorefraction, retinoscopy, or subjective refraction have become widely used because they are easier to operate, relatively fast, and more comfortable for the patients[5]. Due to their benefits, noncycloplegic refraction especially autorefraction has become popular in vision screening, clinical practice, and research settings[6-8].

The errors in measurement found from accommodation in noncycloplegic refraction although controversial are acceptable. Most autorefractors have a built-in automatic fogging mechanism to avoid accommodation and are suggested for use in visual screening programs in children due to their accuracy, which is comparable to cycloplegic refraction[7,9-17]. Conversely, there is evidence that the accommodative effort may not be completely neutralized and that reduced accuracy results tend towards either a minus

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over-correction or plus under-correction[6,7,9,10,13,15,18,19]. Additionally, there is evidence linking minus over-corrected glasses with accommodation resulting in myopic progression[20-22]. Prescription in glasses, according to noncycloplegic refractive measurement, is controversial.

The aim of the present study was to evaluate the accuracy of noncycloplegic refraction including autofraction, retinoscopy, and subjective refraction by comparing them to cycloplegic refraction when diagnosing refractive error in primary school children.

Material and Method

This is a cross-sectional study designed to determine the accuracy of three noncycloplegic refractive measurements compared with cycloplegic refraction.

Study population

All 120 children with complete ophthalmic examination were included in the present study. The present study is based on the data of "Visual Acuity and Visual Behaviors among Primary School Children in Nakhon Hatyai Municipality, Songkla Province[23]", enrolled 1,900 children in April 2007. One hundred sixty eight children ranging from 6-13 years had a visual acuity of 20/40 or worse in at least one eye. Informed consent was obtained from 120 parents to allow their children to have a further eye examination in the eye clinic at Songklanagarind Hospital. The study protocol was approved by the Ethics Committee if Faculty of Medicine, Prince of Songkla University.

Ophthalmic examination

All the children underwent a complete ophthalmic examination by three experienced optometrists and one ophthalmologist. The examination included, in the following order, visual acuity (VA) with an ETDRS chart, orthoptics, noncycloplegic autorefraction, noncycloplegic retinoscopy, noncycloplegic subjective refraction, cycloplegic refraction, slit lamp biomicroscopy, and fundoscopy.

Noncycloplegic refraction was initially performed with autorefraction using a Nikon (NRK-8000), which has a built-in fogging mechanism. Each eye was measured five times with the result reported as a mean value. All the results had more than a 90% confidence level. Next, all the children underwent retinoscopy and subjective refraction without a blind.

Cycloplegia was then induced by two drops of 1% cyclopentolate administered to each eye five minutes apart. After 30 minutes, cycloplegic refraction was performed.

Children whose vision improved with refraction were prescribed spectacles. Children who had other eye problems were treated or underwent further investigation.

Data collection

The main outcome measures of the study were spherical power (SP), cylindrical power (CP), cylindrical axis (CA), and spherical equivalence (SE), which were calculated from the formula: spherical equivalence = sphere + (cylinder/2) from each eye using different measurement techniques. Data collection also included the children's demographic data, visual acuity in logarithm of the minimal angle of resolution (logMAR) unit prior to treatment, best-corrected VA, and the prescription of their glasses.

Statistical analysis

Refractive measurements from the three noncycloplegic techniques were compared with cycloplegic refraction. As the refractive errors in the two eyes were related, only data from the right eye was analyzed using the mean difference, standard deviation, and paired t-test. For clinical practice, the authors also showed the percentage agreement between the data obtained from the three noncycloplegic techniques of both eyes with those from cycloplegic refraction. A measurement technique was determined as accurate when at least 80% of the data was within 0.5 diopter (D) of refractive power and within 10 degrees of the cylindrical axis over the real value obtained for cycloplegic refraction.

Results

Complete data were collected for 120 children from 6 to 13 years old with a mean age of 8.7 ± 1.8 years. The demographic data of all subjects are demonstrated in Table 1.

There was a significant difference between each noncycloplegic techniques and cycloplegic refraction across all the parameters, with the exception of the axis that cannot be calculated by the mean difference, as shown in Table 2. For the SE and SP values, there was a tendency towards either a minus over-correction or plus under-correction in all techniques with autorefraction having the greatest tendency. The data for cylindrical power showed less difference but was also nonetheless significant.

Table 1. Demographic data of the study population

Demographic data	n	Percent (%)	Mean	SD	Range
Gender					
Male	64	53.33			
Female	56	46.67			
Age	120		8.69	1.80	6, 13
Associated disease					
No	102	85.00			
Yes	18	15.00			
Amblyopia	7	5.83			
Exotropia	7	5.83			
Glaucoma	2	1.67			
Other	2	1.67			
Refractive SE (cycloplegia)	120		-0.92	1.85	-7.62, +7.25
Type of refractive error (SE)					
Myopia (≥ -0.5 D)	70	58.33			-0.50, -7.62
Hyperopia (≥ +2.00 D)	2	2.50			+2.37, +7.25
Astigmatism (≥ -0.5 D)	80	66.67			-0.50, -4.25
Previous glasses wearing					
No	102	85.00			
Yes	18	15.00			
Glasses prescription					
No	40	33.33			
Yes	80	66.67			
Visual acuity (VA) (logMAR unit)					
Pre-test VA RE			0.44	0.23	0, 1.1
Pre-test VA LE			0.42	0.21	0, 0.9
Best-corrected VA RE			0.09	0.14	0, 0.9
Best-corrected VA LE			0.07	0.10	0, 0.7

Table 2. Mean difference (MD), SD, and p-value between the data obtained for the three different noncycloplegic techniques with the cycloplegic refractionp

Refractive data of right eyes	MD	SD	p-value
Spherical equivalence (SE)			
Autorefraction	-0.85	0.66	<0.0001
Retinoscopy	-0.19	0.39	<0.0001
Subjective Refraction	-0.26	0.55	<0.0001
Spherical power (SP)			
Autorefraction	-0.76	0.67	<0.0001
Retinoscopy	-0.13	0.38	0.0004
Subjective Refraction	-0.25	0.54	<0.0001
Cylindrical power (CP)			
Autorefraction	-0.18	0.34	<0.0001
Retinoscopy	-0.13	0.22	<0.0001
Subjective Refraction	-0.02	0.23	0.2964

The percentage agreement of the SE data between noncycloplegic retinoscopy and the subjective refraction with cycloplegic refraction were clinically acceptable, within 0.5 D of 80.84% and 81.66%, respectively. Conversely, the results from autorefraction were extremely inaccurate (31.25%), as shown in Fig. 1. The data of the SP was as similar to that obtained with the SE data. Agreement between autorefraction, retinoscopy, and subjective refraction with cycloplegic refraction within 0.5 D were 41.66%, 85.83%, and 82.92%, respectively (Fig. 2).

All noncycloplegic techniques had a clinically acceptable agreement in CP data. As shown in Fig. 3, the agreement of three noncycloplegic techniques within 0.5 D was 87.50%, 94.58%, and 97.50%, respectively. Fig. 4 demonstrates the percentage agreement between the cylindrical axis data obtained from different noncycloplegic techniques with cycloplegic refraction. Only eyes that had a cylindrical power on cycloplegic refraction were analyzed (67.5%). Agreement between noncycloplegic retinoscopy and subjective refraction with cycloplegic refraction were clinically acceptable, within 10 degrees of 96.91% and 97.53%, respectively. The result from autorefraction was quite accurate but did not reach clinical acceptance (73.46%).

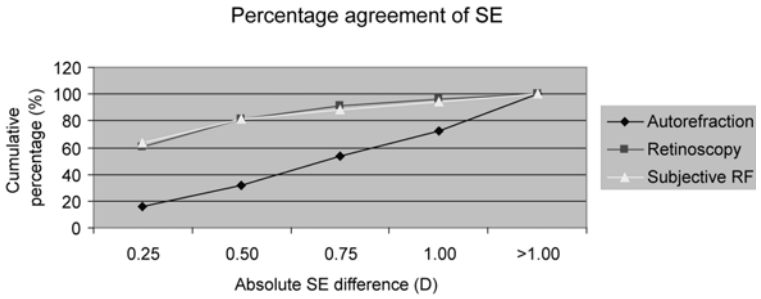

Fig. 1 Percentage agreement of spherical equivalence (SE) between the data obtained for the three noncycloplegic techniques with the cycloplegic refraction

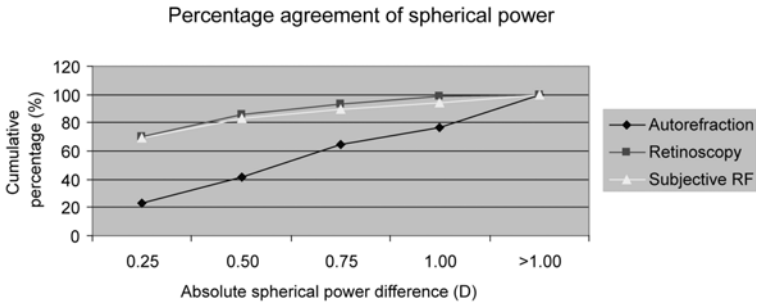

Fig. 2 Percentage agreement of spherical power (SP) between the data obtained for the three noncycloplegic techniques with the cycloplegic refraction

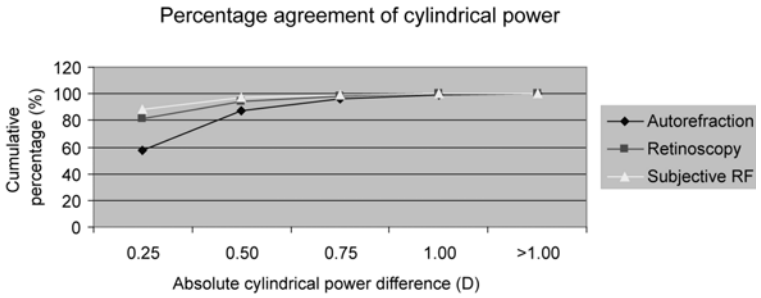

Fig. 3 Percentage agreement of cylindrical power (CP) between the data obtained for the three noncycloplegic techniques with the cycloplegic refraction

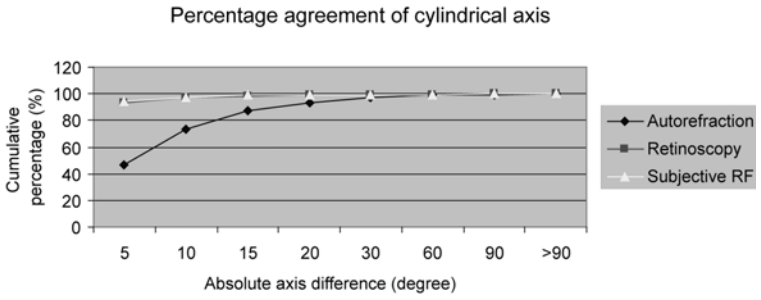

Fig. 4 Percentage agreement of the cylindrical axis (CA) between the data obtained for the three noncycloplegic techniques with the cycloplegic refraction

Discussion

According to the mean difference, there was a significant difference between each noncycloplegic techniques and cycloplegic refraction across all the parameters, with the exception of the axis that cannot be calculated. However, in clinical practice, the percentage agreement might be more useful in evaluating the accuracy of each technique.

Noncycloplegic retinoscopy and subjective refraction are clinically accurate across all parameters and were able be applied to refractive error screening in primary school children aged range from 6 to 13 years old. Noncycloplegic autorefraction is inaccurate, with a tendency towards minus over-correction or plus under-correction, especially in the spherical component.

As in the presented report, several other reports have shown that the noncycloplegic retinoscopy and subjective refraction were accurate when compared to cycloplegic refraction[3,19]. The authors suggest these techniques are suitable for vision screening, clinical practice, and prescribing spectacles or in research settings with children aged range from 6 to 13 years old. However, experienced optometrists are needed with these techniques and they may be unsuitable for large populations.

Other reports indicated the favorable repeatability of autorefraction[15], and suggested this noncycloplegic technique for use with vision screening in children, clinical practice or in the research setting[6-8]. There is also evidence from clinical trials suggesting its accuracy is comparable to cycloplegic refraction in the Western population[7,9-17]. Conversely, in the presented study, the authors found that non-cycloplegic autorefraction was found to be inaccurate and had a tendency towards minus overcorrection especially in the spherical component, which was comparable to many other clinical trials, especially those in Asian populations and more prominent in myopic children[3,6,10,18,19]. Controversy may be the result from a higher incidence of myopia in Asian children, age group, and the type of autorefractors.

One possible source of inaccuracy is the built-in automatic fogging mechanisms found in most autorefractors, which may not completely neutralize the accommodative effort, resulting in a minus over-correction. Several studies have suggested that residual proximal accommodation and human higher-order aberration are responsible for this error[3,19]. Other reports have presented that autorefractors with a binocular open field-of-view mechanism such as the Grand Seiko WR5100K are more accurate due to completely neutralized accommodation[3].

Noncycloplegic autorefraction may be useful as a guide for retinoscopy or subjective refraction, with the aim to shortening examination time. According to the data, 75% of eyes were within 1.00 D of spherical power, and the accuracy of the cylindrical component was quite good. Noncycloplegic autorefraction can also be used for detecting high levels of hyperopia in children. There is evidence suggesting that the real hyperopic refractive value is more than the measured value about 2 D[24], but the authors did not evaluate this in detail.

There were two main limitations to the present study. First, this was a retrospective study with unmasked methodology. Second, there were three optometrists attached to the present study. These limitations may have resulted in the possibility of bias. Additionally, a reliability study using intra-observer and inter-observer measurement was not performed. Unfortunately, the difficulty was encountered in performing repeated measurements among children whose cooperation deteriorated with time.

Recent studies have proposed a high accuracy with cycloplegic autorefraction[3,6]. This technique is less time consuming, and can be performed easily. This controversial finding needs further investigation. A well-designed cross-sectional study with a masking technique is needed, with a high benefit from using small children whose visual development will continue.

In conclusion, noncycloplegic retinoscopy and subjective refraction are clinically accurate and can be applied for refractive error screening in primary school children. Noncycloplegic autorefraction has a tendency towards minus over-correction.

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ความแม่นยำของการวัดแว่นเมื่อไม่ขยายม่านตาในเด็กชั้นประถมศึกษาในภาคใต้ของประเทศไทย

พรรณรพี ฟูนฤนารถ, สุภาภรณ์ เต็งไตรสรณ์, ภาสุรี แสงศุภวานิช, ปริญดา เสียงใหญ่

วัตถุประสงค์: *เพื่อประเมินความแม่นยำของการวัดแว่นเมื่อไม่ขยายม่านตาเทียบกับการหักเหเมื่อขยายม่านตาในการวินิจฉัยภาวะสายตาหักเหผิดปกติในเด็กชั้นประถมศึกษาในภาคใต้ของประเทศไทย*

วัสดุและวิธีการ: *การศึกษาแบบตัดขวางในเด็กนักเรียนระดับประถมศึกษาอายุ 6-13 ปี จำนวน 120 คน ที่ความสามารถในการมองเห็นของตาอย่างน้อยหนึ่งข้างเท่ากับ 20/40 หรือแย่กว่า ด้วยเครื่องตรวจวัดแว่นอัตโนมัติยี่ห้อ Nikon รุ่น NRK-8000 การส่องกล้องตรวจแสงสะท้อนจากจอตา การประเมินเปรียบเทียบโดยผู้ป่วยเมื่อไม่ขยายม่านตา ตามด้วยการตรวจเมื่อขยายม่านตา เปรียบเทียบค่า spherical power (SP), cylindrical power (CP), cylindrical axis (CA) และ spherical equivalence (SE) จากแต่ละวิธีการตรวจเมื่อไม่ขยายม่านตากับการตรวจเมื่อขยายม่านตาด้วยค่าเฉลี่ยผลต่าง และร้อยละความเห็นพ้อง*

ผลการศึกษา: *การตรวจเมื่อไม่ขยายม่านตาด้วยเครื่องตรวจการหักเหอัตโนมัติ การส่องกล้องตรวจแสงสะท้อนจากจอตาและการประเมินเปรียบเทียบโดยผู้ป่วย ค่าเฉลี่ยความต่างของ SE กับการตรวจเมื่อขยายม่านตาเท่ากับ -0.85, -0.19 และ -0.26 ตามลำดับ ($p < 0.0001$) ข้อมูลของ SP คล้ายคลึงกัน ส่วนค่าเฉลี่ยความต่างของ CP เท่ากับ -0.18, -0.13 และ -0.02 ตามลำดับ ร้อยละความเห็นพ้องของ SE ระหว่างการตรวจเมื่อไม่ขยายม่านตาด้วยเครื่องหักเหอัตโนมัติ การส่องกล้องตรวจแสงสะท้อนจากจอตาและการประเมินเปรียบเทียบโดยผู้ป่วยกับการตรวจเมื่อขยายม่านตาภายใน $\pm$ 0.5 ไดออปเตอร์ เท่ากับร้อยละ 31.25, 80.84 และ 81.66 ตามลำดับ ส่วนร้อยละความเห็นพ้องของ CP ภายใน $\pm$ 0.5 ไดออปเตอร์เท่ากับร้อยละ 87.50, 94.58 และ 97.50 สำหรับค่า CA ภายใน 10 องศา เท่ากับร้อยละ 73.46, 96.91 และ 97.53*

สรุป: *การส่องกล้องตรวจแสงสะท้อนจากจอตาและการประเมินเปรียบเทียบโดยผู้ป่วยเมื่อไม่ขยายม่านตามีความแม่นยำและสามารถประยุกต์เป็นการตรวจคัดกรองสายตาผิดปกติในเด็กชั้นประถมศึกษา ส่วนการวัดด้วยเครื่องตรวจอัตโนมัติเมื่อไม่ขยายม่านตามีแนวโน้มให้ค่าไปในทางลบของค่าที่ถูกต้อง*