Original Article

Accuracy of noncycloplegic refraction performed at school screening camps

Rolli Khurana, Shailja Tibrewal, Suma Ganesh, Rajoo Tarkar[1], Phuong Thi Thanh Nguyen[2], Zeeshan Siddiqui[3], Shantanu Dasgupta[3]

Purpose: The aim of this study was to compare noncycloplegic refraction performed in school camp with that performed in eye clinic in children aged 6–16 years. **Methods:** A prospective study of children with unaided vision <0.2 LogMAR who underwent noncycloplegic retinoscopy (NCR) and subjective refraction (SR) in camp and subsequently in eye clinic between February and March 2017 was performed. A masked optometrist performed refractions in both settings. The agreement between refraction values obtained at both settings was compared using the Bland–Altman analysis. **Results:** A total of 217 eyes were included in this study. Between the school camp and eye clinic, the mean absolute error ± standard deviation in spherical equivalent (SE) of NCR was 0.33 ± 0.4D and that of SR was 0.26 ± 0.5D. The limits of agreement for NCR were +0.91D to − 1.09D and for SR was +1.15D to -1.06D. The mean absolute error in SE was ≤0.5D in 92.62% eyes (95% confidence interval 88%–95%). **Conclusion:** A certain degree of variability exists between noncycloplegic refraction done in school camps and eye clinic. It was found to be accurate within 0.5D of SE in 92.62% eyes for refractive errors up to 4.5D of myopia, 3D of cylinder, and 1.5D of hyperopia.

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Uncorrected refractive error is a major cause of visual impairment in school going children.[1-3] Worldwide 12.8 million children are visually impaired due to uncorrected refractive errors.[2] Population-based studies from India show that it accounts for 81.7% of visual impairment in urban and 61% rural children aged 5–15 years.[1,4] School-based screening studies have reported the prevalence of refractive error to range from 2.63% to 7.46%.[5-8] School screening programs have been found to be effective in identifying children with uncorrected refractive errors.[9,10] The most common and cost-effective model is wherein the school teacher or field worker identifies children with poor vision and refers them to ophthalmic assistants and/or ophthalmologists for final refraction and dispensing of spectacles.[10-12] However, one of the limitations of this method is nonreporting of children to referral clinics, the rate of which varies from as low as 9% to as high as 88% in various studies.[10,13,14] On the other hand, performing refraction in the school or campsite allows for provision of spectacles to maximum number of affected children without losing them to follow-up. Although optometrist/refractionists have performed refraction and dispensed spectacles in schools in a number of studies,[5,15,16] the accuracy of refraction performed in makeshift rooms in schools has not been studied so far. The type of vision chart used, ambient light conditions, distance of the chart, and increased load of the number of refractions to be performed may adversely affect the accuracy of refraction. Inaccurate glasses can lead to noncompliance to spectacle usage due to either child not being comfortable with them or development of headaches.[16-18]

Thus, the aim of the present study was to compare the accuracy of noncycloplegic refraction done by an optometrist in school camp with that done in eye clinic in children aged 6–16 years and analyze the factors affecting it.

Methods

This prospective study was conducted over a period of 2 months (February 2017 and March 2017) in the Mathura district of Uttar Pradesh, India. It was approved by the Institutional Review Board and adhered to the tenets of Helsinki. The approval for school screening was obtained from Basic Shiksha Adhikari, Vrindavan. Consent from the parents of children was taken by the class teachers through information about the screening camp in the school diary. Children between the ages of 6–16 years were screened in various schools of the district for detection of visual impairment and ocular morbidity. They were first screened at the school campsite by a team of vision technicians and optometrist. Those who fulfilled the inclusion criteria were called to eye clinic for

Department of Paediatric Ophthalmology and Strabismus, Dr. Shroff's Charity Eye Hospital, New Delhi, [1]Department of Ophthalmology, BHRC-Dr. Shroff Charity Eye Hospital, Mathura, Uttar Pradesh, India, [2]Department of Ophthalmology, Binh Dinh Eye Hospital, Qui Nhon, Vietnam, Asia, [3]Department of Community Ophthalmology, Dr. Shroff's Charity Eye Hospital, New Delhi, India

Correspondence to: Dr. Shailja Tibrewal, Dr. Shroff's Charity Eye Hospital, Daryaganj, New Delhi - 110 002, India. E-mail: shailja1408@gmail.com

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repeat noncycloplegic refractions by the same optometrist. Children who completed examination and refraction at both school camp and eye clinic were ultimately included in the study. Those who were uncooperative for noncycloplegic retinoscopy (NCR) and subjective refraction (SR) at either site were excluded from the study.

Procedure followed in school camp

Visual acuity (VA) was tested by a vision technician using un-illuminated 3 m LogMAR chart. The cutoff vision for screening was considered as <0.2 LogMAR (<6/9). All the children who failed screening were evaluated by the optometrist for strabismus, corneal opacities, pseudophakia, aphakia or any other ocular pathology affecting vision. Such children were referred to eye clinic. NCR was performed on the remaining children using Heine's beta 200 streak retinoscope in a makeshift dark room. A subjective refinement of refraction was then done using the unilluminated 3 m LogMAR chart under lighted conditions. If the child's vision improved to >0.2 LogMAR after SR, he/she was called to eye clinic after 1 week for repeat noncycloplegic refraction. When vision failed to improve >0.2 LogMAR despite best possible SR children were referred to pediatric ophthalmologist. In addition, those with myopia >5D, hyperopia >2.5D, cylinder >3D, and fluctuating retinoscopic reflexes were also referred to eye clinic to either undergo cycloplegic refraction and/or evaluation for anterior segment and posterior segment pathology. These criteria for referrals for cycloplegic refraction were derived by a team of senior optometrists and pediatric ophthalmologists of the hospital based on their experience in both clinic practice and prior school camps performed by the organization.

Procedure followed in eye clinic

All children were first examined by a pediatric ophthalmologist to confirm absence of strabismus and anterior and posterior segment pathology and determination of need for cycloplegia. The same optometrist was masked to the refraction values from school camp, repeated NCR, and SR in the clinic examination room. VA testing and SR were performed using an illuminated 3 m LogMAR chart. Hyperopes were tested using the fogging method. Final spectacles were prescribed to children whose vision improved to >0.2 LogMAR. Glasses were provided free of cost to children. Those with other causes of visual morbidity were treated appropriately for the same.

Analysis

Sample size was calculated considering 5% alpha error, 10% beta error, standard deviation (SD) of 1.5D, and effect size of 0.5D in the spherical equivalent (SE). Based on the above, a sample size of 95 eyes was calculated. The error in refraction (unsigned or absolute) was calculated separately for NCR and SR values obtained at school camp and clinic. Subgroup analysis was done for myopic sphere, hyperopic sphere, and cylindrical refraction separately. An error of >10 degrees in axis of cylinder was considered clinically significant. The factors affecting error were evaluated, namely, age, gender, and magnitude of refractive error. Statistical analysis was carried out using Statistical Package for Social Sciences (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.). Categorical variables were presented in counts and percentages (%) and continuous variables were presented as mean ± SD and median. Normality of data was tested by Kolmogorov–Smirnov test. *t*-test for mean (one-tailed test) was used to compare absolute difference in sphere, cylinder, and SE with 0.5D (clinically significant error). Two-tailed paired *t*-test was applied to evaluate whether refractive error was underestimated or overestimated in camp settings. Spearman rank correlation coefficient was used to correlate quantitative variables with each other. When the data set of quantitative variables was not normally distributed, they were compared

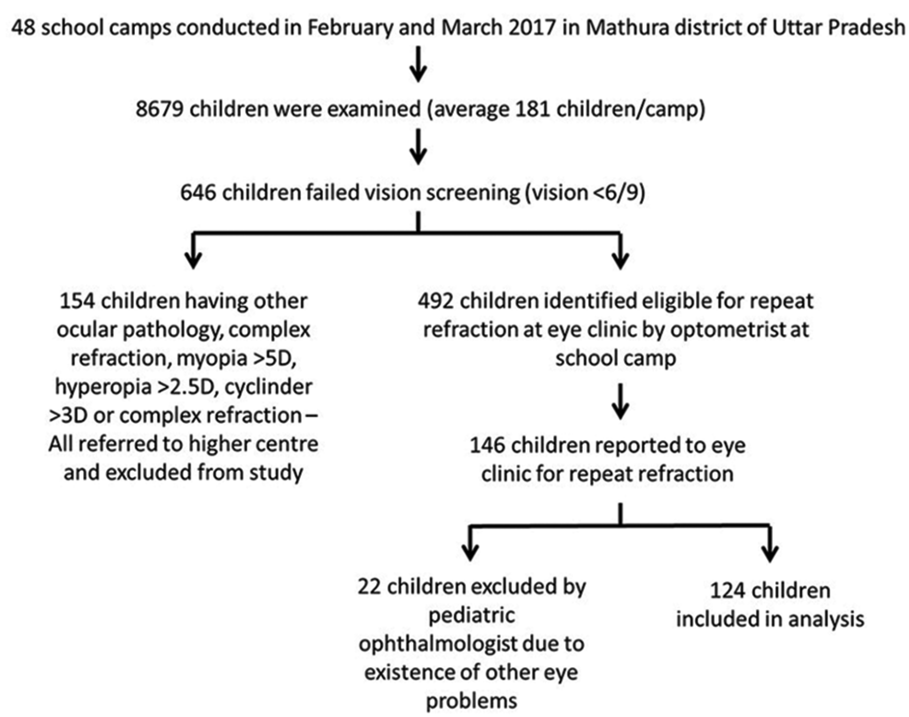

Figure 1: Flow of the process of inclusion of children in the study

Table 1: Difference between camp and clinic noncycloplegic retinoscopy and subjective refraction

Type of refraction	*n* (number of eyes)	Site of refraction	Mean±SD	Mean±SD of paired difference*	*P*#
Noncycloplegic retinoscopy					
Absolute SE	217	Camp	−1.33±1.23 D	0.09±0.51 D	0.007
		Clinic	−1.42±1.30 D		
Absolute sphere	204	Camp	−1.02±1.30 D	0.08±0.47 D	0.018
		Clinic	−1.10±1.34 D		
Absolute cylinder	150	Camp	−1.05±0.95 D	0.02±0.45 D	0.556
		Clinic	−1.07±0.98 D		
Cylindrical axis	150	Camp	110.27°±52.96°	−1.78°±41.95°	0.606
		Clinic	112.05°±50.85°		
Subjective refraction					
Absolute SE	217	Camp	−1.22±1.07 D	0.05±0.56 D	0.213
		Clinic	−1.26±1.15 D		
Absolute sphere	145	Camp	−1.34±1.1 D	0.03±0.61 D	0.563
		Clinic	−1.37±1.2 D		
Absolute cylinder	144	Camp	−0.95±0.88 D	0.02±0.33 D	0.383
		Clinic	−0.98±0.88 D		
Cylindrical axis	144	Camp	112.24°±51.98°	0.85°±40.83°	0.805
		Clinic	111.39°±51.84°		

*Positive difference indicates underestimation of refractive error in camps, #Results of two-tailed paired *t*-test. SE: Spherical equivalent, SD: Standard deviation

using Mann–Whitney Test. $P < 0.05$ was considered statistically significant. Bland–Altman analysis[19] was applied to study the agreement between the NCR and SR done at camp and clinic. The parameters determined were; mean difference (MD), SD, coefficient of agreement (COA = 1.96 × SD), and 95% limits of agreement (LOA; MD ± COA).

Results

Forty-eight school screening camps were organized during the study period of 2 months wherein 8679 children (181 children/day) were screened. Fig. 1 shows the flow of the process of inclusion of children in the study. Inclusion criteria were met by 124 children. After exclusion of 31 emmetropic eyes, 217 eyes were included for analysis. The average age was 11.88 ± 2.96 years. Male children constituted 57.25% of the study population. The average refractive error was 1.38 + 1.07D of SE (based on final spectacle power dispensed). Myopia (range: −0.5 to − 4.5D) was seen in 195 eyes (89.86%), hyperopia (range: +0.5 to + 2.5D) in 22 eyes (10.14%), and cylindrical error (range: −3.5 to + 1.25D) in 144 eyes (73.24%). The most common refractive error was compound myopic astigmatism (39.17%) followed by simple myopia (23.5%) and simple myopic astigmatism (21.65%). The lesser common type of refractive errors was mixed astigmatism (5.52%), simple hyperopic astigmatism (5.06%), simple hyperopia (3.32%), and compound hyperopic astigmatism (1.84%).

The mean absolute error in SE for NCR was 0.33 ± 0.4D and that of SR was 0.26 ± 0.5D. Mean error in spectacles prescription was not greater than the clinically acceptable level of 0.5D ($P > 0.05$). An error of ≤0.5D was observed in 92.62% of eyes (95% confidence interval [CI] 88%–95%), >0.5D was seen in 16 eyes (7.3%; 95% CI 4.9% to 10.8%) and >1D was seen in six eyes (2.76%; 95% CI 1% to 5.9%). Table 1 shows the comparison of refraction (NCR and SR) between school camp and clinic regarding absolute SE, sphere, and cylinder values separately. Refraction in camp underestimated the NCR as well as SR as compared to the clinic refraction. The mean of paired difference assumed statistical significance for noncycloplegic SE and sphere values, however, was within clinically acceptable limit of 0.5D.

Comparison of the median error in SE for NCR between myopia (0.38D; interquartile range [IQR] 0.13–0.5D) and hyperopia (0.25D; IQR 0.13–1.13D) did not reveal any statistically significant difference ($P = 0.073$). However, SR for hyperopia (SE and sphere) showed a statistically significant ($P = 0.001$) higher error (0.38; IQR 0.13–0.75D) as compared to myopia (0.12D; IQR 0–0.25D).

The mean error in SE in SR (final spectacle prescription) was found to be 0.25 ± 0.58D (range 0–5D) in males and 0.26 ± 0.39D (range 0–3D) in females. Similar results were seen for error in SE in NCR in males (0.34 ± 0.32D) and females (0.33 ± 0.48 D).The accuracy of both NCR and SR was not affected by gender of the patient ($P = 0.129$ and 0.137). Similarly, age of the child did not correlate with the amount of error in SE and sphere for both NCR and SR. A weak negative correlation ($\rho = -0.166$, $P = 0.042$) was found between the amount of error in NCR cylinder values and age. However, the association disappeared when SR between school camp and clinic were compared and correlated with age.

The amount of error in final spectacle prescription showed a very weak positive correlation with amount of myopic SE ($\rho = 0.242$, $P = 0.0007$) and negative correlation with hyperopic SE ($\rho = -0.115$ $P = 0.60$). The strongest correlation was found with the hyperopic sphere values ($\rho = 0.819$, $P = 0.0002$). Thus, although the accuracy of refraction tended to reduce with increase in the magnitude of refractive error [Table 2] the change appeared to be insignificant for the range of refractive errors included in the study.

Table 3 shows the agreement between camp and clinic NCR as well as SR. The COA for cylinder was slightly less than

Table 2: Distribution of amount of error as per magnitude of final subjective refraction (spectacle power dispensed)

	Magnitude of refraction (D)	Number of eyes (%)	Mean error (D)	Range of error (D)
Sphere (*n*=168)				
Myopia	3-4.5	17 (10.11)	0.31	0-1.0
	1.5-<3	49 (29.16)	0.22	0-0.75
	0.25-<1.5	71 (42.26)	0.17	0-0.75
Hyperopia	1.5-2.5	3 (1.78)	1.25	0-3.25
	0-<1.5	28 (16.66)	0.47	0-0.5
Cylinder (*n*=165)				
Myopia	3-4.5	5 (3.03)	0.4	0-1.25
	1.5-<3	35 (21.21)	0.19	0-0.75
	0.25-<1.5	104 (63.03)	0.14	0-1.0
Hyperopia	0-<1.5	21 (12.72)	0.35	0-2.5

Table 3: Results of analysis of agreement between school camp and eye clinic for non cycloplegic retinoscopy and subjective refraction regarding spherical equivalent, sphere, and cylinder

Type of measurement	Mean deviation (D)	COA (1.96 SD)	95% LOA (mean±1.96 SD)	Eyes with error within 0.5 D (%)
NCR				
SE	−0.09	1.00	−1.09-0.90	86.67
Sphere	0.07	0.93	−0.85-1.01	90.78
Cylinder	0.02	0.88	−0.85-0.90	90.78
SR				
SE	0.04	1.10	−1.05-1.15	92.62
Sphere	0.02	1.18	−1.16-1.22	95.85
Cylinder	0.02	0.64	−0.62-0.67	94.93

NCR: Noncycloplegic retinoscopy, SR: Subjective refraction, COA: Coefficient of agreement, LOA: Limits of agreement, SD: Standard deviation

sphere. Fig. 2 shows the Bland–Altman plots for final spectacle prescription (SR). The mean deviation was +0.05D and the COA was found to be ±1.12D. 95% LOA was between +1.15 and −1.05D, implying that the difference between the SR done in camp and clinic may lie anywhere within the above range. The plot did not reveal any tendency of the error to increase with increasing dioptric value of refractive error.

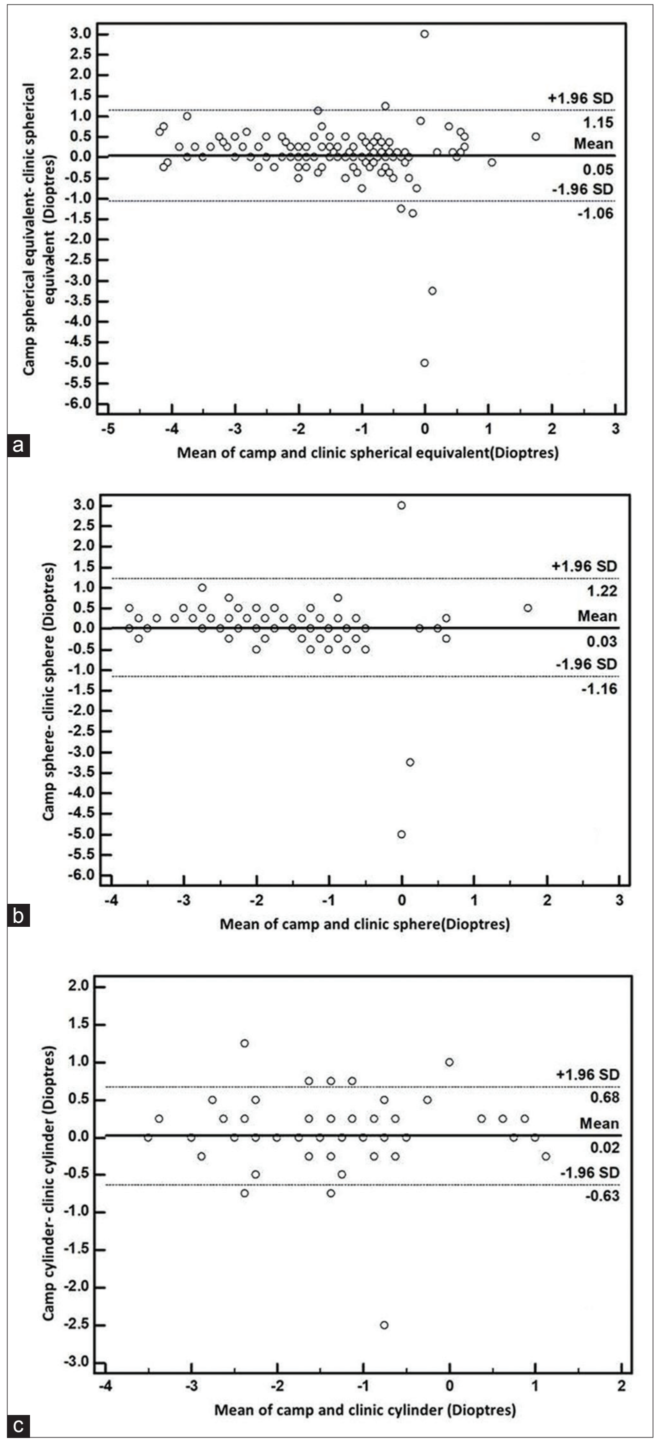

Figure 2: Bland–Altman assessment of agreement between the subjective refraction (spectacles prescribed) done in camps and clinics, regarding spherical equivalent (a), sphere (b) and cylindrical values (c). The solid line depicts the mean deviation and the dotted lines depict the 95% limits of agreement

Discussion

This study was conducted with the goal to determine the accuracy of noncycloplegic refraction performed in school camps for children aged 6–16 years of age. Although cycloplegic refraction is considered gold standard in children,[20,21] it poses practical problems in school camp settings. First, consent from the parents is needed before instillation of cycloplegic drops. We did not use cycloplegic drops in the camps conducted in the present study as the screening was conducted in the absence of an ophthalmologist. Hence, consent could not be obtained from parents. Even if attempt to obtain consent are made, sometimes parents may refuse to consent for instillation of drops in their child's eye in their absence. In a study conducted in schools in rural Delhi, Rustagi *et al*.[22] performed cycloplegic refractions in children after obtaining consent from parents by sending consent forms to them. They observed that 58.5% of those children who needed refraction could not get the form signed from parents. Among the reasons for noncompliance parental refusal (23.6%) and unwillingness to undergo refraction (30.6%) were the major ones. Second, the side effects of cycloplegia such as blurring of near vision and photophobia are not acceptable to teachers and principals of schools, especially in the absence of parents or primary caretakers in such camps. Hence, noncycloplegic refraction is the only alternative in such situations and was the procedure of choice in the current study. Studies have shown that noncycloplegic refraction is fairly accurate when compared to cycloplegic refraction in children over 6 years of age.[23,24] The accuracy can be increased further by coupling it with SR. In a study conducted in school children aged 6–13 years in Thailand,[23] the authors compared noncycloplegic autorefraction, retinoscopy, and SR with subsequent cycloplegic refractions performed in eye hospital. They found that the NCR and SR had high agreement (within +0.5D) of 80.84% and 81.66%, respectively, with cycloplegic refractions. The range of refractive error included in their study was −7.62 to +7.25D; with only two children with hyperopia.

Refractive errors beyond 5D of myopia, 2.5D of hyperopia, and 3.5D of cylinder were excluded because such high refractive errors warrant cycloplegic refraction. Myopia beyond 5D necessitates a dilated fundus evaluation as well. In addition, those children in which a fluctuating or scissoring reflex was found during retinoscopy were referred to ophthalmologist to rule out corneal or lenticular pathology.

We found that the error in noncycloplegic refraction showed considerable variability when compared between school camp and eye clinic. Although the MD was small, the COA was ±1.1D for SE ±1.2D for sphere and ±0.65D for cylinder. Thus, the 95% LOA were beyond the clinically acceptable value of 0.5D. The absolute mean error in SE was however significantly lower than the clinical cutoff of 0.5D. Accurate prescriptions were provided in 92.7% eyes. In fact, an error of more than 1D was seen in only 6 eyes. The error in SR was more for hyperopia. However, there were only 22 eyes with hyperopia in the study. Thus, it is imprudent to derive meaningful conclusion for error in hyperopic prescription from the current data. We did not find the accuracy of noncycloplegic refraction to vary with gender, age, or magnitude of refraction. There was a weak correlation of error in NCR cylinder and age, wherein more inaccuracies were seen in smaller children. This could be explained by the fact that smaller children may be slightly uncooperative in fixing to the distance chart which might adversely affect the cylindrical power as well as axis. This error got eliminated when SR was performed.

There were several school screening camps conducted in India and elsewhere wherein glasses were prescribed after NCR and SR at the campsite.[12,15,16,25] Kalikivayi *et al*.[26] and Pavithra *et al*.[15] performed noncycloplegic refraction in school children in their respective studies. The optometrist prescribed glasses in all children where best-corrected VA was achieved. In both the studies, provision of cycloplegic refraction for children who did not achieve BCVA and all hyperopes was present at camp examination site. Several other studies have mentioned performing refractions in schools and prescribing glasses to children, but fail to mention the method of refraction used.[6,14,25] Apart from cycloplegia, there are other factors that differ in camp settings and eye clinic settings that may adversely affect the accuracy of refraction and spectacle power dispensed. None of the above-mentioned studies discuss these parameters and adversities faced in the school camps. We matched the optometrist and the distance of vision chart in the current study. However, we used unilluminated vision chart in the schools and illuminated charts in the eye clinic. The makeshift dark rooms were not same in each school. Studies have shown that VA testing is affected by the amount of room illumination.[27-29] The ambient light during the SR and vision testing was different in different schools in the current study. Despite these differences, the current study showed that noncycloplegic refraction by an optometrist in the schools is accurate within ±0.5D in 92.7% eyes. To the best of our knowledge, this is the only study so far to perform this comparison. As mentioned before accuracy of spectacle prescription is extremely important and one of the major determinants of compliance. In a focus group discussion conducted by Li *et al*.[30] in China, the students identified "accuracy of power" as their first requirement for regular glasses use. Furthermore, prescribing glasses in schools can lead to reduction in the number of referrals to the eye clinic. In the current study too, 72% of the children who required spectacles failed to report to the eye clinic for repeat refraction.

The results of our study should be interpreted in the light of its limitations. We did not test for the repeatability (test-retest) of noncycloplegic refraction in our participants. Studies testing repeatability of NCR in adults[31,32] have found the 95% LOA to be close to ±0.75D. McCullough *et al*.[33] found the LOA for SE of cycloplegic retinoscopy in children between −0.90 and +0.78D with 81% of examinations being within 0.5D. No such testing was done for noncycloplegic refraction in children. The 95% LOA between school and camp refraction in the current study were slightly more than the above-stated references. We cannot ascertain whether this difference is due to the test-retest variability alone, or due to difference in settings. All the refractions were performed by an optometrist. We understand that optometrists are a class of trained and skilled professionals with higher cost of employment as compared to vision technicians and health-care workers.[34] There is one optometrist for a population of 48,000 in India.[35] There may be a paucity of trained optometrist in some parts of the country. The use of a trained optometrist may result in more accurate refraction as he/she would be an expert in handling larger number of patients in a single day without making considerable mistakes. This factor is highly subjective and variable as retinoscopy is a skill-based art. Finally, we did not evaluate the compliance of the children to the final prescribed spectacles. However, the study aimed to find out whether the spectacle prescription given in camps was as accurate as that given in the eye clinic. Whether prescription of glasses within the cutoff limits derived from this study improves compliance to spectacle usage is a matter of further research.

Conclusion

Noncycloplegic refraction performed in school camps and eye clinic show considerable variability and are noninterchangeable. Nonetheless, refractions done in camps are found to be accurate to ±0.5D in 92.26% eyes for refractive errors up to 4.5D of myopia, 3D of cylinder, and 1.5D of hyperopia. The accuracy was not affected by age, gender, or magnitude of refractive error. Thus, we recommend that noncycloplegic refractions may be performed in school camps when the need exists, due to social, economic, or epidemiological reasons.

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Conflicts of interest

There are no conflicts of interest.

References

1. Dandona R, Dandona L, Srinivas M, Sahare P, Narsaiah S, Muñoz SR, *et al.* Refractive error in children in a rural population in India. Invest Ophthalmol Vis Sci 2002;43:615-22.
2. Resnikoff S, Pascolini D, Mariotti SP, Pokharel GP. Global magnitude of visual impairment caused by uncorrected refractive errors in 2004. Bull World Health Organ 2008;86:63-70.
3. Naidoo KS, Leasher J, Bourne RR, Flaxman SR, Jonas JB, Keeffe J, *et al.* Global vision impairment and blindness due to uncorrected refractive error, 1990-2010. Optom Vis Sci 2016;93:227-34.
4. Murthy GV, Gupta SK, Ellwein LB, Muñoz SR, Pokharel GP, Sanga L, *et al.* Refractive error in children in an urban population in New Delhi. Invest Ophthalmol Vis Sci 2002;43:623-31.
5. Padhye AS, Khandekar R, Dharmadhikari S, Dole K, Gogate P, Deshpande M, *et al.* Prevalence of uncorrected refractive error and other eye problems among urban and rural school children. Middle East Afr J Ophthalmol 2009;16:69-74.
6. Pi LH, Chen L, Liu Q, Ke N, Fang J, Zhang S, *et al.* Refractive status and prevalence of refractive errors in suburban school-age children. Int J Med Sci 2010;7:342-53.
7. Jose R, Sachdeva S. School eye screening and the national program for control of blindness. Indian Pediatr 2009;46:205-8.
8. Kumar D, Singh JV, Ahuja PC, Agarwal J, Mohan U. Ocular morbidity among school children in Sarojini Nagar Lucknow. Indian J Community Med 1992;17:109-13.
9. Sharma A, Congdon N, Patel M, Gilbert C. School-based approaches to the correction of refractive error in children. Surv Ophthalmol 2012;57:272-83.
10. Limburg H, Kansara HT, d'Souza S. Results of school eye screening of 5.4 million children in India – A five-year follow-up study. Acta Ophthalmol Scand 1999;77:310-4.
11. Bhatt NK, Rathi M, Dhull CS, Sumit S, Phogat J. Spectacle compliance amongst school children of Rohtak, Haryana, India. Int J Med Sci Public Health 2017;4:734-7.
12. Aldebasi YH. A descriptive study on compliance of spectacle-wear in children of primary schools at Qassim province, Saudi Arabia. Int J Health Sci (Qassim) 2013;7:291-9.
13. Sudhan A, Pandey A, Pandey S, Srivastava P, Pandey KP, Jain BK, *et al.* Effectiveness of using teachers to screen eyes of school-going children in Satna district of Madhya Pradesh, India. Indian J Ophthalmol 2009;57:455-8.
14. Priya A, Veena K, Thulasiraj R, Fredrick M, Venkatesh R, Sengupta S, *et al.* Vision screening by teachers in Southern Indian schools: Testing a new "all class teacher" model. Ophthalmic Epidemiol 2015;22:60-5.
15. Pavithra MB, Maheshwaran R, Rani MA. A study on the prevalence of refractive errors among school children of 7-15 years age group in the field practice areas of a medical college in Bangalore. Int J Med Sci Public Health 2013;2:641-5.
16. Pavithra MB, Hamsa L, Madhukumar S. Factors associated with spectacle-wear compliance among school children of 7-15 years in South India. Int J Med Public Health 2014;4:146-50.
17. Khandekar R, Sudhan A, Jain BK, Tripathy R, Singh V. Compliance with spectacle wear and its determinants in school students in Central India. Asian J Ophthalmol 2008;10:174-7.
18. Gogate P, Mukhopadhyaya D, Mahadik A, Naduvilath TJ, Sane S, Shinde A, *et al.* Spectacle compliance amongst rural secondary school children in Pune district, India. Indian J Ophthalmol 2013;61:8-12.
19. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1986;1:307-10.
20. Zhao J, Mao J, Luo R, Li F, Pokharel GP, Ellwein LB, *et al.* Accuracy of noncycloplegic autorefraction in school-age children in China. Optom Vis Sci 2004;81:49-55.
21. Zhu D, Wang Y, Yang X, Yang D, Guo K, Guo Y, *et al.* Pre- and postcycloplegic refractions in children and adolescents. PLoS One 2016;11:e0167628.
22. Rustagi N, Uppal Y, Taneja DK. Screening for visual impairment: Outcome among schoolchildren in a rural area of Delhi. Indian J Ophthalmol 2012;60:203-6.
23. Funarunart P, Tengtrisorn S, Sangsupawanich P, Siangyai P. Accuracy of noncycloplegic refraction in primary school children in Southern Thailand. J Med Assoc Thai 2009;92:806-11.
24. Yeotikar NS, Bakaraju RC, Reddy PS, Prasad K. Cycloplegic refraction and non-cycloplegic refraction using contralateral fogging: A comparative study. J Mod Opt 2007;54:1317-24.
25. Kaur G, Koshy J, Thomas S, Kapoor H, Zachariah JG, Bedi S, *et al.* Vision screening of school children by teachers as a community based strategy to address the challenges of childhood blindness. J Clin Diagn Res 2016;10:NC09-14.
26. Kalikivayi V, Naduvilath TJ, Bansal AK, Dandona L. Visual impairment in school children in Southern India. Indian J Ophthalmol 1997;45:129-34.
27. Simpson TL, Barbeito R, Bedell HE. The effect of optical blur on visual acuity for targets of different luminances. Ophthalmic Physiol Opt 1986;6:279-81.
28. Wozniak H, Kelly M, Glover S, Moss N. The effect of room illumination on visual acuity measurement. Aust Orthopt J 1999;34:3-8.
29. Tidbury LP, Czanner G, Newsham D. Fiat lux: The effect of illuminance on acuity testing. Graefes Arch Clin Exp Ophthalmol 2016;254:1091-7.
30. Li L, Lam J, Lu Y, Ye Y, Lam DS, Gao Y, *et al.* Attitudes of students, parents, and teachers toward glasses use in rural china. Arch Ophthalmol 2010;128:759-65.
31. Zadnik K, Mutti DO, Adams AJ. The repeatability of measurement of the ocular components. Invest Ophthalmol Vis Sci 1992;33:2325-33.
32. Leinonen J, Laakkonen E, Laatikainen L. Repeatability (test-retest variability) of refractive error measurement in clinical settings. Acta Ophthalmol Scand 2006;84:532-6.
33. McCullough SJ, Doyle L, Saunders KJ. Intra- and inter- examiner repeatability of cycloplegic retinoscopy among young children. Ophthalmic Physiol Opt 2017;37:16-23.
34. Kumar R. Ophthalmic manpower in India – Need for a serious review. Int Ophthalmol 1993;17:269-75.
35. Thal L, Quintero S, editors. Developing a business plan: New practice, expansion and acquisition. In: Business Aspects of Optometry: Association of Practice Management Educators. 3rd ed. Missouri: Elsevier; 2010. p. 103-69.