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Original Article

Inter-rater reliability for visual acuity, refractive error, corneal reflex, and inter-pupillary distance among two masked optometrists in school children population: a pilot study

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Abstract

Purpose: *To observe the inter-rater reliability between the observers for visual acuity, refractive error, corneal reflex, and inter-pupillary distance.*

Methods: *A random subset of 50 students from primary (1st to 4th grade), higher primary (5th to 7th grade) and secondary school (8th to 10th grade), for a total of 150 students were selected by stratified sampling from the prevalence study VARES (Visual acuity, refractive error, and squint) performed among 1752 school children of Udupi district, India in 2013-2014. The Institutional Ethical Committee & District Health Administration board permission was acquired. There were two examiners: Examiner 1 (JT), a qualified optometrist with two years of experience, and Examiner 2 (MT), an optometry student. Examiners 1 and 2 performed a single measurement for visual acuity using the COMPlog computerized logMAR vision chart at 3 metres; Landolt C or Sloan letter optotypes used. Refractive error, corneal reflex, and inter-pupillary distance was measured by Plusoptix Power-refractor twice by Examiner 1 and thrice by Examiner 2; the average of each value was considered for analysis. Data was tested for normality using the Kolmogorov-Smirnov test. Statistical significance was considered p < 0.05. The agreement between the observers for the two procedures was traced by a Bland-Altman plot.*

Results: *The mean age of the students was 10.21 years (± 2.80 SD). The measurement of agreement for visual acuity (COMPlog) between the examiners was tested using Kappa statistics with 0.79 for OD, p < 0.05 and 1.0 for OS, p < 0.05 supported by Wilcoxon sign rank test showing 0.067 for OD and 0.564 for OS between the observers. The Bland-Altman plot also showed good agreement between the observers. Paired t-test for refractive error showed 0.117 (CI: -0.11¬–0.10) for OD and 0.067 (CI: -0.005–0.157) for OS, with Bland-Altman plot showing good agreement between the observers. Paired t-test showed 0.323 for corneal reflex and 0.520 for inter-pupillary distance.*

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Conclusion: *From the results we report that there is no interobserver variability for visual acuity, refractive error, corneal reflex and inter-pupillary distance in school screening with COMPlog and Plusoptix A09.*

Keywords: *COMPlog, Plusoptix A09, refractive error, school children, visual acuity*

Introduction

Refractive error is one of the most common causes of visual impairment around the world and the second leading cause of treatable blindness.[1] There has been an increasing realization worldwide of the enormous need for correcting refractive error and it has been considered as one of the priorities of the global initiative for the elimination of avoidable blindness, VISION 2020- The Right to Sight.[2]

Vision screening and refractive services for school students have been recommended by the World Health Organization (WHO). There is a great need for effective and reliable methods for screening the school population. The advantage of school screening is that the screening criteria of 100% coverage can conceivably be attained, given that normally a very high percentage of children attend school.[3] Results from the various studies conducted among school-aged children in India shows that the prevalence of uncorrected refractive error varies from 2.63%–7.4%.[4] Thus, an efficient vision screening system in both primary and secondary schools would give all children an equal opportunity for good eyesight.

Foreseeing this, the use of non-standardized vision testing chart and lack of proper illumination during testing usually provides incorrect measurements of visual acuity during mass screenings, leading to a high percentage of false positives and false negatives which in lead to unnecessary false referrals.[5] Conventional print charts used for vision testing are usually memorized by students, and routinely used Snellen acuity charts come with inherent limitations and possess considerable flaws.[6]

This pilot study was conducted to understand the reliability between the examiners using the newer computerized logMAR chart COMPlog[7] and the Plusoptix A09 in a cohort of school children in a province of India.

Materials and methods

A study to find out the prevalence of visual acuity, refractive error, and squint (VARES) in school children of Udupi district, India was conducted during December 2012 to April 2013. Permission was obtained from the Institutional Ethical Committee and District Health Administration board. As part of this VARES study, a sample size of 1752 school children ranging from 5-15 years underwent comprehensive eye screening. Considering the difference in visual acuity between repeated COMPlog values to be ±0.14 logMAR units and expected difference in refractive error ±0.50 D units, keeping power at 80% and assuming an alpha error of 5%, a sample of 150 subjects between 5-15 years was recruited. A random subset of 50 students each from primary school (N = 50), higher primary school (N = 50), and secondary school (N = 50) were evaluated, for a total of 150 students.

Primary school was defined as 1st to 4th grade, upper primary school from 5th to 7th grade, and secondary school from 8th to 10th grade. Examiner 1 was JT, a qualified optometrist with two years of experience; Examiner 2 was MT, an optometry student in training. Both examiners performed a single measurement for visual acuity using the COMPlog acuity chart. Plusoptix measurements were performed twice by Examiner 1 and thrice by Examiner 2, and the average of each value was considered for analysis.

COMPlog and power refractor data from 150 students were used to compare the interobserver variability between the examiners. Both right and left eye data were analysed separately to study the influence of learning curve and laterality effects. All data were tested for normality using KS Test and appropriate statistical tests (parametric /non-parametric) were selected. Statistical significance was considered p <0.05. Bland Altman plot showed agreement between the observers for visual acuity and refractive error.

Results

The mean age of the students is 10.21 years (± 2.80 SD) (Fig. 1). A higher number of male children were the participants all across the schooling sector.

The visual acuity was tested with COMPlog for each of the subjects twice, independently by the two examiners. The one-sample Kolmogorov-Smirnov test for normality showed the p-value > 0.05, the logMAR visual acuity distribution for both the eyes being skewed. Thus, a non-parametric Wilcoxon sign rank test employed showed 0.069 (OD) and 0.564 (OS) between JT and MT (Table 1).

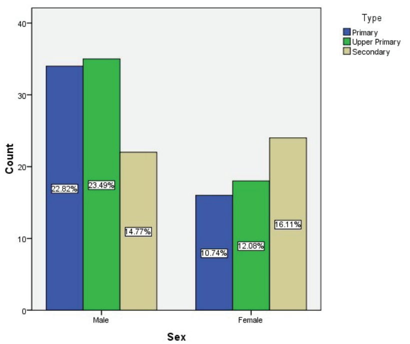

Fig. 1. Student distribution across the schooling sector.

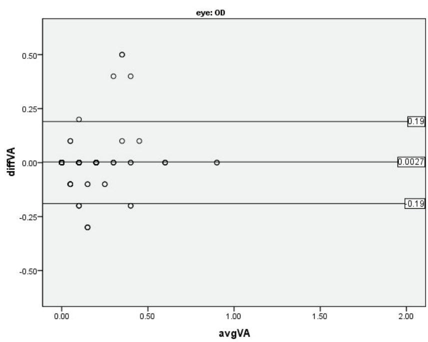

Fig. 2. Bland-Altman plot of visual acuity in right eye, 0.0027 (lower limit -0.19, upper limit 0.19).

Table 1. Visual acuity measurements by both examiners, tested using non-parametric measure Wilcoxon sign rank

Examiner	Eye	Median	Quartiles		Wilcoxon-signed rank test (p-value)
			25th	75th	
JT	OD	0.00	0.00	0.20	0.069
MT	OD	0.00	0.00	0.10	
JT	OS	0.00	0.00	0.20	0.564
MT	OS	0.00	0.00	0.20	

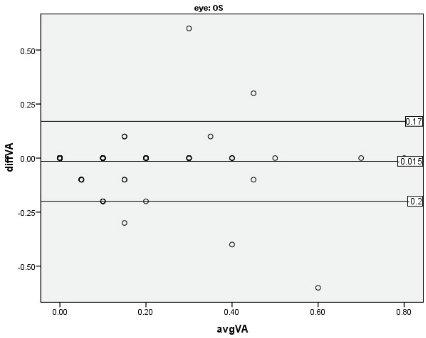

Fig. 3. Bland-Altman plot of visual acuity in left eye, 0.015 (lower limit -0.2, upper limit 0.17).

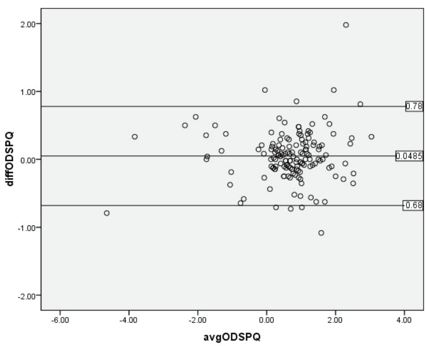

Fig. 4. Bland-Altman plot for spherical equivalent (refractive error) of right eye, 0.0485 (lower limit -0.68, upper limit 0.78).

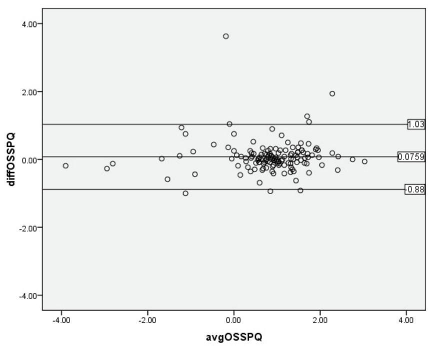

Fig. 5. Bland-Altman plot for spherical equivalent (refractive error) in left eye, 0.075 (lower limit -0.88, upper limit 1.03).

Table 2. Refractive error measurements by both examiners, tested using parametric measure paired t-test

Examiner	Eye	Mean (in D)	Standard Deviation	Paired t-test (p-value)	95% CI
JT	OD	0.6548	1.07	0.117	-0.11–0.10
MT	OD	0.7033	1.10		
JT	OS	0.7771	1.01	0.067	-0.005–0.157
MT	OS	0.8530	1.03		

Table 3. Corneal reflex and inter-pupillary distance (IPD) measurements by both examiners, tested using parametric measure paired t-test

Examiner	Readings	Mean	Standard Deviation	Paired t-test (p-value)
JT	Corneal reflex (mm)	2.90	1.16	0.323
MT	Corneal reflex (mm)	2.97	1.08	
JT	IPD (mm)	56.07	4.72	0.520
MT	IPD (mm)	56.19	4.26	

The agreement between examiners and logMAR visual acuity was represented by the Bland-Altman plot, which showed good agreement between the two examiners for measuring visual acuity (Figs. 2 and 3).

Figure 2 shows the maximum visual acuity values retrieved by the two observers fall within the range of mean ±2 SD, *i.e.*, mean was 0.0027 with upper limit of +0.19 and lower limit of -0.19. Figure 3 shows the maximum visual acuity values retrieved by the two observers fall within the range of mean ±2 SD, *i.e.*, mean was -0.15 with upper limit of +0.17 and lower limit of -0.2. This shows that the majority of points fall within the range of mean ±2 SD, depicting a good agreement between the observers for the visual acuity measurements using COMPlog.

The one-sample Kolmogorov-Smirnov test for normality showed the p-value < 0.05 for refractive error from the Plusoptix measurements, thus subjecting it to a parametric test. An OD value of 0.117 (-0.11 to +0.10) and an OS value of 0.067 (-0.005 to +0.157) was obtained in this test (Table 2). This showed a lack in statistical agreement ($p > 0.05$) for refractive error measurements between the examiners.

The p-value for the readings of corneal reflex and inter-pupillary difference was 0.323 and 0.520, respectively, between the examiners, showing a lack in statistical significance in these measurements (Table 3).

The agreement between examiners and refractive error values from Plusoptix was represented by a Bland-Altman plot, which showed good agreement between the two examiners for measuring refractive error (Figs. 4 and 5). Figure 4 is the Bland-Altman plot for the right eye, showing that the maximum spherical equivalent values taken by the two observers fall within the range of mean 2 SD, *i.e.*, mean was 0.0485 with an upper limit value of 0.78 and a lower limit value of -0.68, showing good agreement for the refractive error values between the two observers. Figure 5 is the Bland-Altman graph for the left eye, showing that the maximum spherical equivalent values taken by the two observers fall within the range of mean ± 2 SD, *i.e.*, mean was 0.0759 with an upper limit value of 1.03 and a lower limit value of -0.88, showing good agreement for the refractive error values between the two observers.

Discussion

This study made an attempt to understand the inter-observer reliability among the two newer instruments, COMPlog and Plusoptix A09 with the aim of employing these quicker modes in community and school screenings a southern province in India if proven reliable. We could observe a good reliability between the examiners for the components of visual acuity measured by COMPlog and for the components of refractive error, corneal reflex, and inter-pupillary distance measured by Plusoptix A09.

In OD, 98% of those with better than 0.3 logMAR visual acuity showed agreement among the examiners and 76% agreement was present for visual acuity worse than 0.3 logMAR (kappa = 0.79, $p < 0.05$). For OS, there was 100% agreement for both visual acuity groups between the two examiners (kappa = 1.0, $p < 0.05$).

The poor inter-rater reliability for extreme values of visual acuity measurements could be a possible drawback of the COMPlog system to capture a consistent acuity in case of worse visual acuity during the projection of optotypes. On the other hand, a variable response from the child during the process could also have led to a poor inter-rater reliability. This was observed at a lower age group of primary section (1st to 4^{th} grade). This is the critical age wherein the detection of amblyopia is pivotal. A change in approach towards the better handling of the instrument from the examiner side after an intervention of training for a stipulated time period may possibly improve inter-rater reliability. A further technology update in the COMPlog system, enabling it to detect the extreme values of acuity and producing a consistent output can also add to improved inter-rater reliability.

The Bland-Altman plots for the differences and averages in visual acuity and refractive error for both eyes performed by the two examiners also showed good agreement, thus showing lack of variability among the examiners. The measurement of agreement between the two examiners for visual acuity 0.3 logMAR or better, tested using Kappa statistics with value ≥ 0.79, showed a good agreement between the observers (p-value < 0.05).

These observations and results substantiate the usefulness of the COMPlog and Plusoptix A09 in a community screening setting primarily focused on the paediatric cohort. We found good agreement between the observers for visual acuity, refractive error, corneal reflex and inter-pupillary distance in the data provided by these instruments. This demonstrates the reliability of the values obtained from the instruments irrespective of the examiner (expert or novice). The combined features of quickness, reliability, ease of use, and portability gives an extra edge to implement them in community screenings, especially due to the short concentration span of the paediatric population. This also negates the factor of recall bias encountered in standard visual acuity testing by substituting the charts with COMPlog. The parallax error and lack of standardized lighting conditions encountered during retinoscopy is also negated by the use of Plusoptix. These kinds of devices, extensively useful in community screenings, also provide clues in detecting a few conditions, among them amblyopia. Early detection in the screening, primarily during the vision assessment by the inability to achieve 6/6 with a difference of 2 or more lines between the eyes even after the best possible refraction and correction, makes such school and community screening important. We detected 10 children out of 150 (6.6%) with amblyopia, who were further referred for a detailed eye examination and treatment to a tertiary eye care hospital.

The Plusoptix A09 is affordable compared to other newer auto refractometers and photo refractors. The feature of non-cycloplegic refraction, pupillary size, corneal reflex, and inter-pupillary distance fits it into a better position. Choi *et al.* compared the auto refractor with the eccentric PowerRefractor (Bremen, Germany) and found similarities in the values between the refractive power ranges of +4 D to -6 D, whereas Cooper *et al.* provided a non-satisfactory report of the MTI photo screener and Tomey ViVA eccentric photo refractor for the purpose of screening. A recent study from Dahlmann-Noor *et al.* tried to determine the intra- and inter-observer variability of the Plusoptix vision screener (CR03).[8] It showed a good intra observer repeatability with a 95% confidence interval for mean spherical equivalent of ±0.63 D to 0.64 D and a good inter observer repeatability with a 95% confidence interval for mean spherical equivalent of -0.62D to 0.68D. It further reported the repeatability coefficients to be identical between the observers.[8] Allen *et al.* reported that the photo refractor is a useful tool for screening in children given its good reproducibility and validity.[9] The results from this study also point to the good reliability of the Plusoptix A09 photo refractor between two examiners, thus agreeing with already published studies. Laidlaw *et al.* reported the reliability of COMPlog with the gold standard Early Treatment Diabetic Retinopathy Study, stating the validity and reproducibility of COMPlog to the standard.[7] Thus, the literature reports high reliability for these two instruments in the domain of screening. This pilot study also found good reliability between the examiners for these instruments, demonstrating their usefulness in community screening among school children.

Conclusion

We report good inter-examiner reliability for the COMPlog and Plusoptix A09 in terms of visual acuity, refractive error, corneal reflex, and inter-pupillary distance. However, extreme values of visual acuity and refractive error (greater than the range of +4 D to -6 D) indicates deviation from good reliability.

References

1. Dandona R, Dandona L. Refractive error blindness. Bull World Health Organ. 2001;79(3):237-243.
2. Pararajasegaram R. VISION 2020-the right to sight: from strategies to action. Am J Ophthalmol. 1999 Sep;128(3):359-360.
3. 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 Jan;86(1):63-70
4. Rustagi N, Uppal Y, Taneja DK. Screening for visual impairment: outcome among schoolchildren in a rural area of Delhi. Indian J Ophthalmol. 2012;60(3):203-206.
5. Sudhan A, Pandey A, Pandey S, Srivastava P, Pandey KP, Jain BK. Effectiveness of using teachers to screen eyes of school-going children in Satna district of Madhya Pradesh, India. Indian J Ophthalmol. 2009;57(6):455-458.
6. Hussain B, Saleh GM, Sivaprasad S, Hammond CJ. Changing from Snellen to LogMAR: debate or delay? Clin Experiment Ophthalmol. 2006;34(1):6-8.
7. Laidlaw DA, Tailor V, Shah N, Atamian S, Harcourt C. Validation of a computerised logMAR visual acuity measurement system (COMPlog): comparison with ETDRS and the electronic ETDRS testing algorithm in adults and amblyopic children. Br J Ophthalmol. 2008;92(2):241-244
8. Dahlmann-Noor AH, Comyn O, Kostakis V, et al. Plusoptix Vision Screener: the accuracy and repeatability of refractive measurements using a new autorefractor. Br J Ophthalmol. 2009;93(3):346-349.
9. Allen PM, Radhakrishnan H, O'Leary DJ. Repeatability and validity of the PowerRefractor and the Nidek AR600-A in an adult population with healthy eyes. Optom Vis Sci. 2003;80(3):245-251.