Original Article

Comparison of the efficacy of Lea Symbol chart and Sheridan Gardiner chart for preschool vision screening

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Purpose: To compare the efficacy of Lea symbols (LS) chart and Sheridan Gardiner (SG) chart for vision screening among preschool children, in a semi-urban district of South India. **Methods:** Vision screening was conducted among 260 preschool children aged 3–5 years in cluster sampled kindergartens using LS chart and SG chart. Pass/fail scores and time taken for visual acuity (VA) estimation were compared. VA scores and time taken were compared using unpaired *t*-test. Sensitivity, specificity, and positive and negative predictive values were compared between the charts. **Results:** There was a significant difference between LS and SG charts in the VA score in both the eyes ($P = 0.04$). LS showed 76.09% pass score and 23.90% fail score, whereas SG showed 87.65% pass score and 12.35% fail score with a cutoff value of > 0.3 log MAR. Time for screening using LS was higher, when compared to SG, both for the right eyes ($P < 0.001$) and the left eyes ($P < 0.001$). The sensitivity of the LS was 94.74% (95% confidence interval [CI]: 70.13%–81.06%) and that of SG was 52.63% (95% CI: 45.29%–59.8%). The specificity of LS was 66.67% (95% CI: 90.26%–97.30%) and SG was 83.33% (95% CI: 70.12%–91.30%). **Conclusion:** LS chart showed better sensitivity and negative predictive value when compared to SG chart. However, SG chart showed better specificity and positive predictive value, and screening was less time-consuming. Considering the high sensitivity and negative predictive value, LS is the preferred tool, when compared to SG chart in preschool vision screening in our population.

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Detection of uncorrected refractive errors and amblyopia is the major goal of pediatric vision screening. Recent studies have demonstrated that the depth of anisometropic amblyopia increases with age,[1,2] and that the effectiveness of amblyopia therapy declines after fifth birthday.[3] These emphasize on the importance of active screening among preschool children for visual deficits.

The selection of age-appropriate and clinically proven optotypes is crucial in visual acuity (VA) screening of preschool children.[4] Furthermore, the screening tests should be rapid, easily administrable, and cost-effective. There is a hierarchy of tests for the measurement of VA in children such as visually evoked potential testing, preferential looking tests, optokinetic nystagmus, picture charts, symbol/letter flash cards, and reading charts. The WHO recommends the use of log MAR based charts for vision screening.[5] In literate children, even though the assessment of VA is easier with Snellen chart, the accuracy of measurements is better with logMAR charts.[6]

Lea symbols (LS) chart was the first pediatric chart based on logMAR scale and is recommended by the National Research Council Committee on Vision.[7] It was developed in 1976 by Lea Hyvarinen and uses three symbols, a house, an apple, and a square, differing in few critical details from the fourth symbol, which is a circle. Below the threshold of recognition, each symbol appears as a small circle. The test is graded in logarithmic steps from 0.1 to 2.0 and is tested at a distance of 3 meters. It is available in single symbol and crowded symbol versions.[6]

The Sheridan Gardiner (SG) test chart is composed of seven vertically symmetrical and easily recognizable letters (H, U, X, T, A, V, and O). The child is to match the letter on the chart on his key card. It is based on Snellen principle.[6] LS chart is popular in the United States, Canada, and Germany, while SG chart is preferred in the United Kingdom.

According to the study done by Omar *et al*, among 700 Malaysian preschool children between 5 and 7 years, Lea symbol chart showed a higher sensitivity (97.5%) compared to SG chart (57.1%). However, SG chart showed higher specificity (92.0%) than LS chart (45%).[8]

Hered *et al* reported that the testing time was significantly less for older children, but was not related to the chart used for VA screening. Reliability indices were similar for LS and SG charts.[9]

Study done by Osaiyuwu and Atuanya among 153 preschool children in Nigeria, using the LS chart and SG chart showed

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a statistical difference in visual acuities ($P < 0.05$) detected by the charts.[10]

There are no previous studies conducted in India regarding the efficacy of LS chart and SG chart among preschool children. However, Sankar *et al*. had compared Bailey Lovie E chart, which is a logMAR-based chart like SG, with LS chart. This study concluded that Bailey Lovie E chart can be used interchangeably with LS chart in children aged 5–6 years, but not those between 3–4 years.[11]

As per the 2011 census, India has 164.48 million children in the age group of 0–6 years, of which 38 million belong to the preschool age group.[12] Although many studies have been done among preschool children in the West, discrepancies exist on the selection of age-appropriate chart for preschool vision screening in the Indian scenario. VA charts that are widely used in Western countries may not be directly applicable in our scenario due to their culture-specific clues and due to the differences in the educational systems for preschool children. The present study is conducted to evaluate the effectiveness of two VA charts, LS chart and SG chart, among preschool children in a semi-urban town of South India

Aim

- To compare the efficacy of LS chart and SG chart for vision screening among preschool children, in a semi-urban town of South India.

Objectives

- To compare the VA measurements by LS and SG in vision screening among preschool children, in a semi-urban town of South India
- To compare the time taken for screening using LS and SG in the above population
- To test the validity of LS and SG in the above population.

Methods

Cluster sampling from an educational district in South India was done, and the sample size was calculated using the formula $4pq/d^2$, based on the study by Omar *et al*.,[8] where p is the prevalence of refractive errors among preschool children, q is 100-p, and d is 20% of p. A multiplication factor of 2 was used to account for the design effect.

Preschool children between 3 and 5 years of age, from whom reliable VA measurements could be obtained, were included in the study. Children with neurological deficits, mental retardation, and multiple disabilities were excluded from the study.

The study adhered to the tenets of the Declaration of Helsinki and was approved by the Ethical Committee of the tertiary care eye hospital, before the commencement of the study. Informed consent letter was obtained from teachers/parents of children before the examination.

Procedure

Before the examination for VA, all the children underwent pretesting using LS and SG to ascertain whether the child could identify the symbols/letters on the charts. A card with a single large symbol in LS or letter in SG was held at 60 cm from the child, and the child was asked to match the symbol or letter on his/her key card. This procedure was repeated for the four symbols and six letters. Maximum of two chances to respond correctly to each card was given. Those children who responded correctly to all the cards were included in the study and others were excluded from the study.

Those who passed the pretest underwent vision screening using LG and SG. VA testing was conducted during the school hours in a room with good illumination (>300 lux). Simple random sampling using random number tables was used to determine the order of testing for the charts. LS was tested first for 125 children and SG for 126 children. The right eye was tested first followed by the left eye and care was taken to completely occlude the other eye. The scores were recorded in logMAR based on the number of correctly identified optotypes.[13]

LS 10-line folding pediatric eye chart and key card (250200, Good-Lite Co; Elgin, IL) was used and SG VA chart (with red and yellow covers, measuring the visual acuity ranges 6/60–6/18 and 6/18–6/6, respectively) and corresponding key cards (2204-P-1004, Keeler, Windsor, The United Kingdom) were used for screening and examination distance was 3 m. After building rapport with the patient, a standard procedure for screening of VA was performed. Testing always commenced at a well-recognizable level where the child instantly answered. If the first three questions at that level were answered correctly, the next higher line was used. If only two of the three symbols were answered correctly, the fourth symbol was asked. If this symbol was answered correctly, the examiner proceeded to the next line. If there were fewer than three correct answers, the previous line was taken as VA. If an answer was wrong, second chance was not permitted.

With SG chart, children who could identify all the letters in a row were tested for the next line. If the child could not identify all the letters in a line, the value of the previous line was considered as the threshold of VA. VA cutoff score for LS and SG was taken as the line corresponding to 0.3 logMAR. Those who could identify the cutoff line were denoted as "pass" and those who failed to identify the cutoff were denoted as "fail."

All the VA measurements were done by a single observer. Time taken for VA measurements of right and left eyes of each child was recorded using a stopwatch by a second independent observer, to which the first observer was blinded.

All the children underwent comprehensive ophthalmic examination at the base hospital. LS 10 line folding pediatric eye chart and key card (250200, Good-Lite Co; Elgin, IL) and SG VA chart (with red and yellow covers, measuring 6/60–6/18 and 6/18–6/6 respectively) and corresponding key cards (2204-P-1004, Keeler, Windsor, The United Kingdom) were used for VA testing at the base hospital, at a distance of 3 m by a single experienced examiner. Manifest refraction, cycloplegic retinoscopy, slit-lamp examination, and dilated fundus examination were also done under standard conditions. Cycloplegic refraction was done following instillation of one drop of Cyclopentolate 1% eye drops (Cyclomid eye drops 1% – JAWA pharmaceuticals) three times, 10 min apart. Cycloplegic refraction was done 30 min after the instillation of the last drop, by a single experienced pediatric optometrist.

Cycloplegic retinoscopy was considered as the gold standard and values obtained during screening with the two charts were classified as true positives (TP), false positives (FP),

true negatives (TN), and false negatives (FN), in relation to the cycloplegic values. Cylindrical or spherical errors from retinoscopy cross obtained after cycloplegia was used as a guide for estimating manifest refraction in our patients. The screening VA and the cycloplegic values were compared to categorize TP, FP, TN, and FN. Subjects, in whom both the cycloplegic retinoscopy and the VA estimated during screening indicated refractive error, were considered as TP. If both cycloplegic retinoscopy and VA estimated during screening did not indicate the presence of refractive error, they were considered as TN. If the cycloplegic retinoscopy did not indicate any refractive error, but VA estimated during screening did, they were considered as FP. If cycloplegic retinoscopy indicated refractive error; but VA screening did not, they were considered as FN. Glasses were prescribed for preschool children who required spectacle correction after postmydriatic test, 2 weeks later.[14]

Statistical analysis

Statistical analysis was performed using SPSS software for Windows version 20.0 (SPSS Inc., Chicago, Illinois, USA). Descriptive tests were used to analyze the VA data to determine the mean, standard deviation, and 95% confidence intervals. Comparison between the efficiency of LS and SG was determined using validity tests and unpaired *t*-test. $P < 0.05$ was taken as significant.

Results

In this cross-sectional observational study, 260 preschool children between 3 and 5 years of age were enrolled by cluster sampling and screened through onsite preschool vision screening camps by a trained ophthalmic team. Of the 260 children screened, only 251 children could pass the pretest and were allotted for the study. The final sample for analysis consisted of 502 eyes of 251 children between 3 and 5 years. Out of the total 251 children, 53.4% were 4 years of age, 39.4% were 5 years of age, and 7.2% were 3 years of age. There were 125 boys (48.80%) and 126 girls (50.20%) included in the study. One child did not turn up for detailed evaluation at the base hospital and was excluded from the validity analysis.

The mean VA score for right eye with LS was 0.19 ± 0.16 logMAR that for the left eye was 0.19 ± 0.15 logMAR. The mean VA score for right eye with SG was 0.03 ± 0.14 logMAR that for the left eye was 0.03 ± 0.10 logMAR. There was a significant difference between LS and SG charts in the VA scores in the right eyes ($P = 0.04$) and the left eyes ($P = 0.04$) [Table 1].

Vision screening with LS showed 76.09% pass score and 23.90% fail score with a cutoff value of 0.3 logMAR. Vision screening with SG chart showed 87.65% pass score and 12.35% fail score with the same cutoff value [Fig. 1].

Comparison of time taken for VA measurement during screening showed significant difference between the two charts. Mean time for measurement in the right eye was 77.10 ± 48.93 s for LS and 47.27 ± 30.18 s for SG. Mean time for measurement in the left eye was 69.13 ± 39.18 s for LS and 45.20 ± 29.57 s for SG. Mean time for LS was higher compared to SG both for the right eyes ($P = 0.001$) and the left eyes ($P = 0.001$).

Comparison of VA measurement time across the three different ages showed that mean time was higher among 3 years old group when compared to 4 and 5 years old groups ($P = 0.00$, ANOVA) [Table 2]. *Post hoc* tests using Bonferroni correction revealed that the difference was significant when the 3-year-old group was compared with 4- and 5-year old groups ($P = 0.04$ and $P = 0.02$, respectively). There was no significant difference between the 4- and 5-year old groups ($P = 0.32$).

Table 1: Estimated visual acuity scores with Lea Symbols and Sheridan Gardiner charts

Chart/eye tested	*n*	Mean±SD (logMAR)	*P*
LS: Right eye	251	0.19±0.16	0.04
SG: Right eye	251	0.03±0.14	
LS: Left eye	251	0.19±0.15	0.04
SG: Left eye	251	0.03±0.10	

LS: Lea symbols chart, SG: Sheridan Gardiner chart,
SD: Standard deviation, logMAR: Logarithm of minimum angle of resolution

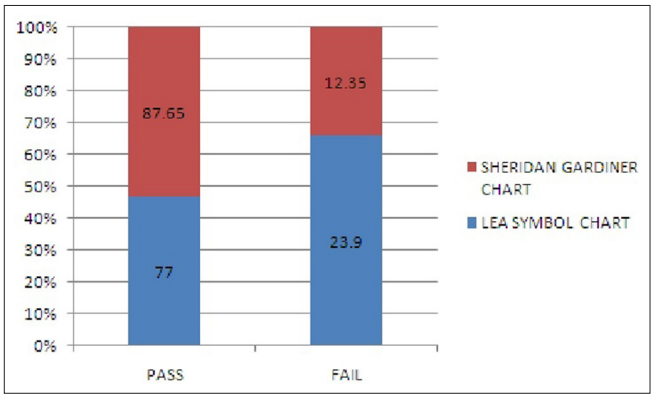

Figure 1: Comparison of outcomes of screening between Lea Symbols chart and Sheridan Gardiner chart

The VA estimates obtained from LS and SG of 500 eyes of 250 children were analyzed against the gold standard of cycloplegic retinoscopy, using 2 × 2 tables. Based on 2 × 2 tables, sensitivity, specificity, positive predictive value, and negative predictive values were calculated. The results of validity tests are shown in Table 3 and Fig. 2.

Discussion

According to our study, the mean VA scores were higher by 0.16 ± 0.02 logMAR in the right eyes ($P = 0.04$) and 0.17 ± 0.05 logMAR for the left eyes (0.04) in the SG when compared to the LS. This indicates that our sample of preschool children had more difficulty in identifying the LS optotypes than SG optotypes. This could be attributed to the difference in the nature of optotypes, grading scales, and the technique of scoring the VA used in both the charts. LS had consistent scales with an increment of 0.10 log unit for each line compared to SG, which uses a 0.20 log unit scale for every change in the unit.

Our study showed that there was a significant difference in the VA scores obtained from LS and SG. Previous studies have also documented this difference.[8,10,15] We also observed that the SG tends to overestimate VA scores when compared to LS. Studies done by Simmers *et al*.,[15], Schlenker *et al*.,[16] and Osaiyuwu and Atuanya[10] have documented this previously. Osaiyuwu and Atuanya[10] also commented that this tendency is seen the lower logMAR VA scores. However, a few other studies did not show a statistical difference in the estimated VA scores between LS and the HOTV chart among 3–3.5 year olds.[9,17-19]

Table 2: Time taken for screening with Lea Symbol and Sheridan Gardiner charts in different age groups

Chart/eye tested	Age	Number of children	Mean time±SD (s)
LS: Right eye	3	18	139.34±79.57
	4	134	80.85±42.86
	5	99	63.54±38.38
SG: Right eye	3	18	109.50±58.36
	4	134	72.36±35.29
	5	99	59.85±32.61
LS: Left eye	3	18	75.06±35.08
	4	134	55.25±31.04
	5	99	30.92±17.44
SG: Left eye	3	18	67.95±29.86
	4	134	53.83±31.08
	5	99	29.37±17.77

LS: Lea symbols chart, SG: Sheridan Gardiner chart, SD: Standard deviation

There was a significant difference in testing time between two charts. Mean time for LS was higher compared to SG both for the right eyes ($P < 0.001$) and the left eyes ($P < 0.001$). Generally, in India, the education system mainly focuses on familiarizing letters at very early age than symbols. This could have made the identification of optotypes in SG easier than the LS. Moreover, the identification and verbalization of symbols in the LS was observed to be more difficult among our sample.

There was a significant difference in VA testing time among the different age groups. As expected, testing time was higher for the youngest 3-year-old group, which could be due to the shorter attention span of younger children. Similar findings in VA score were found in previous Osaiyuwu and Atuanya[10] Hered *et al*. had observed that, among the 3 year olds, the cooperation rate was 92% with LS, whereas it was 85% with HOTV chart.[9] Becker *et al*.[20] reported that LS had an acceptability of 77% compared to Landolt C chart (48%), in children older than 30 months. Mean time was higher for the right eyes with both the charts and could be explained with the help of learning curve involved during testing.

In the present study, LS showed a higher sensitivity (94.74%) than SG chart (53.63%) and the number of children who failed screening with LS (23.90%) was almost twice than those who failed SG (12.35%). This indicates that LS had a greater pickup rate than SG when the VA threshold for detection was 0.33 logMAR units. In other words, if the SG was used for screening preschool children, 43.67% children would not be identified to have refractive errors, compared to 5.26% if the LS were used.

In the study done by Omar *et al*.[8] among 700 children between the age groups of 5 and 7 years, LS showed a sensitivity of 97.5% and SG showed a sensitivity of 57.1%. However, SG chart had higher specificity (92.0%) than LS (45.0%). Simmers *et al*. observed that SG was less sensitive in detecting amblyopia when compared to the Glasgow Acuity chart, which is a logMAR-based chart similar to the LS chart.[15] Sanker *et al*. found that LS was comparable to the Bailey Lovie E chart for screening preschool children.[11]

SG chart had higher specificity (83.33%) compared to LS (66.67%). This was observed by Omar *et al*. also.[8] This does

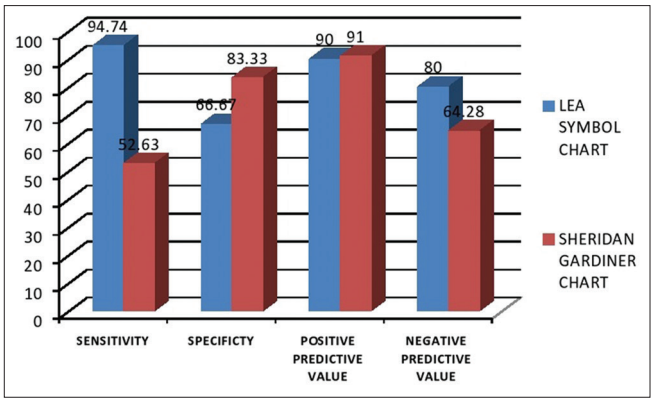

Figure 2: Comparison of validity indices between Lea Symbols chart and Sheridan Gardiner chart

not provide any added advantage to the SG in terms of its utility as a screening tool. The strength of a VA screening tool depends on the sensitivity and negative predictive value. As per our study, LS performed better than SG in terms of sensitivity and negative predictive value. Hence, it is the preferred tool over SG for preschool vision screening in our population.

The merits of our study include relatively large sample size and adequate numbers turning up for follow-up examinations. This has helped us in analyzing validity tests for the two charts with reliability. Another factor which ensured reliability of the tests was inclusion of only those children who had passed the pretest. Although the testability and between-test agreement of LS and HOTV tests had been previously reported in the Western population,[20] this was repeated in our study so as to account for the culture-specific learning patterns of Indian preschool children.

A limitation of our study was that subgroup analysis based on the type of refractive error and severity of visual deficit was not performed. This precludes interpretations based on these factors. The influence of age and attention span are likely to affect the time for screening as well as the reliability of measurements in preschool children. These factors are to be considered during the interpretation of any studies on VA estimates in young children. Measured acuity largely depends on the examined group, the situation, and the motivation of the child.[21]

In our study, LS showed better sensitivity and negative predictive value, when compared to SG. Therefore, LS is the preferred VA screening tool for preschool children in our population. However, screening with LS was more time-consuming than that with SG. This should not be seen as a hurdle, and more emphasis should be on the reliability of measurements rather than time required for screening, to ensure success and sustainability of screening models.

Conclusion

In our study, LS showed better sensitivity and negative predictive value, when compared to SG chart. However, SG showed better specificity and positive predictive value and was less time-consuming. Considering the high sensitivity and negative predictive value, LS is the preferred tool than SG in preschool vision screening in our population.

Table 3: Comparison of validity tests between Lea Symbols chart and Sheridan Gardiner chart

	Refractive error estimated in cycloplegic retinoscopy			Validity tests			
	Present	Absent	Total	Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)
Lea symbols chart							
Test positive	180	20	200	94.74% (70.13%-81.06%)	66.67% (90.26%-97.30%)	90.00% (84.77%-93.63%)	80.00% (80.00%-65.55%)
Test negative	10	40	50				
Total	190	60	250				
Sheridan Gardiner chart							
Test positive	100	10	110	52.63% (45.29%-59.8%)	83.33% (70.12%-91.30%)	91.00% (83.52%-95.31%)	64.28% (55.70%-72.07%)
Test negative	90	50	140				
Total	190	60	250				

CI: Confidence interval

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Conflicts of interest

There are no conflicts of interest.

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