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ORIGINAL ARTICLE

Agreement between Lea Symbols and Patti Pics visual acuity in children and adults

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Abstract
Background: Patti Pics (PP) and Lea Symbols (LS) are commonly used by eye care practitioners worldwide. Although the relationship between the two tests is fairly well understood, the availability of different chart designs (single optotypes, multiple optotypes, multiple optotypes with crowding box) merits futher understanding. The purpose of this study is to explore the agreement between the acuity measures obtained with Patti Pics and Lea Symbols in children and adults and compare their performance with the Sloan Letter (SL) chart in adults.
Methods: Monocular visual acuity was obtained from ninety-three 3 to 5-year-old children using Patti Pics and Lea Symbols. Acuities were also obtained from 113 adults using the same tests under identical conditions. Acuity results obtained with the pediatric tests were compared with the gold-standard Sloan Letter chart in adults. The Bland-Altman method was implemented to compare the level of agreement between tests.
Results: Patti Pics yielded worse visual acuity than the Lea Symbols by approximately half a logMAR line in both children (mean difference: -0.07 ± 0.07 logMAR, p <0.01) and adults (Mean difference: -0.05 ± 0.06 logMAR, p <0.01). The 95% limits of agreement between Lea Symbol acuity and Patti pics acuity in children was ± 0.14 logMAR. Mean difference between the Sloan Letter chart and Lea Symbols acuity was not statistically significant (p = 0.08) in adults but the difference was statistically significant between PP and SL (p<0.001). The 95% limits of agreement between LS and SL and between PP and SL was ± 0.19 logMAR and ± 0.22 logMAR, respectively.
Conclusion: Patti Pics consistently underestimated visual acuity as compared to Lea Symbols both in children and adults although the differences were not clinically significant. The LS and PP did not yield clinically significant differences in acuities when compared with Sloan letters in adults.

Abbreviations: VA, visual acuity; LogMAR, logarithm of the minimum angle of resolution; MassVAT, Massachusetts visual acuity test; ETDRS, early treatment diabetic retinopathy study; LVRC, Low Vision Resource Centre; LS, Lea symbols; PP, Patti pics; SL, Sloan letters.

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Background

Detecting vision anomalies and treating them in as early as possible in life is crucial not only to ensure normal visual development,[1] but also for unimpeded cognitive development.[2] Recognition visual acuity is the most commonly assessed domain of the visual function and is considered as a standard measure of visual performance in humans.[3] Recognition visual acuity in adults is assessed using letter charts however such charts are not applicable to preschool children due to their poor verbal fluency, limited attention span and active behavior.[4,5] Over the last 15–20 years, realizing the importance of vision in early life various professional organizations and societies worldwide have shown a significant amount of interest in vision screening in preschool children.[6] The main aim of such screening programs is the early detection of refractive error and amblyopia, the two most common treatable visual disorders in children. In line with this increasing interest in preschool screening, there has been a rapid increase in the development of tests for recognition acuity. To our knowledge, over 30 recognition acuity tests applicable to children below 5 years are commercially available.[5] The results of the tests, however, are inconsistent among one another and also as compared to the adult gold standard ETDRS test or the Sloan Letter chart. The tests differ in the type of optotype design (object vs. letters) and layout (flipchart vs. single chart). Moreover, they also differ in cognitive demand. For instance, Cardiff acuity test requires a relatively low cognitive demand as compared to the HOTV, the Cambridge Acuity test or the Landolt's C.[5] Based on our experience there also appears to be a preference on use of pediatric acuity tests by clinicians according to regions of the world.

While most of the US-based practices use Lea Symbols or HOTV for measuring acuity in preschool children[7,8] UK based practices are inclined to use Kay Picture test, Sonksen Acuity Test or the Cambridge Acuity tests.[9–11] The situation may have changed lately but we still belive that there is some preference of chart use according to their geographical region of development.

Nevertheless, the Lea Symbols test has been the most popular test for assessing visual acuity in preschool children worldwide.[12] In recent years, the Patti Pics acuity test has also gained a lot of interest among pediatric practices which could be due to its optotypes (Flower, house, circle, square, apple) being more appealing to children than the Lea Symbols. As different clinicians may use different tests to measure acuity, it is necessary to understand the relationship between the tests so that appropriate modifications can be made to enhance diagnostic accuracy. Therefore, in this study, we aimed to compare visual acuity performance of children and adults between the two most commonly used pediatric tests {the Lea Symbols and Patti Pics and also with the gold standard adult acuity test (the Sloan Letter Chart)} in adults.

Methods

The ethical approval was obtained from the Institutional Review Board, Institute of Medicine, Tribhuvan University, Nepal. The tenets of the Declaration of Helsinki were followed while assessing participants. Written informed consent was obtained from adults participants, and consent from guardians was obtained for the child participants. All of the participants were clinic attending population who attended our center (B.P.Koirala Lions Centre for Ophthalmic Studies, Kathmandu, Nepal) for different ophthalmic conditions. Monocular presenting visual acuity was obtained from 93 children (47% male) aged 3–5 years and 113 adults (57% male) aged 18–55 years. Externally illuminated Patti Pics Chart (Patti Pics 10 Line Folding Chart, Precision Vision, USA)[14] and Lea Symbols chart (LEA SYMBOLS® 10-Line Distance Chart, Good Lite, USA)[15] were used. (Fig. 1) The order of the testing chart was randomized for each child and adult. The same charts were used in adults in addition to the Sloan Letter Chart (Low Vision Resource Centre, LogMAR Chart, Hong Kong Society for the Blind) (Fig. 1). The pediatric charts were used at 3 m whereas the Sloan Letter Chart was used at 4 m. The test charts used in our study were without crowding bars unlike those of the MassVAT charts. The testing was conducted under identical illumination (normal clinical examination illumination) for children as well as adults. The optotype-by-optotype scoring was employed for measuring the threshold visual acuity. The stopping rule was when three or more optotypes/letters in a line were read incorrectly. If the participant was unable to name any two optotypes in a given line, then threshold acuity was calculated by considering the VA value of the preceding line and the number of optotypes read in the given line. But if the participant could identify three optotypes out of 5, then the test was continued until they were unable to identify 2 or more optotypes of a particular line. The final VA was adjusted accordingly. Differences greater than 1 logMAR line were considered clinically significant as differences below 1 logMAR are within test-retest variability of adult gold standard logMAR tests.[13]

Results

The mean ± SD age of the child participants was 4.14 ± 0.80 years, and the mean ± SD age of adult participants were 33.6 ± 10.40 years.

Visual acuity in children

The mean Lea Symbols visual acuity was 0.18 ± 0.14 logMAR (range, 0.00 to 0.54 logMAR) whereas the mean Patti Pics visual acuity was 0.25 ± 0.13 logMAR (range, 0.00 to 0.60). A significant difference was observed between the acuities measured with the two tests (Mean difference: −0.07 ± 0.07 logMAR, 95% CI: −0.08 to −0.05, $p<0.001$, paired sample test)) whereby the Lea symbols acuity was one half a line (3.5 letters) better than the Patti Pics acuity. Further analysis revealed that, in 84% of the measurements, Lea Symbols determined better acuity than the Patti Pics. Six percent of the measurements revealed identical estimation of visual acuity between the two tests. There was a strong correlation between the acuities obtained via the two tests (r = 0.85, p <0.001). The Bland Altman method of comparison revealed that the 95% Limits of Agreement (LoA) between the two tests were 0.07 to −0.22 logMAR (Fig. 2).

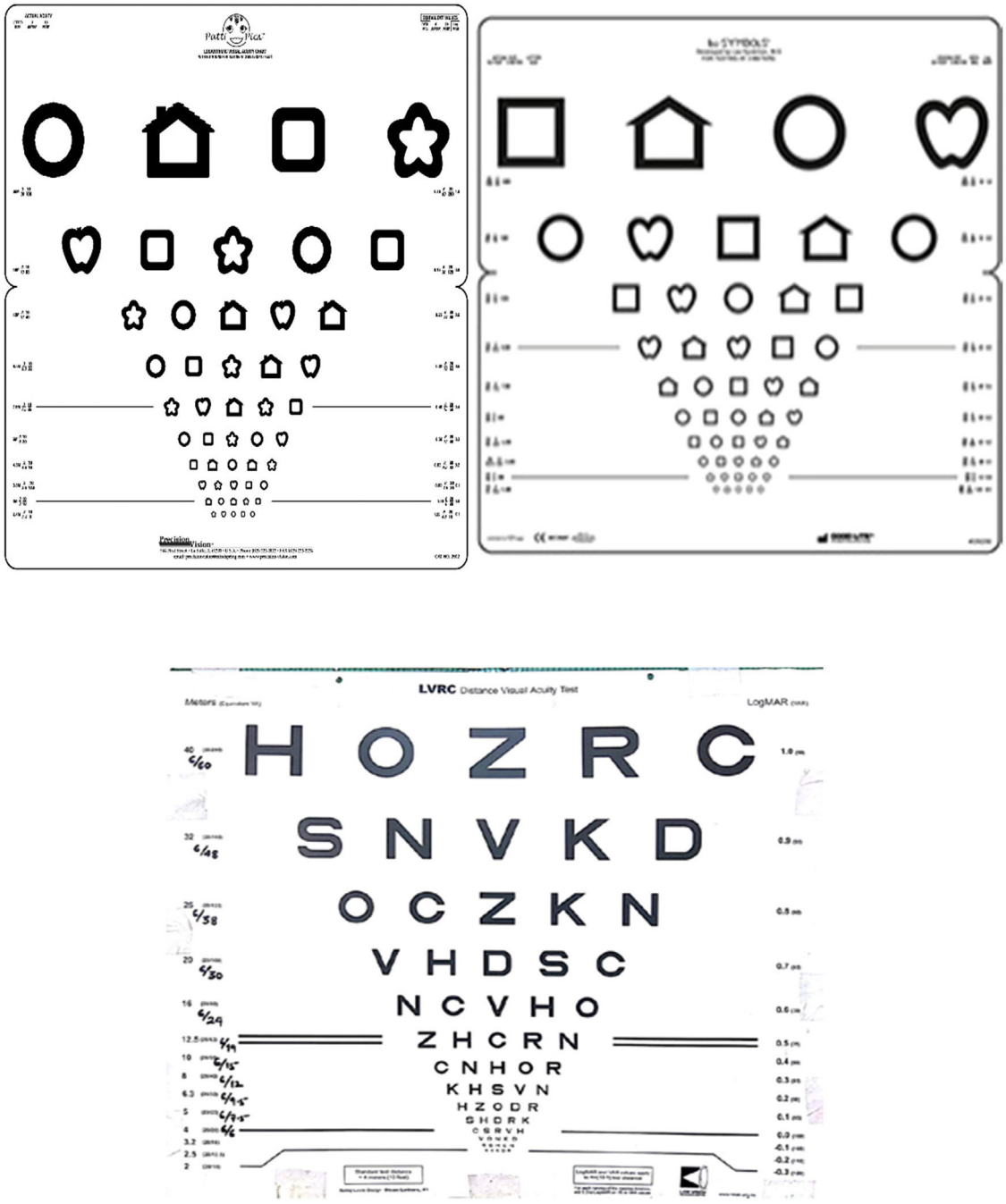

Fig. 1 Patti Pics (Left), Lea Symbols (Right) and Bailey- Lovie chart (Below).

Visual acuity in adults

The mean ± SD Lea Symbols visual acuity was 0.08 ± 0.10 logMAR (range, 0.00 to 0.44), the mean ± SD Patti Pics visual acuity was 0.13 ± 0.12 logMAR (range, 0.00 to 0.48) and the mean ± SD Sloan Letter acuity was 0.06 ± 0.09 logMAR (range, 0.00 to 0.38). An one way repeated measures ANOVA with a Greenhouse-Geisser correction revealed that the mean visual acuity differed statistically significantly between the three tests ($F(2336)) = 13.54$, $p < 0.001$). Post hoc tests using the Bonferroni correction revealed a significant difference between Lea Symbols acuity and the Sloan Letter acuity (mean difference: 0.02 ± 0.10 logMAR (1 letter), 95% CI: −0.01 to 0.05, $p = 0.02$), the Lea Symbols acuity and the Patti Pics acuity (mean difference: −0.05 ± 0.06 (2 and half letters), 95% CI, −0.08 to −0.02, $p<0.001$) and the Patti Pics and the Sloan Letter acuity (mean difference: 0.07± 0.10 (3.5 letters), 95% CI, 0.03 to 0.01, $p < 0.001$). None of these differences can be considered as clinically significant as they are within the range of test-retest variability of adult gold standard tests. Between the Lea Symbols and Patti Pics, 71% of the acuities measured were better with Lea Symbols whereas 25% acuities were identical. Between the Lea Symbols and Sloan Letter chart, 50% of the acuities

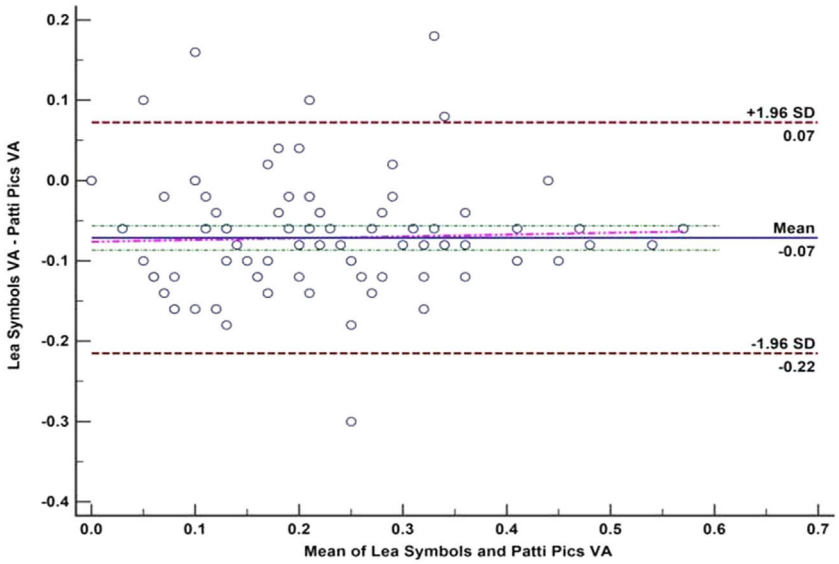

Fig. 2 Bland and Altman Plot: Lea symbols vs Patti Pics in children.

were better with Lea Symbols whereas 35% acuities were identical. Between the Patti Pics and Sloan Letter chart, 51% of the acuities were better with Sloan Letter chart whereas 22% of the acuities were identical.

The Bland Altman method of comparison revealed that the 95% Limits of Agreement (LoA) between the LS and PP was 0.07 to −0.17 logMAR (a range of 2 and half logMAR lines) (Fig. 3). Simlarly, the 95% limits of agreement between LS and SL and PP and SL were 0.23 to −0.18 logMAR (Fig. 4) and 0.29 to −0.14 logMAR (Fig. 5) respectively (a range of 4 logMAR lines).

Even when the adult and children's data were combined, Lea Symbols yielded significantly better estimates of VA than the Patti Pics (mean difference, −0.06 ± 0.06 logMAR, $p<0.001$).

Discussion

Our study aimed to compare visual acuity performance of children and adults between the two most widely used pediatric tests. Considering the children data first, our results demonstrated that Lea Symbols yield better estimates of visual acuity than the Patti Pics. The mean difference between the two tests was identical to a similar previous study.[14] The limit of agreement between the two tests was also moderate ± 0.14 log MAR and was slightly narrower than in the previous study.[17] The regression line within the Bland Altman plot demonstrated a symmetrical bias over the range of acuities. This indicates that within the range of acuity included in this study it may be possible to utilize a correction factor while converting acuity values between Lea Symbols and Patti Pics. The correction factor basically being the mean difference between the two tests.

Similar to children, Lea symbols yielded better estimates of acuity than Patti Pics in adults. However, the magnitude of difference was smaller than in children. This was in contrast to a previous study that found an increase in the magnitude of difference in adults as compared to children.[14] Interestingly, the Sloan Letter chart yielded better estimates of acuity than the Patti Pics but identical estimates with Lea Symbols in adults in this study. This again was in contrast to the study by Mercer et al., where they found identical estimation between Patti Pics and Sloan chart but better acuity estimation by Lea Symbols as compared to Sloan Letters.[14] One of the reasons for this difference could be the use of different test charts between the studies. We used the crowded Sloan Letter chart without a surrounding box whereas Mercer et al. used crowded MassVAT Sloan letters chart with crowding boxes positioned at the distance of 0.5 letter width away from the letters.[7,15,16] Patti Pics yielded worse acuity than LS in children and LS and Sloan Letter chart in adults. The discrepancy in the estimation by Lea Symbols, Patti Pics and Sloan Letter chart could be due to their inherent optotype design. Patti Pics could be the hardest optotypes to recognize when the recognition limit is approached. The Lea Symbol and Sloan Letters optotype have sharp edges and borders whereas some of the Patti Pics optotypes have curved edges (square, flower, apple) and irregular borders (circle, house) (Fig. 1). This property of the optotype may render Patti Pics more difficult to recognize when the recognition limit is approached. Another possibility could be the significant optotype dissimilarity of Patti Pics as reported by Candy et al.[19] Candy et al. showed that while the Lea Symbols and the Sloan letters have non-significant dissimilarity between their optotype sets, the Patti Pics optotypes have significant dissimilarity among one another. However, Candy et al.'s study was conducted among adult participants with normal acuity which could be different when the same optotypes are presented to participants with poor acuity or in children. The finding that the Lea Symbols yielded better visual acuity as compared to Patti Pics was true even when the adult and children data were combined. This finding was in contrast with the study by Singman et al.[18] where Lea Symbols and Patti pics revealed similar results.

The magnitude of the difference between the two pediatric tests in adults in our study was smaller than an earlier

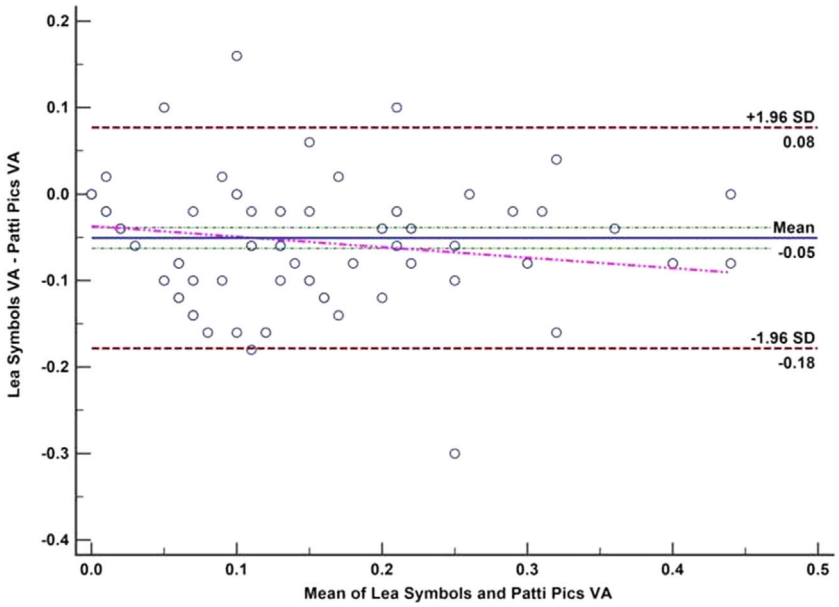

Fig. 3 Bland and Altman Plot: Lea symbols vs Patti Pics in adult.

study.[14] This could be due to our study involving adults with a range of visual acuities, unlike the earlier study that had 60% of the adults with an acuity of - 0.1 log MAR. The previous study further argues that the discrepancy could have been more if the Lea Symbols and Patti Pics tests had acuity levels better than −0.1 log MAR. Our study demonstrated a significant but small difference between the Lea Symbols and Sloan Letter Chart which is in contrast to previous studies that have found over-estimation of Lea Symbols as compared to ETDRS, Bailey Lovie, and Landolt's C by between 0.05 to 1 logMAR line both in adults and children. The use of different chart designs used in this study and previous studies may have led to this discrepancy. One possibility of the small between LS and SL but a slightly bigger difference between PP and SL in our study could be due to the design of LS which was essentially designed by empirically matching with letters whereas the Patti Pics were based on the Snellen principle wherein the width of the optotype is 1/5th of the total size. Our finding was in line with the study by Richardson and Davis[18] where Lea Symbols and ETDRS chart yielded similar estimates of acuity. It must be noted that none of the previous studies have compared the same charts that we used in this study hence some discrepancy between their studies and ours is expected. Even though there was a non-significant difference between the acuity values obtained with the Lea Symbols and the Sloan Letter chart, the 95%

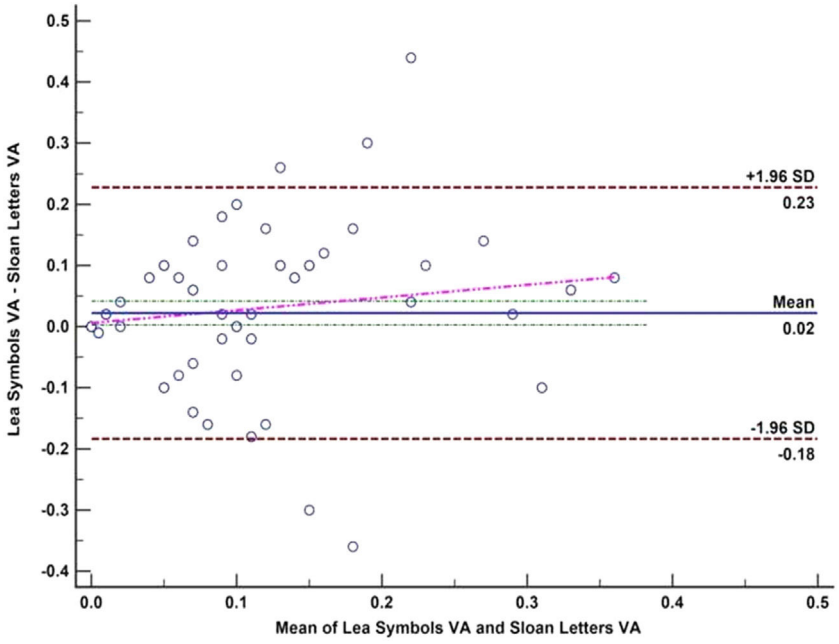

Fig. 4 Bland and Altman Plot: Lea symbols vs Sloan in adult.

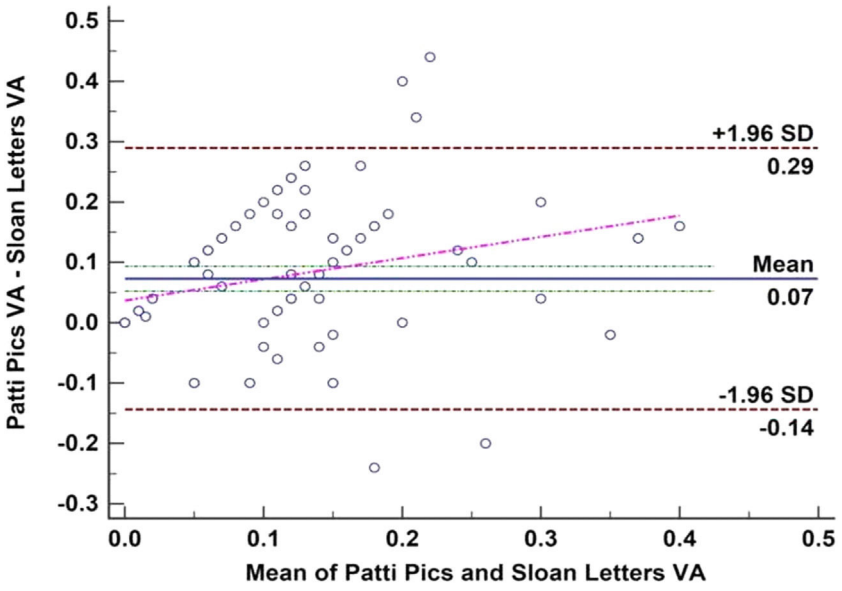

Fig. 5 Bland and Altman Plot: Patti vs Sloan in adult.

limit of agreement was essentially similar to that between Patti Pics and Sloan Letter chart. This signifies that both the Patti Pics and Lea Symbols provide estimates similar to that of Sloan Letter chart in adults.

Some limitations of this study must be acknowledged. Firstly, the range of acuity in our study was between 0.00 to 0.54 logMAR for Lea Symbols and 0.00 to 0.60 logMAR for Patti Pics which limit the generalisability of our research findings in all preschool children, particularly those at risk of having very poor vision (poor than 0.60 logMAR). However, studies have shown that visual acuity lies between this range for the vast majority of the preschool population. Two major studies[12,16] have revealed that the majority of the children's visual acuity lies within this range. It could be argued, therefore, that our findings are applicable to the vast majority of the typical clinical population. Secondly, researchers may argue on the usefulness of such a study when electronic visual acuity tests are gaining popularity among clinicians and researchers. However, we still think that this study will be a valuable addition to the clinical community as there is very little evidence on the validation of such electronic pediatric visual acuity tests. We believe that researchers and clinicians, particularly those working in developing countries will continue to use non-electronic tests at least for a few more years. Thirdly, we did not compare the performance of the tests based on ocular pathology. Grouping participants according to different ocular conditions would have given a more detail on how these charts perform under different pathological conditions.

Conclusion

In conclusion, Lea Symbols consistently provided better acuity than Patti Pics both in adults and children but these differences were clinically insignificant. The symmetrical bias between the two tests over a range of acuities used in our study signifies that the LS and the PP may be interchangeably used. Lea Symbols and Patti Pics provided statistical significant difference but it was clinically irrelevant to Sloan Letter chart in adults. However, the wide spread of limits of agreement between LS and SL and PP and SL may imply that we be cautious while interpreting these findings. These findings will be particularly crucial while determining referral criteria in children, converting visual acuity results from one test to another while visiting different clinicians who may use different tests and predicting long-term visual outcome.

Ethics approval and consent to participate

Ethical approval was obtained from the Institutional review Board, Institute of Medicine, Tribhuvan University, Kathmandu, Nepal. Written consent to participate was taken from guardians of all of the children for children and from adult themselves for adult participants.

Consent for publication

Not applicable.

Availability of data and material

The data can be available from the authors on reasonable request.

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Authors' contribution

AS performed data collection, analysed the data and drafted the first version of the manuscript. SS, GSS, BK and NDJ supervised the overall project, provided important intellectual input to various versions of the manuscript.AS, NP conceptualized the project and methodology, assisted with data analysis and reviewed various versions of the manuscript for intellectual content. All authors read and approved the final manuscript.

Conflicts of interest

No competing interest to declare.

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