Original Article

Comparison of Applicability of Different Visual Acuity Charts for Pediatric Outpatient Visual Tests

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Abstract

Purpose: To evaluate the applicability of different visual acuity charts for outpatient pediatric visual tests.

Methods: Fifty-three children (53 eyes) aged 4-8 years undergoing visual acuity tests as outpatients were randomly selected for this study. The best corrected visual acuity (BCVA) of the eye with better visual acuity was measured for each child using the digital LogMAR visual chart, the ETDRS visual chart, and a new standard logarithm visual chart; all measurements were repeated twice and the BCVA was recorded. Paired comparisons were made between the LogMAR visual acuity chart and ETDRS chart measurements or between the ETDRS chart and logarithm visual acuity chart measurements for statistical analysis of the differences in measurement of visual acuity. The results of different measurements by the same chart were compared to evaluate the consistency of the measurement results. Bland-Altman analysis was employed to evaluate the most suitable chart for outpatient measurement of visual acuity in children.

Results: Bland-Altman analysis revealed that the mean visual acuity measured was (0.447±0.017 LogMAR) by the digital LogMAR chart, (0.301±0.024 LogMAR) by the standard logarithm visual acuity chart, and (0.309±0.018 LogMAR) by the ETDRS visual acuity chart. The BCVA was significantly lower when measured by the LogMAR visual acuity chart than by the ETDRS chart ($P<0.01$). The BCVA was slightly higher when measured by the logarithm visual acuity chart than by the ETDRS chart, but the difference was not statistically significant($P>0.05$). The Bland-Altman plot showed that the highest consistency was obtained with the digital LogMAR chart, with a difference between two repeated measurements of 0.068 LogMAR, compared to 0.090 and 0.072 LogMAR for the logarithm and ETDRS visual acuity charts, respectively.

Conclusion: All three types of visual acuity charts are applicable for outpatient measurement of pediatric visual acuity. The ETDRS and logarithm visual acuity charts have a higher consistency, but the LogMAR visual acuity chart shows better reproducibility. Consequently, it is difficult to identify and distinguish which acuity chart is most suitable for cooperative children. (***Eye Science 2014*; *29*:*90-94***)

Keywords: visual acuity chart; children; visual acuity; applicability

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Introduction

At present, no consensus has been reached on the best visual acuity chart for use on outpatients in China. Different patients have different requirements for the visual acuity chart. Patients with severe fundus diseases present with significantly low contrast, sensitivity, and visual acuity, and therefore require a visual acuity chart with relatively high contrast[1-3]. If the same visual acuity chart is adopted for all outpatients, this would influence the accuracy of the visual acuity test for these special patients[4,5]. Consequently, an appropriate visual acuity chart should be selected for different types of patients in order to guarantee the accuracy of the visual test and to contribute to correct evaluation of the severity of diseases in outpatients.

Compared with normal adults, children have poorer cooperation ability, understanding capacity, and reaction speed[6-8]. Consequently, children require a visual acuity chart with high stability and accuracy. In this study, the logarithm visual acuity, ETDRS, and digital LogMAR charts were employed to measure the visual acuity in 53 children admitted to our hospital in 2014. Our aim was to evaluate their applicability for visual acuity tests by statistical comparison in order to identify a scientific and rational visual acuity chart for use in children in outpatient conditions.

Subjects and methods

Study subjects

Fifty-three children (53 eyes) aged 4-8 years (24 males and 29 females) were randomly chosen for outpatient visual acuity tests. All patients received training prior to the study and had good cooperation and cognitive capacity. The Digital LogMAR, ETDRS and logarithm visual acuity charts were selected to perform visual acuity measurements under natural lighting (illumination 400-500 lux).

Methods

Examination distance: the examination distance of logarithm visual acuity chart was 5 m, while it was 3 m for the ETDRS and digital visual acuity charts.

Visual acuity test: the patients stood at a corresponding distance and covered their eyes using a plate, without eyeball oppression. The patients kept their heads straight and eye open during the examination. The right eye was first examined and then the left one. The eye with better visual acuity (either eye, when the visual acuity was identical) was selected for visual tests by three categories of visual acuity charts. Each measurement was repeated twice at an interval of 2-3 min. The visual test proceeded at a uniform speed until the BCVA was measured and recorded. The measured data were expressed as Snellen fractions and transformed into the logarithm of minimum separable angle.

Statistical analysis

MedCalc 13.2 and SPSS statistical softwares were utilized for data analysis. Bland-Altman analysis was adopted for statistical comparison of the difference in measurement outcomes by the three types of visual charts. The consistency of two repeated measurements by the same visual chart was calculated and compared among the three categories of visual charts.

Results

The Bland-Altman plots of LogMAR and ETDRS visual acuity charts are shown in Figure 1.

The maximum value within the consistency limits

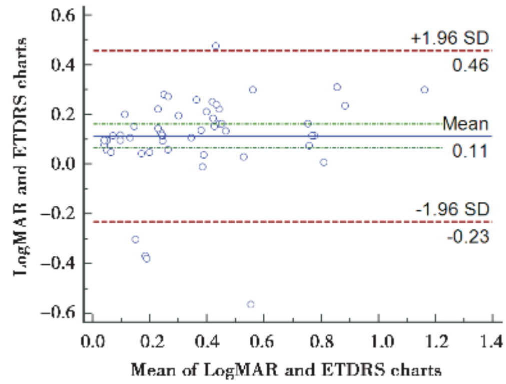

Figure 1 The full line denotes the mean difference between two repeated measurements. The upper and lower dashed lines denote the limits of 95% consistency.

was 0.46 LogMAR and the minimum was -0.23 LogMAR. The upper limit of 95% consistency was 0.69 LogMAR, which exceeded the general error range (0.2 LogMAR), indicating that these two visual charts had a low consistency.

The Bland-Altman plots of the logarithm and ETDRS visual acuity charts are shown in Table 2.

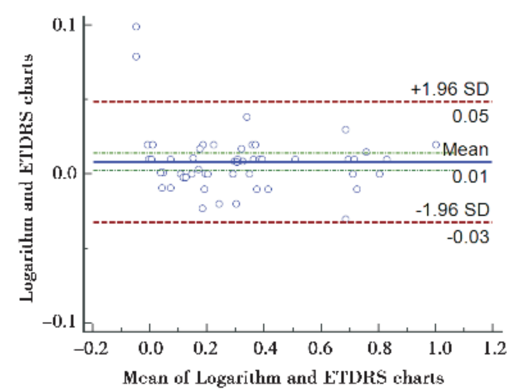

Figure 2 The maximum value within the consistency limits was 0.05 LogMAR and the minimum was -0.03 LogMAR. The upper limit of 95% consistency was 0.08 LogMAR, consistent with the general error range (0.2 LogMAR), indicating that these two visual charts have a high consistency.

Comparison of two repeated measurements using the same visual chart

The Bland-Altman plot of two repeated measurements of the logarithm visual acuity chart is illustrated in Figure 3.

The Bland-Altman plot of two repeated measurements for the ETDRS visual acuity chart is illustrat-

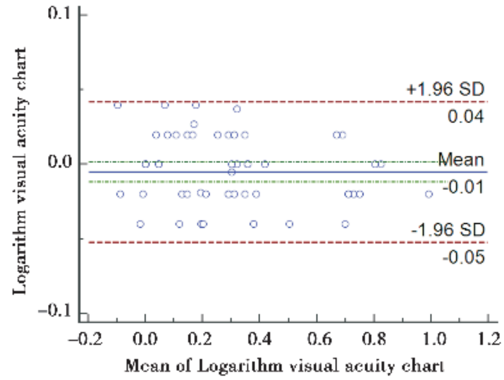

Figure 3 The maximum value within the consistency limits was 0.04 LogMAR and the minimum was -0.05 LogMAR. The upper limit of 95% consistency was less than 0.2 LogMAR, indicating that these two charts have a high consistency.

ed in Figure 4.

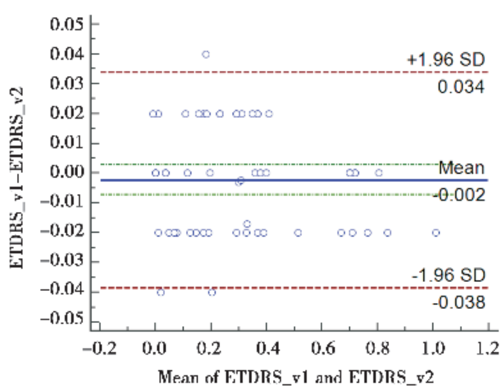

Figure 4 The maximum value within consistency limits was 0.034 LogMAR and the minimum was -0.038 LogMAR. The upper limit of 95% consistency was less than 0.072 LogMAR, indicating that these two charts have a high consistency.

Bland-Altman plot of two repeated measurements of the LogMAR visual acuity chart is illustrated in Figure 5.

Discussion

The three categories of visual charts studied here were designed based upon the Weber-Fechner law by using the incremental principle. The new standard logarithm visual chart GB11533-2011 had the 0.05 line deleted and the 0.12 line added. In addition, the minimum target was increased from 1 to 2. The proportion of the target of each line was 1:1. The incidence of the crowded phenomenon was decreased in amblyopic patients by increasing the number of tar-

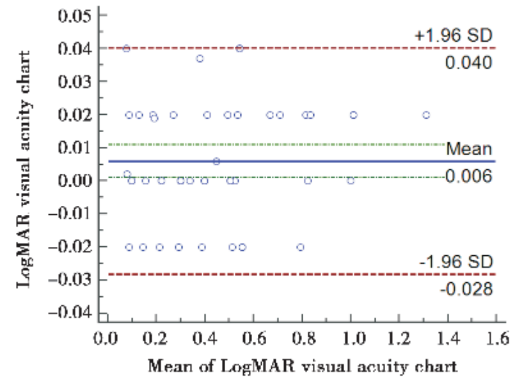

Figure 5 The maximum value within consistency limits was 0.04 LogMAR and the minimum was −0.028 LogMAR. The upper limit of 95% consistency was less than 0.12 LogMAR, indicating that these two charts have a high consistency.

gets in each line[9,10]. The ETDRS visual chart is recommended by the United States National Academy of Science and is regarded globally as the gold standard for visual acuity examination. This chart has been widely applied in clinical practice due to its high accuracy[11,12]. For the purpose of convenient identification for Chinese individuals, the digital LogMAR and E visual charts were re-designed based on the original ETDRS visual chart by converting English targets into numbers and E characters. The digital LogMAR visual chart has six targets including 2, 3, 5, 6, 8, and 9, which is more difficult to distinguish when compared with the E visual chart. Bland-Altman analysis revealed that the difference in visual acuity measured by the LogMAR and ETDRS visual charts was 0.69 LogMAR, which was higher than the general limit of 0.2 LogMAR. A paired t-test also indicated a statistical significance between the two charts (P<0.01). In all cases, 3 children were able to recognize the E visual chart rather than the digital LogMAR visual chart. Previous studies reported that children showed better behavioral expression than language expression[13,14]. Patients could use their fingers to point out a direction during a visual test with the E chart. In the present study, significantly more time was required to conduct a visual examination using the LogMAR visual chart compared with the other two charts, which was not applicable to a large number of hospital visits.

The difference in measurement data between the logarithm and ETDRS visual charts was 0.08 LogMAR. A paired *t*-test revealed no statistically significant difference between the two charts ($P > 0.05$). Weifeng Song et al. utilized the standard logarithm and ETDRS visual charts to measure the BCVA of healthy and amblyopic eyes in children and found no statistically significant difference in the values[15]. In the present study, more time was spent in measurement of the BCVA of amblyopic eyes. Thus, doctors should be more patient when performing visual tests in children.

Bland-Altman analysis was conducted to compare the consistency of two repeated measurements with the same chart. The difference in two measurements by the LogMAR visual chart was 0.068 LogMAR, while it was 0.72 and 0.09 LogMAR for the logarithm and ETDRS visual acuity charts, respectively. These results indicated that the reproducibility is higher for the LogMAR visual acuity chart than for the other two charts. During BCVA measurement by the digital visual chart, the probability of correctly recognizing 6 number targets was 1/6, while the probability was 1/4 for accurately identifying the 4 directions of the letter 'E.' Therefore, the measurement results from the E visual chart may be influenced by guessing.

The accuracy of an outpatient visual test is subject to a variety of influential factors, such as a quiet environment, children's attentiveness, and the patience of doctors, *etc*.[17,18]. Three categories of visual charts can be applied in visual acuity tests. For a large number of outpatient visits, ETDRS and standard logarithm visual charts are easier to recognize and distinguish when compared with the digital LogMAR chart. In addition, these two visual charts have a high consistency in repeated measurements. Thus, the ETDRS and logarithm visual charts are applicable for visual acuity tests in young children.

The digital LogMAR visual acuity chart has a demanding requirement of recognition and identification and thus it is time-consuming. However, it has a high degree of reproducibility, consistency, and stability, which is applicable for visual acuity tests in older children. Compared with the logarithm visual acuity chart, the butterfly-shaped design of the ETDRS chart properly resolves the crowded phenomenon when performing a visual test in amblyopic children, so it is more suitable for different types of patients (both normal and amblyopic subjects) in outpatient conditions and has a relatively high accuracy.

Taken together, proper visual acuity charts should be selected based upon the volume of outpatient visits and the age distribution of pediatric patients.

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