Is patient identification of ‘comfortable’ print size a useful clinical parameter for low vision reading assessment?

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Running head: Comfortable print size

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Abstract

Purpose

The purpose of this study was to determine what a person with vision loss considers a 'comfortable' print size to read, and examine whether this parameter reflects any of three currently used parameters for identifying print size required for sustained reading tasks: minimum size to achieve maximum reading speed (the critical print size (CPS)), minimum size for functional reading at 80wpm, and / or a size that is double the reading acuity (representing an acuity reserve of 2:1).

Methods

Forty-seven participants entering low vision rehabilitation (mean age 77 years, 24 with macular degeneration) were assessed using MNREAD charts to determine reading acuity, maximum reading speed, CPS, and the minimum size allowing functional (80wpm) reading. Comfortable print size was assessed by asking participants to identify 'the smallest print size that you would find comfortable using' on the MNREAD chart.

Results

There was little difference between comfortable print size and CPS (mean difference 0.05 (SD 0.18) logMAR; $p=0.08$, limits of agreement ±0.35logMAR), and no trend for the difference between values to differ across the functional range. Size for functional reading could only be assessed for 41 participants, and the difference between this and comfortable print size varied across the functional range. Comfortable print size was consistently smaller than twice the reading acuity size (mean difference 0.11 (SD 0.17) logMAR; $p<.001$), with an average acuity reserve of 1.74:1.

Conclusions

Asking people with visual impairment to identify a print size that is comfortable to read provides a print size similar to the CPS to use as a guide in selecting magnification for sustained reading without having to undertake further analyses. Identification of perceived comfortable print size may offer a time-efficient clinical method of estimating magnification requirements and be relevant for undertaking effective remote consultations.

Keywords: Reading; Low Vision, Ocular; Physical Examination; Vision tests.

Key points:

- Patient identification of print that is 'comfortable' to read provides a good estimate of the smallest print that can be read at maximum speed (critical print size).
- Comfortable print size can be used in determining magnification requirements for functional or sustained reading tasks, and may be particularly valuable in remote consultations.
- The difference between critical print size and reading acuity (acuity reserve) was 1.74:1, lower than seen in other studies.

Introduction

Reading is the goal of greatest rehabilitative need for people entering low vision services.[1] Appropriate evaluation of reading function in the low vision assessment so as to address patients' needs effectively is therefore important. One parameter of particular clinical value is the identification of the print size required for sustained reading tasks, which will guide the calculation of magnification needed for such tasks.

If reading speed is examined across a range of print sizes, a reading function curve can be plotted which has several key features. The maximum reading speed (MRS) is the speed at which print can be read at larger sizes with performance unconstrained by print size.[2,3] The 'knee-point' at which reading speed begins to depend on print size is the critical print size (CPS), and is important as it indicates the minimum print size that allows MRS.[2,3] Reading speed drops progressively for print sizes smaller than the CPS until the reading acuity (RA) is reached, which is the smallest size of print that can be read. For people with visual impairment, the reading function curve is often impacted due to loss in visual acuity, contrast sensitivity or visual field extent. While there are different patterns in how the reading curves can be affected,[2,4] typically curves are shifted down to lower reading speeds and horizontally towards larger print sizes. All of these reading parameters (MRS, CPS, RA) can be assessed using reading charts such as the MNREAD acuity charts,[2,5] which provide standardised sentences of text across a range of print sizes in logarithmic size progression. It can be time-consuming to assess a full reading speed curve by timing and plotting reading speeds over a range of print sizes in clinical practice, although an app is available that does streamline the process.[6]

The print size needed for reading tasks therefore depends on the reading speed required, and reading goals are commonly dichotomised in clinical practice as being 'survival' or 'sustained' tasks. Survival or 'spot' reading tasks[7] are those that involve accurate reading of a few words but for which speed of reading is not crucial, including examples such as reading medication labels, price tags or food labels. Sustained or 'functional' reading tasks[7] are those involving reading for a prolonged period, such as reading a book or engaging with correspondence, and require a faster reading speed to achieve comfortably. There are several different options to identify an appropriate print size for a person with vision loss to use for sustained reading tasks, and three of these are outlined below.

Firstly, CPS is recommended as a size to aim for when providing magnification for sustained reading tasks,[8,9] since it reflects the minimum size required to read at or near to maximum speed. The identification of the CPS is not without issues.[8] There are a number of ways of determining CPS, including the original algorithm specifying the CPS as the smallest size supporting a reading speed within 1.96 standard deviations of the MRS[2,6] which is also called SDev,[4] a non-linear mixed effects model (NLME) involving fitting an exponential decay function to the data,[4,10,11] identifying the CPS as the smallest size achieving some proportion (such as 80%) of MRS,[12,13] or inspection of the plotted reading function to determine the CPS (either as an additional step to the use of an algorithm,[6] or on its own[4]). Each method will result in slightly different values obtained for CPS,[4,12] and algorithms are noted to particularly struggle with the noisier data of those with very impaired vision to the point that manual inspection of reading curves is also recommended.[4,6] Even when assessed using a consistent method, CPS is a less repeatable parameter than other reading parameters like RA or MRS.[4,12–15] Lack of repeatability is driven by several factors, including the large grading interval of 0.1log units as opposed to smaller graduations of 0.01logMAR for RA that leads to less precise data,[16] and the errors inherent in timing the reading of individual sentences.[8]

Maximum oral reading speed with MNREAD charts in normally sighted observers is in the region of 200wpm,[17,18] which can be described as 'optimal' reading.[7] For people with visual impairment, optimal reading speeds may not be possible to achieve, and the fastest reading speed that can be achieved is strongly related to visual quality of life.[19] It has been suggested that 'functional' reading can be achieved at a speed of 80wpm,[7,20] so the second option of potential functional relevance is the identification of the minimum print size that would allow a reading speed of 80wpm, rather than specifically maximum reading speed.

Thirdly, extrapolation of RA data to provide an estimate of CPS or size for functional reading can be used. The difference in size between the larger print size used for sustained tasks and RA is termed the 'acuity reserve'.[7] The acuity reserve for functional reading (80wpm) is often taken as 2:1.[9,20,21] Thus, an estimate of the print size required for sustained reading can be obtained by doubling the RA size, or in logMAR terms by adding 0.3 logMAR to RA. The acuity reserve for CPS (and thus maximum reading speed) has been determined as 3:1 (0.5 logMAR) or more by some, [9,20,21] and slightly lower than this on average by others (2:1 [22]; 2.5:1 [23]) but with wide variation between individuals.[9,22,23] For the purposes of this study a 2:1 reserve has been selected as a reasonable starting point for exploring magnification needs for sustained tasks with a patient.

All three methods outlined above for determining the print size required for sustained reading need some element of data analysis or calculation. Clinically, it would be very straightforward to ask a person with vision loss to select the smallest print size they considered as being 'comfortable' to read for a prolonged period. What would that print size represent, and how would it relate to the more established parameters defined above? The purpose of this study is to examine what a person with vision loss considers a comfortable print size to read, and whether this parameter reflects the minimum size to achieve maximum reading speed (CPS), the minimum size for functional reading (at 80wpm), and / or a size that is double the reading acuity. The answers to these questions have potential implications regarding how to proceed clinically with determining magnification in an efficient way and may also be relevant for undertaking remote consultations effectively.

Methods

Participants

Participants took part in this study as part of a comprehensive evaluation of visual function and rehabilitation needs.[1] Participants were recruited on entry to low vision rehabilitation services in Leicestershire, UK. Entry to services was triggered by referral from the consultant ophthalmologist to the Eye Clinic Liaison Officer for discussion of vision impairment certification. Certification is available to people with loss of visual acuity and / or visual field in their better eye.[24] Inclusion criteria were adults aged at least 18 years, with vision loss from any cause. Participants were excluded if they were unable to complete the reading assessments due to their vision, were unable to complete the reading assessments in English or were found to be cognitively impaired using the Six-item Brief Cognitive Screener.[25] Ethical approval was received from Anglia Ruskin University Faculty of Science and Engineering Research Ethics Committee, and informed consent was obtained from all participants.

Procedures

Demographic characteristics of sex, age, previous level of education,[26] visual impairment registration status, duration of vision loss affecting daily life, and self-reported cause of visual loss were recorded.

High contrast distance visual acuity was recorded binocularly with a letter by letter scoring protocol using an externally illuminated Bailey-Lovie distance acuity chart with the participant wearing any current habitual correction. Participants were encouraged to guess and measurements terminated when four or more mistakes were made on a line.[27] Additional lighting was provided to ensure that chart illumination was even and within the recommended range of 80-320 cd m^{-2}.[28]

MNREAD acuity charts[5] were used to assess reading function. A focimeter was used to record the participant's habitual distance spectacle correction, which was then presented in a trial frame and adjusted for the standard viewing distance of 40cm using a +2.50DS reading addition, when relevant. The participant held the chart at 40cm and the chart was externally illuminated to the manufacturer's recommended even level of illumination of 80 cd m^{-2}.[29] If the participant was unable to read the largest text at this distance, the chart was brought in to a working distance of 20cm with a reading addition of +5.00DS provided. At the shorter working distance, an additional +0.30logMAR was added to the size scores. An audio recording was made while the participant read down the chart and used for later analysis. Assessment was terminated when the participant was unable to read any more words.

To determine the comfortable print size, the participant was then asked 'what is the smallest print size that you would find comfortable using?' whilst viewing the MNREAD chart at the working distance outlined above. The selected size was recorded in logMAR. The rationale for using a straightforward sentence such as this was to identify the print size required for sustained reading tasks from a patient's perspective in as time-efficient a manner as possible for potential use in clinical practice.

In off-line analysis, the time taken to read each sentence and any errors made were recorded from the audio file, and then plotted graphically on the score sheets provided with the chart. The RA (logMAR) was calculated by determining the smallest print size attempted, plus 0.01logMAR score added for each word read incorrectly. The CPS (logMAR) was determined by inspection of the plotted graph of reading speeds recorded for each print size by an experienced rater (JM) and identified as the smallest print size that supported the participant's maximum reading speed.[2,4,6] MRS (words per minute) was calculated as the mean reading speed across print sizes including, and larger than, the CPS. The minimum size for functional reading was determined as the smallest size at which a reading speed of at least 80wpm was achieved. All data was collected and analysed by JM, but the derivation of MNREAD parameters was undertaken with anonymised data completely separately from the comfortable print size data.

Results

Descriptive statistics

Sixty participants were recruited to the study. Two participants were unable to read aloud following brain injury associated with their visual impairment and a further three were found to have corrupt audio files. Four participants were unable to read the MNREAD acuity charts at either the standard or the closer working distance. Comfortable print size was not assessed for a further four participants. There were therefore 47 participants with MNREAD and comfortable print size data available for analysis.

Of the 47 participants, there were 29 females and 18 males, mean age 77 (SD 13, range 38-96) years. Previous level of education was less than 12 years (left school before age 16) for 25 people (53%), 12 years (left school at 16) for 6 people (13%), 13-15 years (secondary education to age 19) for 6 people (13%) and more than 16 years (participated in further or higher education) for 10 people (21%). Forty had been registered as Sight Impaired, 6 as Severely Sight Impaired, and 1 had chosen not to be registered as visually impaired. Mean duration of vision loss affecting daily living was reported as 41 (SD 72; range 2-360) months. Participants reported primary causes of visual loss of age-related macular degeneration (n=24; coloured pink in graphs), glaucoma (7), diabetic retinopathy / maculopathy (3), retinitis pigmentosa (2), retinal vascular occlusions (3), stroke (2), optic / retrobulbar neuritis (2), retinal detachment (1), uveitis (1), Fuch's endothelial dystrophy (1) and unknown (1) (people with causes of visual loss other than macular degeneration coloured blue in graphs). Table 1 presents the visual function of the participants.

Table 1. Binocular visual function of 47 participants, assessed with presenting refractive correction for distance, and with appropriate adaptation of refractive correction made for near assessment.

Visual function (unit)	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Distance visual acuity (logMAR)	0.71	0.33	0.02	1.30
Reading acuity (logMAR)	0.52	0.29	-0.20	1.23
Critical print size (logMAR)	0.76	0.31	0.10	1.30
Maximum reading speed (wpm)	79	29	24	151
Comfortable print size (logMAR)	0.71	0.27	0.10	1.30

Comfortable print size compared to CPS

Comfortable print size and CPS were highly correlated (Pearson's r = 0.81; p<0.001). Mean CPS (0.76 (SD 0.31) logMAR) was slightly larger than mean comfortable print size (0.71 (SD 0.27) logMAR), but this difference was not statistically significant (mean difference 0.05±0.18 logMAR; paired-samples t-test: t (df 46) = 1.77; p= 0.08) and the effect size was negligible (Cohen's d= 0.16). For this difference to be statistically significant at the 5% level would need a sample size of 176.[30]

A Bland Altman plot (Figure 1) further evaluates the differences between comfortable and critical print sizes. The difference between the two measures did not vary across the functional range, with a linear regression fitted to the data (not shown) having little slope (Difference = 0.06 - (0.14 x mean)) and no statistical significance (Pearson's r=0.22, p=0.14). The limits of agreement (1.96 x SD) around the mean difference were ±0.35 logMAR, and the outer and inner exact confidence intervals for the limits of agreement[31] are also shown in Figure 1. The outer confidence interval indicates that there is a 97.5% probability that 95% of the differences between the measures lie in this range.[31]

Agreement between comfortable and critical print sizes was summarised using intra-class correlation coefficients (ICC), which provides a value between 0 (no agreement) and 1 (perfect agreement) in the comparison of two ratings.[32] A 2-way mixed effects model, with single measures and absolute agreement was used. ICC was 0.79 (95% CI [0.66, 0.88]), which can be categorised as ‘good’ agreement as it falls in the range 0.75-0.90.[32]

If comfortable print size was used as a surrogate for measuring CPS, agreement would have been no more than 2 lines different (0.2 logMAR, or 1.6x magnification) in 85% of cases, no more than 1 line different (0.1 logMAR, or 1.3x magnification) in 53% of cases, and exact in 28% of cases.

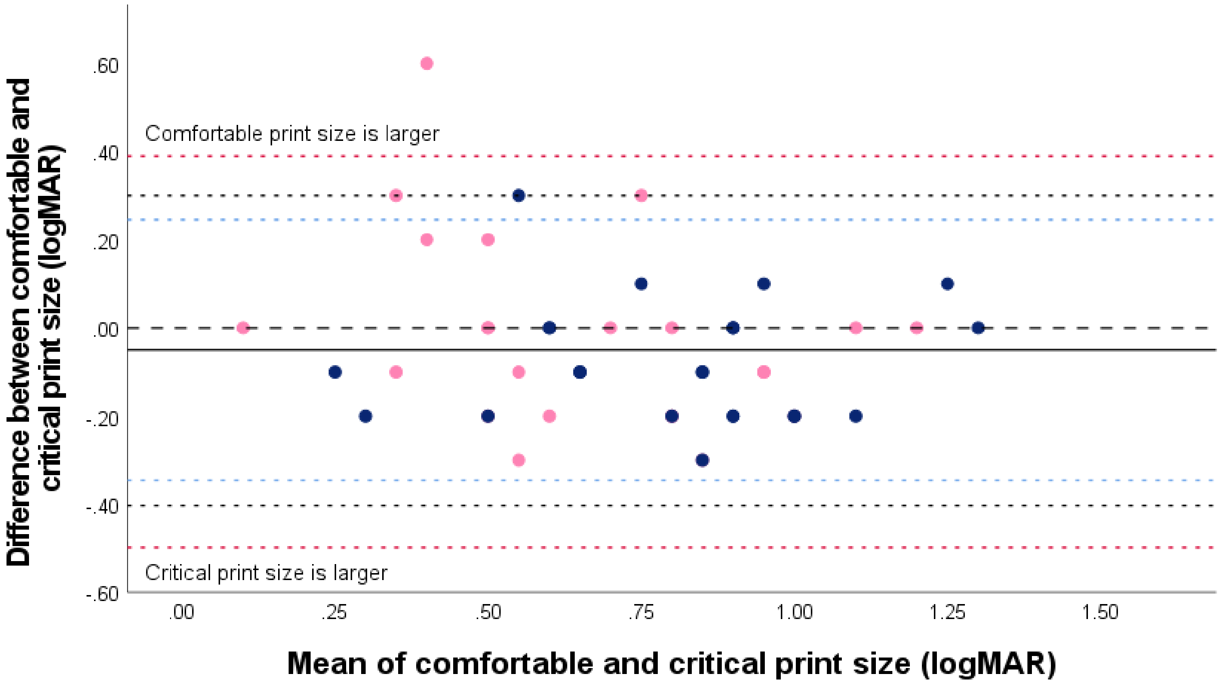

Figure 1. Bland-Altman analysis of the difference between comfortable and critical print sizes as a function of their mean value. The solid line represents the mean difference (critical print size is 0.05 logMAR larger than comfortable print size) and the black dashed line indicates zero bias. The upper and lower limits of agreement (+0.30 to -0.40 logMAR) are shown by black dotted lines. The outer 95% confidence interval[31] to the limits of agreement (+0.40 to -0.50) are indicated by the dotted red lines, and the inner confidence interval (+0.25 to -0.35) by the dotted blue lines. Pink symbols: AMD; blue symbols: all other causes of vision loss.

Comfortable print size compared to functional print size (minimum size for 80wpm)

A minimum reading speed of 80wpm is suggested to be needed for functional reading.[7,20] Forty-one participants achieved reading speeds at or in excess of this value, and the minimum print size to achieve 80wpm was 0.66 (SD 0.36; range 0.10-1.30) logMAR. In this subset of participants, the comfortable print size was 0.68 (SD 0.24) logMAR.

Of the 6 people who did not achieve a reading speed of 80wpm, only 1 had left school before age 16, and 3 had completed 16 years or more of education. Educational factors would appear unlikely to have significantly limited the number of people achieving functional reading speeds as compared to visual factors.

Comfortable print size and size for functional reading were highly correlated (Pearson’s r = 0.80; p <0.001), and there was no statistically significant difference between comfortable and functional reading sizes (mean difference 0.01 (SD 0.20) logMAR; paired-samples t-test: t (df 40) = 0.38; p= 0.70, Cohen's d= 0.07). Bland Altman analysis (Figure 2) demonstrates the minimal overall difference between comfortable and functional print sizes, and similar limits of agreement to that seen in Figure 1. However, the difference between comfortable and functional print sizes varied across the range of performance. A linear regression fitted to the data (Difference = 0.25 – (0.35 x mean); r=-0.47, p<0.01) indicates that the comfortable print size was progressively bigger than the functional print size at smaller mean sizes.

ICC (2-way mixed effects model, single measures and absolute agreement) for comfortable and functional print sizes was 0.76 (95% CI [0.60, 0.87]), which was again categorised as 'good' agreement.[32]

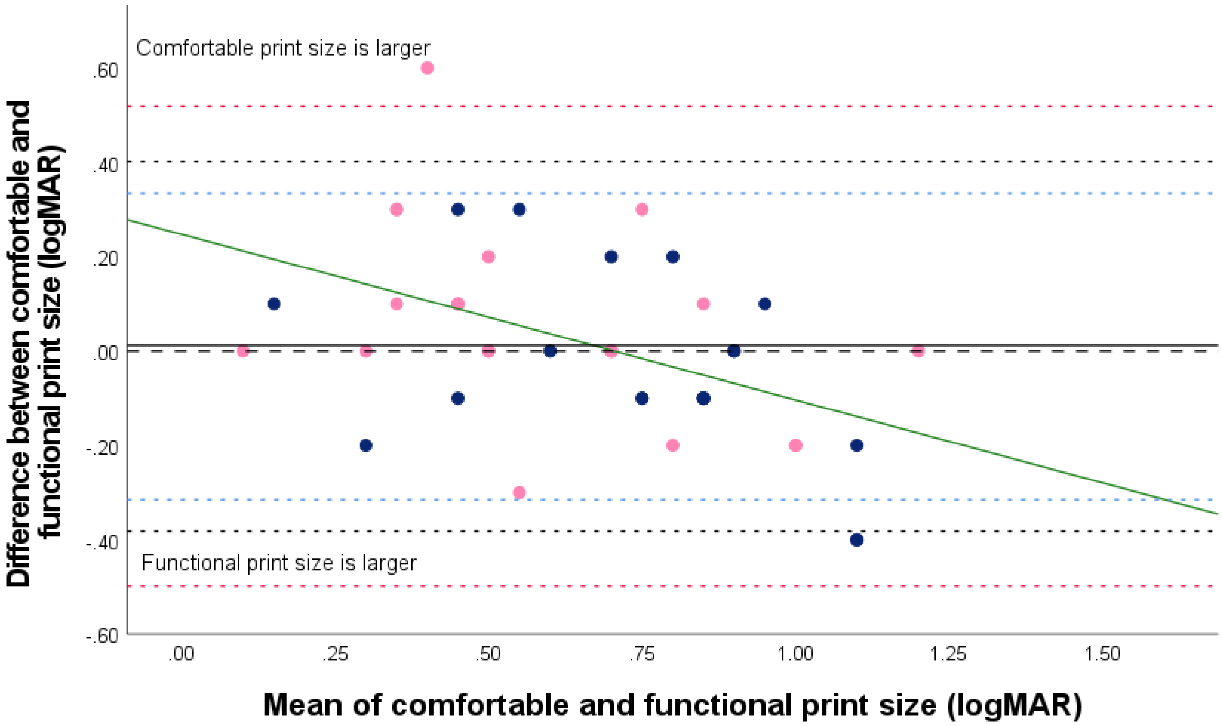

Figure 2. Bland-Altman analysis of the difference between comfortable print size and the minimum print size allowing functional reading (80wpm) as a function of their mean value. The solid line represents the mean difference (comfortable print size is 0.01 logMAR larger than functional print size) and the black dashed line indicates zero bias. The upper and lower limits of agreement (+0.41 to -0.39 logMAR) are shown by black dotted lines. The outer 95% confidence interval[31] to the limits of agreement (+0.52 to -0.50) are indicated by the dotted red lines, and the inner confidence interval (+0.33 to -0.31) by the dotted blue lines. The solid green line indicates the linear regression fitted to the data (y=0.25-0.35x; r=-0.47, p<0.01). Pink symbols: AMD; blue symbols: all other causes of vision loss.

Comfortable print size compared to twice reading acuity size

Print of twice the size of reading acuity incorporates a 2:1 'acuity reserve' suggested to be suitable for sustained reading in people with visual impairment.[9,20–23] Twice the reading acuity size is provided by adding 0.3 logMAR to the MNREAD reading acuity value.

Comfortable print size and twice reading acuity values were highly correlated (Pearson's r = 0.82; p <0.001). The mean value for twice reading acuity (0.82 (SD 0.29) logMAR) was larger than mean comfortable print size (0.71 (SD 0.27) logMAR), and this difference of around a line was statistically significant (mean difference -0.11 (SD 0.17) logMAR; paired-samples t-test: t (df 46)=-4.57, p<.001) although the effect size was small (Cohen's d=0.39).

A Bland Altman plot (Figure 3) further evaluates the differences between comfortable print size and twice reading acuity, with no trend observed for difference to vary as a function of the mean. A linear regression fitted to the data (not shown) had little slope (Difference = -0.04 - (0.09 x mean)) and was not statistically significant (Pearson's r=-0.15, p=0.31).

ICC (2-way mixed effects model, single measures and absolute agreement) for comfortable print size and twice reading acuity was 0.76 (95% CI [0.46, 0.89]), which was again categorised as 'good' agreement.[32]

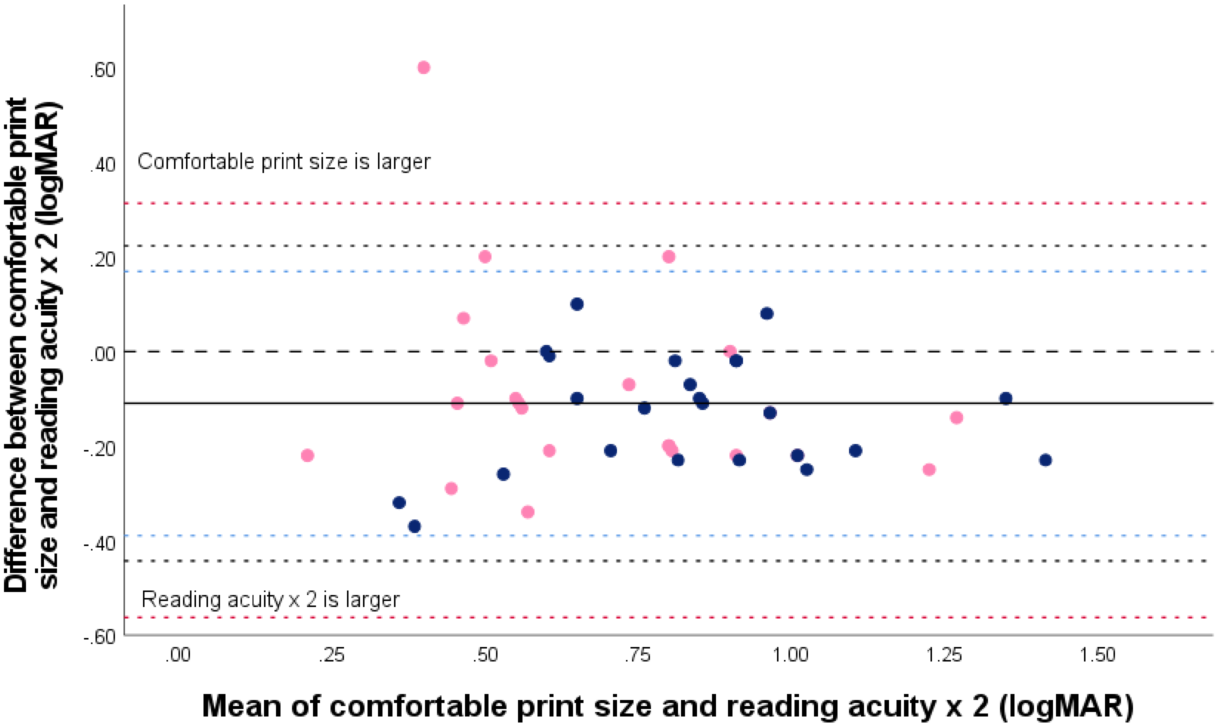

Figure 3. Bland-Altman analysis of the difference between comfortable print size and a size which is double the reading acuity, as a function of their mean value. The solid line represents the mean difference (reading acuity x 2 is 0.11 logMAR larger than comfortable print size) and the black dashed line indicates zero bias. The upper and lower limits of agreement (+0.21 to -0.49 logMAR) are shown by black dotted lines. The outer 95% confidence interval[31] to the limits of agreement (+0.31 to -0.53) are indicated by the dotted red lines, and the inner confidence interval (0.17 to -0.39) by the dotted blue lines. Pink symbols: AMD; blue symbols: all other causes of vision loss.

Discussion

In a low vision assessment, can we ask people to identify a comfortable print size as a size to aim for with magnification for sustained reading? Doing so could provide an efficient use of clinical time, with identification of comfortable print size being much quicker than a full analysis of a reading speed and size plot, even when a full reading curve assessment can be semi-automated by use of an app.[6] Additionally, with the rise of telerehabilitation in low vision during the COVID-19 pandemic,[33–35] could determination of comfortable print size be a useful way of assessing reading function with larger print sizes remotely? The present study suggests that the comfortable print size identified by a visually impaired person can tell the clinician something useful. Comfortable print size is, on average, similar to the CPS and relates better to CPS than to functional reading size or twice reading acuity.

The comfortable print size selected by people with vision loss relates well to CPS, or the smallest size supporting the maximum reading speed as determined by inspection of plotted reading speed curves. The mean difference between the two sizes is less than a line of logMAR print (0.05 (SD 0.18) logMAR, p=0.08), and there is no trend for the difference between values to differ across the range of function, or between people with AMD or other causes of visual loss.

Whilst the mean difference between comfortable and critical print sizes is non-significant, there is a reasonably wide interval to encompass the range of differences observed, with limits of agreement of ±0.35 logMAR of the measured CPS (±0.45 logMAR if considering the outer bounds of the confidence interval around the limits of agreement). However, it should be noted for context that the limits of agreement observed are no wider than those seen for the difference between CPS values with MNREAD charts when measured using different algorithms (e.g ±0.37logMAR for SDev vs NLME methods[4]) or test-rest repeatability over a period of weeks (e.g. ±0.44-0.67 for different methods of CPS calculation[12]).

In practical terms, 85% of comfortable print size selections were within 2 lines of the CPS value, indicating a maximum difference of 1.6x to the magnification predicted for sustained reading in the majority of cases. Given that reading assessments are generally used to provide a starting point for magnification requirements, which can then be fine-tuned according to patient need once appropriate magnifier designs have been identified, the level of accuracy achieved by patient selection of comfortable print size appears reasonable from a clinical perspective.

The assessment of CPS itself does have a number of issues, and may not be an ideal 'gold standard' parameter,[8] as outlined earlier. There are several methods available for CPS determination, and in the present study inspection of the plotted reading curve was used. The rationale for this was two-fold. Firstly, this method would be available for use by all clinicians without needing additional software or calculation. Secondly, inspection is considered a robust approach and is used to double check the results obtained using algorithms,[4,6] particularly in ambiguous cases or with noisy data which are more likely to be observed with visually impaired observers. The inter-rater agreement of CPS by inspection is 'good' (intraclass correlation coefficient 0.82) for experienced raters,[4] and the sole rater in this study (JM) was very experienced.

The relationship between comfortable print size and the other parameters assessed was not as good as for CPS. The size to achieve 'functional' reading at 80wpm was applicable to fewer of the group (only 41 of 47 participants could achieve this speed). The difference between functional reading size and comfortable print size varied systematically across the functional range, indicating that for those with better function, the size selected as comfortable was more likely to be in excess of that required for 80wpm, and more indicative of the size providing MRS. Although the difference between comfortable print size and twice reading acuity (to provide a 2:1 acuity reserve) was consistent across the range of mean values, there was a significant difference of a logMAR line between the values (-0.11 (SD 0.17) logMAR; p<.001), with the comfortable print size selected being smaller than twice the reading acuity. Although an acuity reserve of 2:1 was chosen as a standard value from the literature,[9,20–23] in this sample the difference between reading acuity and CPS was smaller than this, with a mean difference of 0.24 (SD 0.13) logMAR, or a mean acuity reserve of 1.74:1. It is known that individual acuity reserves are variable[9,20–23], and it has previously been noted that those with poorer visual function tend to have lower reserves.[22,23] However, mean reading acuity in the present study was reasonably good (0.52 (SD 0.29) logMAR) compared to other studies (0.71-0.73 logMAR[20]; 0.81 logMAR[22]; 1.03 logMAR[23]). It is unclear why the average acuity reserve is lower in this study than previously reported values. All MNREAD parameters (including both critical and comfortable print sizes) are obtained using a brief test of reading, which is all that is likely to be feasible within the timeframe of a clinical assessment. More extended reading tasks might require additional reserve,[36] but would require different assessments for direct evaluation.[37,38]

Discrepancies have previously been observed between self-reported patient measures and assessed performance in reading.[39–42] Why then should the patient's perception of comfortable print size be considered as potentially valid measure? In this instance, the patient is not being asked to provide a global indication of their difficulty on a Likert scale, but is being presented with an assessment chart and being asked for their opinion of it. A more specific observation is therefore being asked for, and it has previously been observed that relationships between perceived and assessed visual function are closer for more specific items.[42]

Two limitations of the study should be noted. Participants were asked to identify their comfortable print size after having the read the MNREAD chart orally. It is possible that this may have led to participants identifying CPS for themselves based on when they felt they slowed down in the verbal recording and the same value might not be obtained if the chart is read silently or simply observed. Further, intra-subject variability of comfortable print size has not been investigated. Having established that patient identification of their perceived 'comfortable print size' might be useful as a parameter, it would be useful to assess test-retest repeatability and variation dependent on presentation method in future work.

Conclusion

Asking people with visual impairment to identify a print size that is comfortable to read will identify a print size similar to that of the CPS to use as a guide in selecting required magnification, without having to plot a full reading curve.

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