Title

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Journal

Translational Vision Science & Technology, 13(1)

ISSN

2164-2591

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Publication Date

2024-01-12

DOI

10.1167/tvst.13.1.6

tvst

Clinical Trials

Outcomes of Telerehabilitation Versus In-Office Training With Magnification Devices for Low Vision: A Randomized Controlled Trial

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Received: October 18, 2023
Accepted: December 17, 2023
Published: January 12, 2024

Keywords: low vision; vision rehabilitation; magnification; reading

Citation: Bittner AK, Kaminski JE, Yoshinaga PD, Shepherd JD, Chan TL, Malkin AG, Deemer A, Gobeille M, Thoene SJ, Rossi A, Ross NC. Outcomes of telerehabilitation versus in-office training with magnification devices for low vision: A randomized controlled trial. Transl Vis Sci Technol. 2024;13(1):6, https://doi.org/10.1167/tvst.13.1.6

Purpose: An evidence basis is lacking but needed to compare reading ability outcomes after magnification device training remotely via telerehabilitation versus in office.

Methods: A multicenter randomized controlled trial at academic centers and vision rehabilitation private practices randomized 61 visually impaired adults to telerehabilitation or in-office training 1 to 4 months after dispensing new portable electronic, hand-held, or stand optical magnifiers. Telerehabilitation included loaner equipment for Zoom videoconferencing with remote control access software. Using a multilevel regression model, changes in Activity Inventory responses using Rasch analysis estimated reading ability in dimensionless log odds units (logits) (0.14-logit change corresponds with ability change expected from a one-line change in visual acuity).

Results: Across 47 participants who completed the trial, reading ability with new magnifiers improved significantly by 0.61 logits on average (95% confidence interval [CI], 0.36–0.86; $P < 0.001$) from baseline to 1 month, and by an additional 0.44 logits on average (95% CI, 0.19–0.69; $P < 0.001$) from 1 to 4months (i.e., after magnifier training), with very similar significant findings for both telerehabilitation ($n = 29$; mean improvement = 0.44 logits; 95% CI, 0.08–0.80; $P = 0.018$) and in-office training ($n = 18$; mean improvement = 0.43 logits; 95% CI, 0.15–0.71; $P = .003$), and no significant difference between randomized groups across both follow-ups (95% CI, −0.43 to 0.61; $P = .73$). Vision, demographics, and health factors were nonsignificantly related to reading ability changes from 1 to 4 months.

Conclusions: Reading ability improved after the provision of newly dispensed magnifiers, with further improvements following additional magnifier training via either telerehabilitation or in-office usual care.

Translational Relevance: These findings provide support for the use of telerehabilitation to enhance reading ability with newly prescribed magnifiers as an alternative modality of care delivery.

Introduction

Telerehabilitation using videoconferencing to remotely evaluate and provide visual aid training to patients with low vision at home is feasible[1,2] and can overcome several barriers to care[3–6]; however, it is not yet widely implemented in clinical practice. There is a lack of a rigorous evidence basis for telerehabilitation involving magnification device training for low vision; randomized controlled trials have not yet been conducted.[7,8] Skills taught by providers in office may not carry over when patients use magnifiers at home if the lighting, working distance, viewing angle, and/or ergonomics are not ideal. Additionally, patients may not retain the specific instructions that are essential to improve reading ability with magnifiers. Telerehabilitation might offer a convenient means to conduct virtual follow-ups in the homes of patients who received new magnifiers to determine if they are using them correctly or could benefit from further training or support.

Potential advantages of telerehabilitation are that it allows for more personalized care, because providers can assess and implement modifications according to patients' unique home environments and usual reading materials that affect real-world visual difficulty. Telerehabilitation may increase compliance because it eliminates travel-related barriers, such as transportation, time, cost, weather, and safety concerns. Conversely, a potential advantage of in-office training is the provider's ability to give hands-on support with visual aids instead of purely verbal instructions. In the office, there are no technical disruptions (e.g., videoconferencing connectivity, audio quality, or viewing angle). It is important to assess and compare outcomes for these two modalities to provide evidence-based practice recommendations and support continued insurance reimbursement in the future. Telerehabilitation by ophthalmologists, optometrists, or occupational therapists is currently covered by medical insurance in the United States since recent legislation authorized an extension of many of the Medicare telehealth flexibilities that were in place during the coronavirus disease 2019 public health emergency through December 31, 2024.

One clinical model for telerehabilitation in a Veterans' Affairs population required patients with low vision to attend videoconference sessions at local optometrists' offices to remotely connect to vision rehabilitation providers.[9,10] This protocol was modified to take place in patients' homes at the start of the coronavirus disease 2019 pandemic.[11] However, nearly one-half of the patients lacked videoconferencing access and could not receive telerehabilitation.[11] Similarly, occupational therapists at other practice sites outside of the Veterans' Affairs system who used telerehabilitation for low vision clinically during the pandemic reported that access to materials at home was a barrier.[12] Our study team sought to overcome this by providing loaner smartphones with remote access control to connect patients to videoconference sessions.[1,13] This factor was important because 58% of our previous telerehabilitation study participants had never used videoconferencing between 2016 and 2022.[1] We found high levels of acceptance of telerehabilitation, with no significant differences between telerehabilitation and in-office magnifier training for participants' comfort level, satisfaction, self-rated improvement in magnifier use, or interest in having another session.[1] Between the first and second telerehabilitation sessions, near reading acuity and speed improved significantly after magnifier training for participants who were not using it optimally at the initial session.[13] However, we have not previously compared changes in reading ability after telerehabilitation with a comparator group that received in-office training per the current standard for usual care.

This randomized controlled trial aimed to evaluate procedures to support telerehabilitation for patients with low vision and determine estimates of effect size and variability of the primary outcome measure for self-reported reading ability after magnifier training in-office or via telerehabilitation. We anticipated that reading outcomes would be similar for both modalities because each has its advantages. We sought to determine which patients would benefit from additional magnifier training by exploring potentially influential factors or covariates, such as demographics and vision and health status. Given the projected dramatic increase in the expected number of visually impaired people over the next several decades,[14,15] it is imperative to validate effective solutions to increase access to vision rehabilitation services and quality care for these individuals.

Methods

The multicenter protocol was approved by the institutional review board at the University of California, Los Angeles (UCLA), and followed the tenets of the Declaration of Helsinki. All participants provided oral informed consent by phone, obtained by the UCLA study coordinators. The study protocol was listed on clinicaltrials.gov (identifier NCT04066075) before enrolling the first participant.

The following numbers of participants who completed the trial (included in our final analyses) were recruited at 10 vision rehabilitation clinical practices, including four academic institutions: University of Nebraska Medical Center in Omaha, Nebraska (n = 9), New England College of Optometry in Boston, Massachusetts (n = 10), Southern California College of Optometry in Fullerton, California (n = 7), UCLA Stein Eye Institute in Los Angeles, California (n = 4), and six private practices: Mid-Michigan Eye Care in Midland, Michigan (n = 10), Frank Stein & Paul S. May Center for Low Vision Rehabilitation in San Francisco, California (n = 2), Chan Family Optometry in Grass Valley California (n = 2), See What You Miss Optometry in Santa Monica, California (n = 1), Low Vision Services in Alexandria, Virginia (n = 1), and Boston University Eye Associates in Brockton, Massachusetts (n = 1).

At an in-office visit before study enrollment, vision rehabilitation providers prescribed new portable electronic video magnifiers, hand-held or stand optical magnifiers after measuring best-corrected visual acuity (BCVA) at distance with either an Early Treatment of Diabetic Retinopathy Study chart or Snellen chart and at near with a continuous text reading card or the MNRead test.[16] Magnifier type and power were determined by each provider according to usual care clinical practice methods. All participants received initial training in office with the magnifier at the visit at which it was first evaluated and dispensed. The cost of the magnifiers was not covered by the study; thus, the findings are generalizable to clinical academic and private practices in the United States because magnifiers are not covered by many insurers. Participants were English-speaking adults aged 18 years or older with any BCVA, ocular disease, and no greater than mild cognitive impairment (on modified Telephone Interview for Cognitive Impairment [m-TICS], which was assessed after a new magnifier was prescribed and after enrollment); exclusion criteria were detailed previously.[1,13,17] Participants were allowed to have previously used a prescribed magnifier (i.e., different type or power; n = 10 or 21% of participants had a previously prescribed magnifier) and/or previously received vision rehabilitation services (34%; n = 16 of 47), but nearly two-thirds of participants (66%) were completely new to these interventions. For the participants who had previously received vision rehabilitation services, four (8.5%) were seen more than 3 years ago and 12 (25.5%) were seen within the past 3 years. Eligible patients were consecutively recruited for the trial.

We conducted a minimal risk, phase I/II randomized controlled trial with a parallel design and 2:1 allocation to telerehabilitation or in-office (active control) training provided by one of our eight optometrists or two occupational therapists (at Nebraska Medicine and the Frank Stein & Paul S. May Center for Low Vision Rehabilitation). The 2:1 allocation was intended to give us more experience with telerehabilitation as the novel intervention in this early phase trial. Randomization and interventions were administered on an individual basis, rather than to groups. The training sessions via telerehabilitation or in-office (per randomization) occurred over a period of 3-months, any time between 1 and 4 months after dispensing the new magnifier. Randomization procedures attempted to balance two potentially important covariates: participating site and BCVA group (i.e., $\leq$0.5 or >0.5 logarithm of the minimum angle of resolution [logMAR]). The principal investigator (A.K.B.) created a unique randomization scheme using an online application tool (https://clinicalresearch-apps.shinyapps.io/rrapp/) for each site that involved blocking (sizes of 4 and 6) with stratification by BCVA group. She maintained sole access to the randomization schemes and provided randomization assignments to the study coordinator after participants completed baseline assessment. Sample size was determined a priori using a matched pairs t test that revealed 18 participants per group would detect a within-patient mean improvement of 0.14 logits with the Activity Inventory (equivalent to 1 line or 0.1 logMAR visual acuity [VA]), with 0.17 logits standard deviation for the differences, 0.80 power and 0.05 type I error probability. We accounted for a dropout rate or approximately 10%, and planned to enroll 20 in-office patients and 40 telerehabilitation patients.

We shipped a kit of loaner equipment to participants' homes before telerehabilitation, which included a loaner smartphone (Samsung Galaxy S6; Verizon cellular data), adjustable stand, and standardized near reading tests in sealed envelopes with instructions to open only during the session.[1,13] We used remote access control software (RescueAssist by LogMeIn, Inc.) on the loaner smartphones to connect participants to Zoom.us videoconferencing after confirming by phone that they were ready to begin. A standard telerehabilitation protocol (see the Supplemental Material for details) for interactions between the vision rehabilitation provider in-office and participant at home was used consistently across all sessions, which lasted approximately 1 hour. Participants were asked to set-up the session where they typically did most reading with the magnifier. Then providers confirmed how they had been using any recent spectacle prescription updates, the new magnifier, and any supporting items

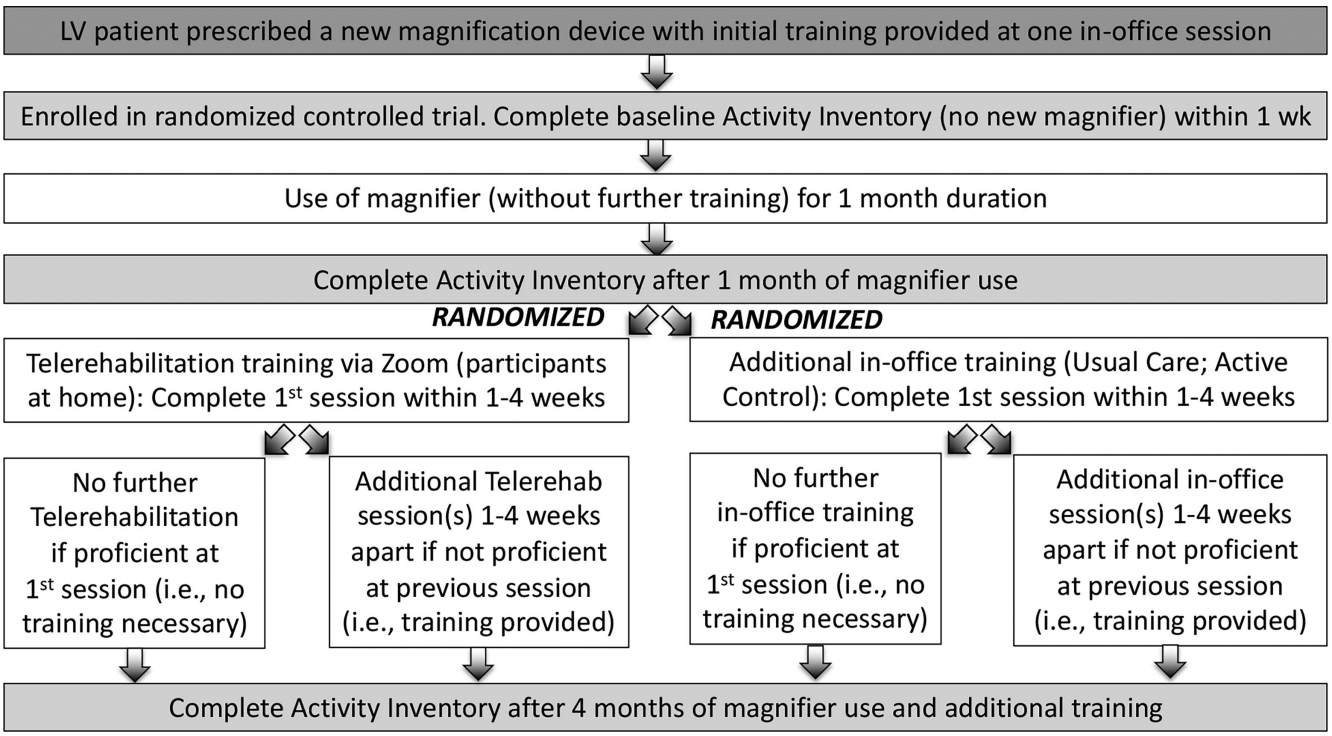

Figure 1. Flow chart for timing of study procedures and outcomes assessments. LV, low vision.

(e.g., a gooseneck lamp or reading stand). Participants' reading fluency and technique using the magnifier were assessed with the Lighthouse continuous text card and MNRead test, followed by their own reading materials. Magnifier training was individualized based on participants' needs, by providing verbal instructions to make adjustments to the placement of the magnifier and/or reading material, including feedback on the working distance, viewing angle, movement, and/or obtaining appropriate magnification levels and field of view while reading. In-office sessions were conducted by the same providers as the telerehabilitation sessions who used the same approach for magnifier assessment and training for both the initial session at time of magnifier dispense and the follow-ups from 1 to 4 months.

The flow chart in Figure 1 outlines the timing of study procedures and outcomes assessment. The prespecified primary study outcome was changes in items pertaining to near reading from the Activity Inventory,[22] which is a validated patient-reported outcome measure to assess visual ability by comparing self-reported difficulty for each item with the inherent difficulty level of that item. It is adaptive; measures are based only on participants' self-reported level of ability to complete reading tasks without help that are related to their important, difficult goals. We administered 105 Activity Inventory questions related to reading tasks that could be accomplished with a magnifier. All of these Activity Inventory reading items were administered to newly enrolled participants at baseline who initially rated the difficulty of the items without the new magnifier. Then, at the follow-up assessments at 1 and 4 months, the relevant items that were reported as important and difficult at baseline were rated for difficulty while using the new magnifier.

All study questionnaires were administered by phone by UCLA research assistants who were masked to participants' intervention allocation and identically trained by the principal investigator. It was not possible to mask participants or providers. The following questionnaires to assess covariates were administered at study enrollment and completion 4 months later: m-TICS,[18] Short-Form Health Survey-36 general health questionnaire,[19] Geriatric Depression Scale,[20] and Hospital Anxiety and Depression Scale.[21]

Data Analyses

Rasch analysis using the method of successive dichotomizations was applied to Activity Inventory data using the R package 'msd' to estimate person measures (i.e., a person's ability to perform visually mediated tasks based on their ratings of numerous items) from a polytomous Rasch model derived from the logistic difference model.[23,24] Per estab-

Table 1. Frequency of Errors Made by Participants When Using Their New Magnifier for Reading Observed During the Telerehabilitation Sessions

Errors	Proportion of Telerehabilitation Participants With Observed Errors During Magnifier Use
No errors (proficient)	35%
Variable, unsteady working distance with hand-held magnifier	19%
Forgot to turn on light on optical magnifier	15%
Held magnifier too far from reading material	15%
Incorrect angle for magnification	15%
Unaware of all features/settings on portable electronic magnifier	15%
Magnifier or reading material placed too far from eye	15%
Incorrect eyeglasses used with magnifier	7%

lished protocols for Activity Inventory analysis, person measures were anchored to item measure and rating category thresholds developed from Activity Inventory calibration in approximately 3700 patients with low vision.[25] Item filtering was applied, wherein items rated not difficult or not important at baseline were scored as missing, which enables standardized outcomes informed by patient preferences.[26] Results for the reading domain of the Activity Inventory are reported as our primary outcome. Participants were considered to have achieved the minimal clinically important difference criteria if their Activity Inventory change score from baseline to 4 months exceeded the 95% confidence interval (CI) of the baseline person measure (i.e., 1.96 times the standard error for the baseline person measure) for each individual.[27]

Descriptive statistics summarized the baseline data and findings. Multilevel modeling accounted for within-patient correlations for the three assessments. Simple and multiple linear regressions checked for significant differences between randomized groups or other potentially influential factors (covariates) that were previously related to visual ability measured with the Activity Inventory.[28–31] Multiple logistic regressions evaluated whether there were any significant factors related to the odds of trial completion versus withdrawal, or the odds of proficiency with the magnifier at the initial telerehabilitation session. Proficiency with the magnifier was determined by the vision rehabilitation provider who observed whether they were using it correctly while performing the reading tasks during the telerehabilitation session; key reasons for nonproficiency are listed in Table 1. Pearson $\chi 2$ tests analyzed relationships between two dichotomous variables. Data were analyzed using Stata/IC version 15.1 (Stata Corp., College Station, TX).

Results

Enrollment began on October 10, 2019, and data collection with the last participant was completed on March 20, 2023. The end of the trial (i.e., last participant enrolled) corresponded with the end of the National Institutes of Health funding period. Figures 1 and 2 show the flow of participants through the trial. A total of 152 patients were assessed for eligibility after they received a new magnifier, of whom 91 were excluded. Anecdotally, the top reasons were for declining to participate were related to the time commitment, that the participant could not return in-person for training, that the patient did not want to be randomized (i.e., preference for one training modality), a perception that they did not need training, general health issues, or that the participant was unable to be reached despite multiple attempts to contact. Randomization was completed for 61 participants, with 38 assigned to telerehabilitation and 23 in the in-office usual care control group. The most common reasons for exclusion were loss to follow-up or discontinuation owing to participants' busy schedules. Thirteen participants discontinued before the final 4-month assessment, but two of them became ineligible because a magnifier was no longer indicated, for a total withdrawal rate of 18%. Trial completion versus withdrawal rates were similar for the two randomized groups ($\chi 2 = 0.01$; $P = 0.91$). Participants with greater baseline m-TICS scores had significantly greater odds of completion (odds ratio [OR], 1.23; 95% CI, 1.07–1.42; $P = 0.004$). Dropouts were not included in an intention-to-treat analysis because we did not use missing data imputation methods or last observation carried forward because the missing data are likely not at random and

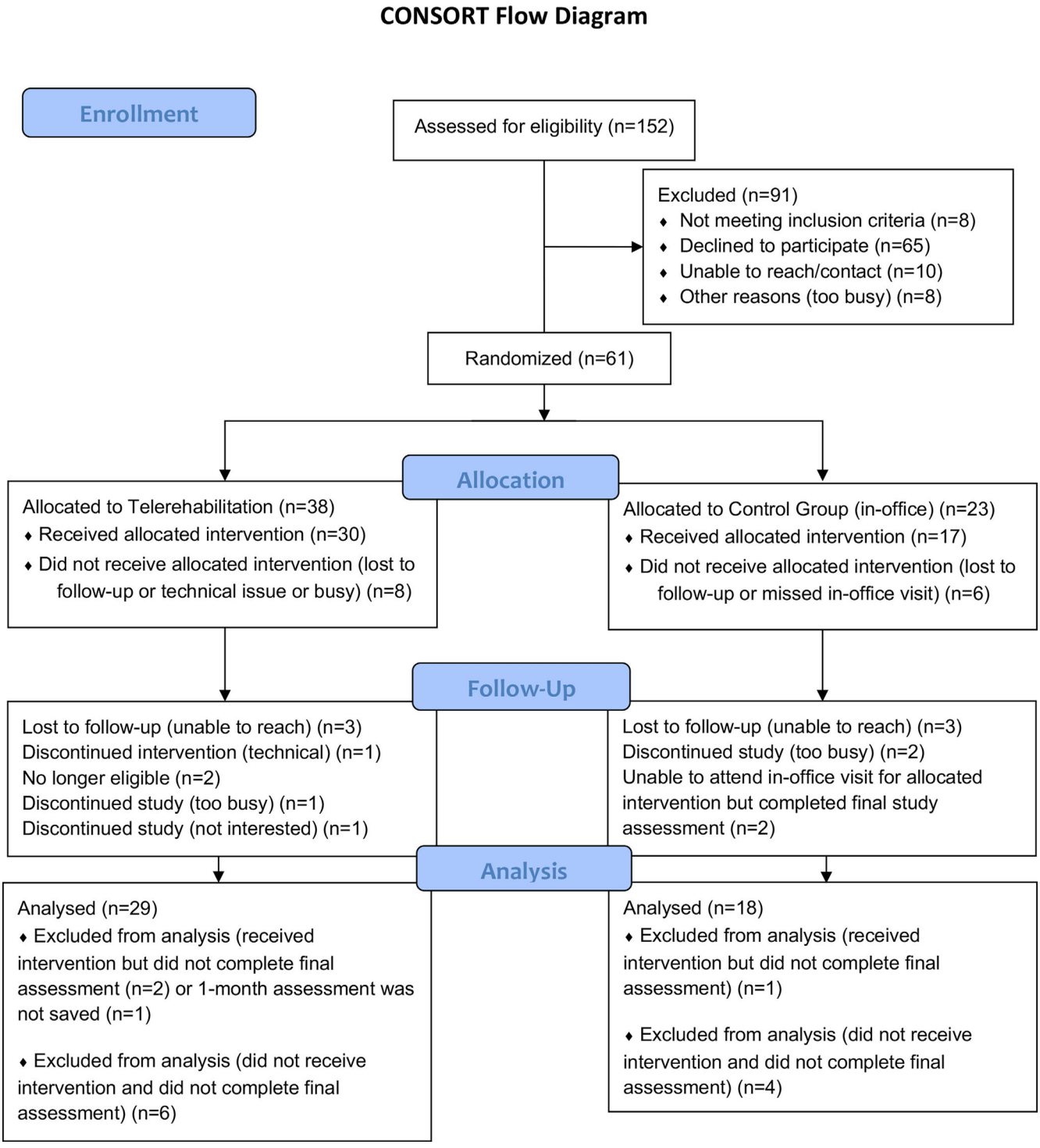

Figure 2. CONSORT flow diagram.

because of our sample size. Final analyses included 47 participants who completed the last assessment at 4 months, according to randomized group assignments ($n = 29$ telerehabilitation and $n = 18$ in office); no participants crossed-over to receive the other intervention during the trial.

Table 2 displays participants' baseline characteristics for demographics and visual/health status in each randomized group. Most were older adults, slightly more than one-half were women, approximately one-fifth were minorities, more than one-half had age-related macular degeneration, and the majority received a new hand-held optical LED magnifier. Slightly more than one-half had distance BCVA in the better eye that was 0.5 logMAR or better (20/63 Snellen equivalent) and a wide range of smallest text

Table 2. Baseline Characteristics and Health Status of Participants

Baseline Characteristics	Telerehabilitation ($n = 29$)	In-office Usual Care ($n = 18$)
Median age (years)	70 (20–93)	72 (25–91)
Female gender	20 (69)	11 (61)
Minority race (Black or Hispanic)	7 (24)	3 (18)
Education: college graduate	7 (24)	6 (38)
m-TICS cognitive status	34 ± 6	37 ± 5
Short-Form Health Survey-36 general health subscale	56 ± 19	65 ± 17
Geriatric Depression Scale (depression)	3 (1–12)	2 (0–9)
Hospital Anxiety and Depression Scale (depression)	5 (0–10)	2.5 (0–12)
Hospital Anxiety and Depression Scale (anxiety)	4 (0–13)	2 (0–12)
logMAR distance BCVA (better eye)	0.50 (0.18–1.5)	0.42 (0.06–1.0)
Distance BCVA >0.5 logMAR	14 (48)	7 (39)
Near text size with spectacles* (M-notation)	1.3 (0.5–7.0)	0.9 (0.5–2.5)
Near text size with magnifier (M-notation)	0.5 (0.4–2.0)	0.5 (0.4–0.8)
Optical magnifier power (D)	11 ± 4	10 ± 3
Newly prescribed magnifiers		
Hand-held optical LED magnifier	21 (72)	13 (72)
Stand optical LED magnifier	3 (10)	3 (17)
Portable electronic magnifier	6 (21)	2 (11)
Ocular diagnosis of age-related macular degeneration	15 (52)	11 (61)
Activity Inventory: reading ability (logits)	–0.61 (0.88; SE: 0.51)	–0.54 (0.75; SE: 0.49)

*No magnification device used, but high add powers were permitted in spectacle correction.
SE, standard error.
Values are number (%), mean ± standard deviation, or median (range).

sizes were accessible with near spectacle correction across participants. Depressive symptoms, anxiety, or cognitive impairment were mild to none (i.e., higher scores indicate greater cognition, depressive symptoms, or anxiety). There were no meaningful between-group differences in baseline characteristics.

Table 3 and Figure 3 display the changes in the primary outcome of reading ability measured by the Activity Inventory from baseline to 1 and 4 months in each group. Across all participants in both groups, reading ability improved significantly (mean = 0.61 logits; $P < 0.001$) from baseline without the new magnifier to 1 month after initial training in office when the magnifier was dispensed. Following additional magnifier training from 1 to 4 months, there were further, significant improvements in reading ability (mean = 0.44 logits for telerehabilitation; $P = 0.018$) (mean = 0.43 logits for in-office training; $P = 0.003$), equivalent to approximately three lines of VA improvement. There was no significant difference between randomized groups for reading ability changes from baseline to 1 month and 1 to 4 months (95% CI, −0.43 to 0.61; $P = 0.73$ for the main effect of group). We found a large Cohen's d effect size from baseline to 4 months of 1.02 (95% CI, 0.59–1.45) across participants, and medium Cohen's d effect size from 1 to 4 months of 0.42 (95% CI, 0.005–0.830) across participants. Table 3 displays changes in individual covariates from baseline to 4 months across all participants and each randomized group. There were no significant changes in health or cognition across all participants. The mean changes in depressive or anxiety symptoms were minimal and not significantly different over time across patients and within each group.

There was no significant difference in mean reading ability change from 1 to 4 months when comparing telerehabilitation to in-office training with the new magnifiers (0.04 logits; 95% CI, −0.52 to 0.60; $P = 0.89$). The following potentially influential factors were each nonsignificantly related to reading ability change from 1 to 4 months across patients: distance BCVA worse or better than 0.5 logMAR (−0.12 logits; 95% CI, −0.61 to 0.37; $P = 0.63$), age (−0.03 logits for every 10-year increase; 95% CI, −0.15 to 0.08; $P = 0.57$), male versus female gender (−0.23 logits; 95% CI, −0.74 to 0.28; $P = 0.36$), baseline m-TICS (−0.05 logits for every 10-point increase; 95% CI, −0.47 to 0.37; $P = 0.81$), baseline Hospital Anxiety and Depression Scale depressive symptoms (−0.09 logits for every 10-point increase; 95% CI, −0.82 to 0.64; $P = 0.81$), and baseline

Table 3. Changes in Outcomes and Covariates From Baseline to 1 and 4 Months for all Participants and According to Randomized Group

Outcomes	All Participants	Telerehabilitation	In-Office Usual Care
Mean Change From Baseline to 1 Month			
Reading ability (logits)	0.61 (0.36 to 0.86) $P < 0.001$*	0.70 (0.34 to 1.07) $P < 0.001$*	0.47 (0.19 to 0.75) $P = 0.001$*
Mean change from 1 month to 4 months			
Reading Ability (logits)	0.438 (0.19 to 0.69) $P = 0.001$*	0.44 (0.08 to 0.80) $P = 0.018$*	0.43 (0.15 to 0.71) $P = 0.003$*
Mean change from baseline to 4 months			
Reading ability (logits)	10.05 (0.80 to 10.30) $P < 0.001$*	1.14 (0.78 to 1.51) $P < 0.001$*	0.90 (0.63 to 1.18) $P < 0.001$*
TICS cognitive status	1.02 (−0.41 to 2.45) $P = 0.16$	1.85 (−0.06 to 3.76) $P = 0.057$	−0.22 (−2.46 to 2.01) $P = 0.84$
Short-Form Health Survey-36 general health	0.65 (−3.90 to 5.21) $P = 0.77$	4.82 (−1.30 to 10.9) $P = 0.12$	−5.83 (−12.0 to 0.33) $P = 0.06$
Geriatric Depression Scale	0.35 (−0.47 to 1.17) $P = 0.40$	−0.14 (−1.18 to 0.89) $P = 0.78$	1.11 (−0.29 to 2.52) $P = 0.11$
Hospital Anxiety and Depression Scale (depression)	−0.09 (−0.79 to 0.61) $P = 0.80$	−0.29 (−1.16 to 0.59) $P = 0.51$	0.22 (−1.04 to 1.48) $P = 0.71$
Hospital Anxiety and Depression Scale (anxiety)	−0.09 (−0.80 to 0.63) $P = 0.81$	−0.50 (−1.42 to 0.42) $P = 0.28$	0.72 (−0.63 to 1.74) $P = 0.34$
Reading ability (logits) for New vs. established patients	0.17 (−0.43 to 0.76) $P = 0.57$	0.44 (−0.43 to 1.31) $P = 0.31$	−0.27 (−0.97 to 0.43) $P = 0.43$
Previous prescribed magnifier vs. never	−0.34 (−1.02 to 0.34) $P = 0.32$	−0.74 (−1.71 to 0.22) $P = 0.13$	0.43 (−0.40 to 1.25) $P = 0.29$

*$P < 0.05$.
Values are median (95% CI).

Short-Form Health Survey-36 general health subscale score (0.04 logits for every 10-point increase; 95% CI, −0.10 to 0.17; $P = 0.60$). Activity Inventory reading ability changes were not significantly related to whether participants had not versus had previously received vision rehabilitation services in the years before the study (baseline to 1 month: 95% CI, −0.17 to 0.75; $P = 0.21$) (1–4 months: 95% CI, −0.70 to 0.42; $P = 0.62$) (baseline to 4 months, see Table 3; $P = 0.57$) or if they were previously prescribed a magnification device for near (baseline to 1 month: 95% CI, −0.83 to 0.24; $P = 0.27$) (1–4 months: 95% CI, −0.68 to 0.62; $P = 0.93$) (baseline to 4 months, see Table 3; $P = 0.32$) across all participants.

Slightly more than one-half ($n = 24$ [51%]) of participants achieved the minimal clinically important difference for the Activity Inventory change from baseline to 4 months. The odds of achieving the minimal clinically important difference were not significantly related to participants' age ($P = 0.64$), distance BCVA ($P = 0.87$), baseline Activity Inventory person measures ($P = 0.34$), baseline m-TICS scores ($P = 0.98$), whether they were new to vision rehabilitation services ($P = 0.59$), had been previously prescribed a magnification device for near ($P = 0.78$), or their randomization to telerehabilitation versus in-office training ($P = 0.95$).

Table 1 displays the types of errors that were observed while nonproficient participants used their magnifiers for reading during the telerehabilitation sessions, as well as the proportion of telerehabilitation participants who did not use the magnifier optimally according to each type of error. There was a variety of errors related to magnifier use across participants, but there was not a single type of error that tended to occur most often, indicating there is diversity in the various mistakes made by participants when first learning to use a magnifier for which providers gave individualized training.

Nearly one-quarter (24%; $n = 7$) of telerehabilitation participants had not accessed the Internet for any reason (e.g., websites or email) anytime in the 6-month period before their participation in the trial.

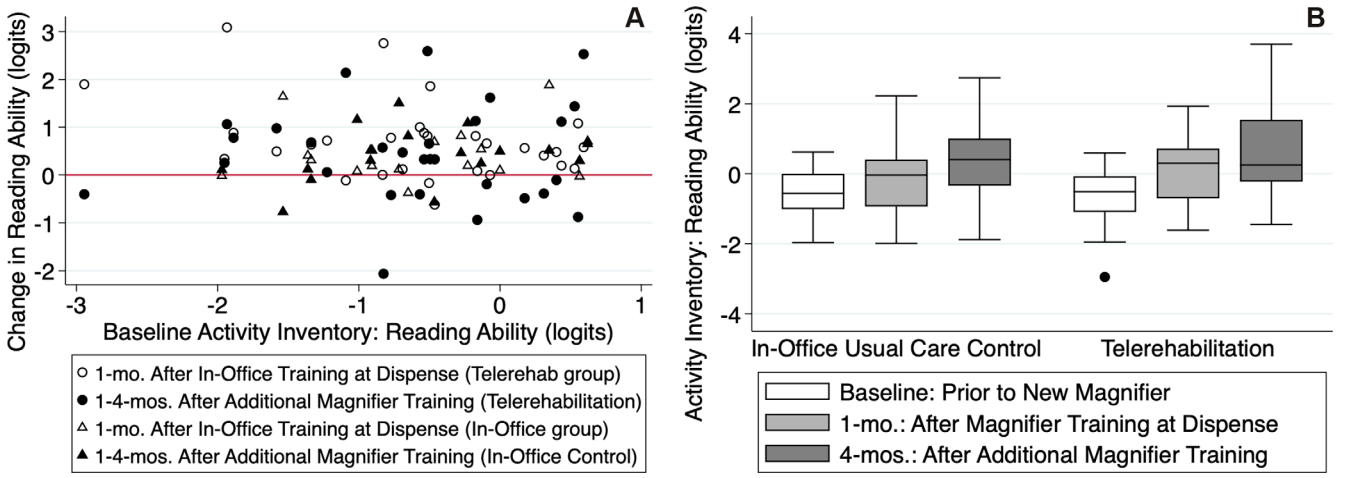

Figure 3. (**A**) Scatterplot displaying the change in logit scores for reading ability measured with the Activity Inventory after 1 month of new magnifier use (open symbols), and after 4 months following additional magnifier training (filled symbols) when compared with the baseline reading ability scores without the new magnifier for the telerehabilitation (circle symbols) versus in-office usual care control (triangles) groups. (**B**) Box plot displaying the logit scores for reading ability measured with the Activity Inventory at baseline without the new magnifier, after 1 month with the new magnifier, and after 4 months with the new magnifier following additional training for the telerehabilitation versus in-office usual care control groups. In the box plots, the bottom and top of the box are the 25th and 75th percentiles (i.e., the upper and lower quartiles, respectively), and the band near the middle of the box is the 50th percentile (i.e., the median). The dot represents outlier data from one participant.

All of them reported their magnifier use after telerehabilitation versus two-thirds (67%) who accessed the Internet reported improved magnifier use (Pearson $\chi 2 = 3.02$; $P = 0.08$). The number of telerehabilitation sessions ranged from one to four sessions (mean/media $n = 2$); 34.5% of participants ($n = 10$) were deemed proficient with their magnifier at the initial telerehabilitation evaluation and did not require additional sessions. Approximately one-half (48%) had two telerehabilitation sessions to gain proficiency. Participants who were not proficient with the magnifier initially and needed a second telerehabilitation session had a significantly greater odds of being older (OR, 1.08; 95% CI, 1.02,1.14; $P = 0.007$) or not being a college graduate (OR, 32.7; 95% CI, 1.87,573; $P = 0.02$). All except one participant who was initially proficient read 0.4 to 0.5 M text size with their magnifier, while only 32% of participants who had multiple sessions could achieve the same print size initially ($\chi^2 = 8.96$; $P = 0.003$). Other factors related to demographics or health status were not significantly related to requiring more than one session to demonstrate proficiency (each $P > 0.05$).

For the group randomized to in-office sessions, two-thirds (66.67%) had only one office visit for additional training with the new magnifier from 1 to 4 months, whereas two in-office participants (11%) included in the analyses were unable to attend any in-person sessions with their provider owing to a lack of transportation or nonvisual medical issues. Only 22% of the in-office participants had two additional training sessions in person 1 to 4 months after receiving the new magnifier. There was a significantly greater proportion of telerehabilitation participants (65.5%) who had more than one training session when compared with participants randomized to in-office training ($\chi 2 = 8.33$; $P = 0.004$). Across participants, change in Activity Inventory reading ability from 1 to 4 months was not significantly related to having more than one training session (95% CI, −0.34 to 0.73; $P = 0.48$).

Discussion

Significantly improved Activity Inventory reading person measures (i.e., equivalent to approximately 3 lines of VA) were observed after new optical or electronic portable magnifier training, with no difference between telerehabilitation and in-office interventions. We found that magnifier training may be indicated across all adult ages and visual impairment levels in patients with mild to no cognitive impairment. This trial provides support for the beneficial effects of additional magnifier training through either telerehabilitation or in-office visits, because it seems to be possible that either modality of care delivery may be suitable.

Significant visual ability improvements in the Activity Inventory were measured in another randomized controlled trial of newly dispensed optical magnifiers in adults with low vision owing to any cause after an additional in-office training session (mean = 0.73 logits improvement) or no further training (mean = 0.53 logits improvement).[33] The magnitude of improvement for the additional in-office training in this previous trial may have been less than our trial, because only a single training session was provided and visual ability was reported rather than reading ability that may be more specific to magnifier use. Similarly, legally blind adults who received in-person visual aid training through a mobile clinic had significantly improved Activity Inventory reading ability scores (mean = 0.76 logits).[34] The large Cohen's d effect size of 1.02 in our study from baseline to 4 months was greater than previously reported effect sizes for outpatient vision rehabilitation services[26] and the effect size for the Veterans Affairs Low Vision Intervention Trial II (LOVIT II) trial.[35]

The LOVIT II trial in U.S. Veterans who received new visual aids found no significant reading ability change with the VA-LV-VFQ following additional in-office training for mild vision loss (≤0.5 logMAR).[35] In contrast, our trial found that patients with mild vison loss benefitted from training because there was no significant difference in reading ability improvement according to whether BCVA was better or worse than 0.5 logMAR. We hypothesized that our outcomes may differ from the LOVIT II trial because we enrolled a different study population without U.S. Veterans and used the Activity Inventory as a more appropriate assessment for mild vision loss since items that are not difficult at baseline are filtered (i.e., excluded), potentially making it less susceptible to ceiling effects. It was important for us to compare findings for participants with moderate to severe vision loss with those for mild vision loss patients because they are a growing segment of the low vision population owing to effective medical treatments for age-related macular degeneration and diabetic retinopathy that decrease the likelihood of severe impairment.

We attempted to estimate the change in reading ability from baseline without the new magnifier to 1 month of magnifier use after the initial training at time of magnifier dispensing. However, an inherent limitation was that some participants had already received their magnifier at the time of the baseline assessment, so there is some potential for bias, although we cannot anticipate if participants tended to overestimate or underestimate their reading ability without the magnifier, and the baseline does not impact our primary outcome for changes after additional training from 1 to 4 months. The difference in baseline mean reading person measures between our study (−0.6 logit) and previous studies of vision rehabilitation (0.6 [Tabrett and Latham[28]] and 0.8 [Low Vision Rehabilitation Outcomes Study[30]] logit) may be partly owing to our use of MSD for the Rasch analysis rather than the Andrich model that was used in the previous referenced studies. However, these measures are known to be highly correlated.[36] It is possible there were other differences in our participant sample versus previous studies, for example, perhaps participants with worse baseline reading ability might have been more willing to pursue additional training with a new magnifier as in our study. Not all of the participants in the previous studies were prescribed a new magnifier (83% Tabrett and Latham[28]) and only 66% of Low Vision Rehabilitation Outcomes Study participants had a functional complaint related to reading,[30] which was the focus of our study.

Using remote access control on loaner equipment, we successfully demonstrated how telehealth services can be made readily accessible to those with low vision, including those who had not used videoconferencing previously. It is important to provide accommodations to support access because our participants without recent Internet experience benefitted from telerehabilitation and should not be excluded. The feasibility of delivering telerehabilitation compared with in-office care was supported by a greater number of telerehabilitation sessions that were completed to provide training and follow-ups conveniently. We successfully conducted multiple telerehabilitation training sessions as needed to enable participants to achieve proficiency with their magnifier. One telerehabilitation participant discontinued owing to videoconference connection issues. However, with the exception of this one case, we were able to overcome any technical issues and would recommend our methodology to enable telerehabilitation for patients who have difficulty accessing videoconference platforms. Another potential limitation of telerehabilitation is the inability to provide hands-on adjustments to the magnifier and reading materials, but the providers were able to compensate by giving verbal instructions that were successfully implemented by participants.

Magnifiers are abandoned by visually impaired patients when they are perceived as ineffective,[32] which may be preventable with follow-up. No participants in our trial abandoned their magnifier during the 4-month period, likely owing to both training and occasional provider-initiated changes in the device that was initially dispensed for three participants; that is, switched from a hand-held to stand magnifier, from

an optical to electronic magnifier, or replaced with the same hand-held magnifier owing to its broken light. These changes were based on observations of limitations encountered by participants during follow-ups and more suitable devices were issued when needed. The ability to follow-up with either via telerehabilitation or in the office was valuable to determine if the magnifier met the patient's needs beyond the dispensing visit.

The generalizability of our trial's findings are enhanced by the inclusion of both academic centers and private practice settings in different regions of the United States, as well as various providers, including optometrists, occupational therapists, and an ophthalmologist. Additionally, we included any hand-held magnifier, because both optical or portable electronic aids are commonly prescribed in clinical practice. Future work with larger samples will need to determine if reading ability improvements vary according to magnifier type, vision rehabilitation provider, or number or duration of sessions. An inherent limitation was the inability to mask providers and participants, but our providers maintained equipoise to the efficacy of either intervention as each has potential advantages. To attempt to reduce potential confounding factors from participants (e.g., the perception of advantages or disadvantages for their randomized modality of care), future clinical trials could obtain and account for informant input from close acquaintances of participants who have observed their magnifier use during the study period. Also, future studies should evaluate extensive training that is based on the participant's specific goals to accomplish difficult reading tasks, after their achievement of proficiency with the magnifier.

Using telerehabilitation to conduct follow-ups for newly prescribed magnifiers or other reading aids can offer another viable means for rendering vision rehabilitation services via an approach that is more convenient, safe, and resource efficient, in order to improve access to care.[6] The current findings can be used to justify and design a larger-scale noninferiority trial to determine if telerehabilitation is at least as effective as in-office usual care and that the two approaches do not result in different outcomes. This would be critical information for providers to reassure patients that either modality is acceptable.

Acknowledgments

Contributions to the trial from other members of the BeST-AID study team included: Lynn Watt Kurata in private practice in Santa Monica, California; Suleiman Alibhai in private practice in Alexandria, Virginia; Alicia Donahue at the New England College of Optometry; Melissa Chun at the UCLA Stein Eye Institute; the UCLA study coordinators, Kelly Hofschneider and Max Estabrook; and the UCLA student research assistants (Tameen Ahmed, Sarah Bui, Jewel Chu, Samantha Ito, Xuan Kuang, Joyce Kuo, Leanne Lee, Hannah Liu, and Megan Yu).

Financial Support: Funding for this trial was provided by NIH/NEI R21 EY029883 to AKB, the 2019 Clinical Research Award from the American Academy of Optometry Foundation, and support to AKB from an unrestricted award from Research to Prevent Blindness to the Department of Ophthalmology at UCLA. The sponsors or funding organizations had no role in the design or conduct of this research.

Trial Registration: Clinicaltrials.gov (identifier NCT04066075).

Disclosure: **A.K. Bittner,** None; **J.E. Kaminski,** None; **P.D. Yoshinaga,** None; **J.D. Shepherd,** None; **T.L. Chan,** None; **A.G. Malkin,** None; **A. Deemer,** None; **M. Gobeille,** None; **S.J. Thoene,** None; **A. Rossi,** None; **N.C. Ross,** None

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