Visual magnification through a smartphone application designed to assist presbyopia

Ampliação visual por meio de um aplicativo para smartphone desenvolvido para auxiliar a presbiopia

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ABSTRACT

Objective: To develop and validate a smartphone application capable of magnifying near images and, through educational videos, informing users about presbyopia.

Methods: This was a cross-sectional, quantitative study conducted by a multidisciplinary team of ophthalmologists and software engineers. The development and validation of the application, named PRESB, occurred in three main stages. First, the user interface and native functions were designed. Second, the application was tested by patients who had undergone bilateral age-related cataract surgery with implantation of a monofocal intraocular lens in both eyes, targeted for emmetropia, and were evaluated 30 days after surgery in the second eye. Usability was assessed with the System Usability Scale questionnaire. Third, the collected data were analyzed to determine users' satisfaction, perceived usability, near visual acuity, and reading performance.

Results: A total of 39 volunteers evaluated PRESB. The application provided a simple and intuitive interface, and the mean System Usability Scale score was 75, indicating good acceptance and usability. Unaided near visual acuity improved significantly when the application was used, changing from approximately J5 ± J4 without the application to about J2 ± J1 with the application ($p < 0.05$). The mean reading speed with the application reached 162.72 ± 21.20 words per minute. Regarding the interactive educational videos, 87% of volunteers considered them very useful for improving both smartphone use and understanding of presbyopia.

Conclusion: The PRESB application proved to be effective and valid in achieving its main objective, as it led to a significant improvement in unaided near visual acuity compared with not using the application. Therefore, it appears to be a useful adjunct in the daily activities of individuals with presbyopia.

RESUMO

Objetivo: Desenvolver e validar um aplicativo para *smartphone* capaz de ampliar imagens de perto e, por meio de vídeos educativos, informar os usuários sobre presbiopia.

Métodos: Este foi um estudo transversal quantitativo conduzido por uma equipe multidisciplinar de oftalmologistas e engenheiros de *software*. O desenvolvimento e a validação do aplicativo, denominado PRESB, ocorreram em três etapas principais. Primeiro, a interface do usuário e as funções nativas foram projetadas. Segundo, o aplicativo foi testado por pacientes submetidos à cirurgia bilateral de catarata relacionada à idade com implante de lente intraocular monofocal em ambos os olhos, com o objetivo de alcançar emetropia; esses pacientes foram avaliados 30 dias após a cirurgia no segundo olho. A usabilidade foi avaliada com o questionário *System Usability Scale*. Terceiro, os dados coletados foram analisados para determinar a satisfação dos usuários, a usabilidade percebida, a acuidade visual de perto e o desempenho de leitura.

Resultados: Um total de 39 voluntários avaliaram o PRESB. O aplicativo apresentou uma interface simples e intuitiva, e a pontuação média no *System Usability Scale* foi de 75, indicando boa aceitação e usabilidade. A acuidade visual para perto sem correção melhorou significativamente com o uso do aplicativo, passando de aproximadamente J5 ± J4, sem o aplicativo, para cerca de J2 ± J1, com o aplicativo ($p < 0,05$). A velocidade média de leitura com o aplicativo atingiu 162,72 ± 21,20 palavras por minuto. Em relação aos vídeos educativos interativos, 87% dos voluntários os consideraram muito úteis para melhorar tanto o uso do *smartphone* quanto a compreensão da presbiopia.

Conclusão: O aplicativo PRESB mostrou-se eficaz e válido para atingir seu objetivo principal, pois levou a uma melhora significativa na acuidade visual para perto sem correção em comparação com a ausência do aplicativo. Portanto, parece ser um complemento útil nas atividades diárias de indivíduos com presbiopia.

INTRODUCTION

Refractive errors remain one of the leading causes of blindness worldwide, either because of high refractive error itself or because visual problems are left uncorrected.[1] Presbyopia, an irreversible reduction in the accommodative capacity of the crystalline lens that leads to difficulty focusing on near objects, is among the most common refractive errors.[2] Accommodation, the process that allows clear vision at near, depends on contraction of the ciliary muscle, convergence of the eyes, and pupillary miosis. Together, these actions allow the crystalline lens to become more spherical and ensure that light rays are focused on the retinal plane.[3,4] Therefore, presbyopia is a condition intrinsically related to aging and may also occur after surgical removal of the lens. A 2018 study estimated that, by 2050, about 20% of the global population will have presbyopia associated with senility.[5]

A decrease in near visual acuity is usually the first sign of presbyopia, and the safest and least invasive treatment continues to be prescription glasses, whether monofocal, bifocal or progressive.[6] As technologies related to health continue to advance, alternative approaches that complement standard treatment may offer additional benefits and improve visual satisfaction and quality of life.

This study aimed to develop and validate a smartphone application capable of magnifying near images and, through educational videos, informing users about presbyopia. Within this population, we aimed to develop a smartphone application that provides optical support in addition to conventional treatments for presbyopia and to assess patient and user acceptance of this tool, while also promoting understanding of the condition.

METHODS

This study was approved by the Institutional Review Board (CAAE: 47544221.4.0000.5049) in accordance with Resolution 466/12 of the National Health Council, and all participants provided written informed consent.

This was a prospective, cross-sectional quantitative study conducted between January 2023 and June 2024 at *Instituto Cearense de Oftalmologia* (Fortaleza, Ceará, Brazil), in collaboration with the Innovation Laboratory of Technology at the *Universidade Christus*. The study was carried out by a multidisciplinary team of ophthalmologists and software engineers. The primary steps in creating and validating the PRESB application were: designing the user interface and implementing the app's native functions; validating the application among pseudophakic presbyopes who had undergone bilateral cataract surgery with implantation of monofocal intraocular lenses in both eyes, targeted for emmetropia, and who were evaluated at least 30 days after surgery in the second eye, using the System Usability Scale questionnaire; and analyzing the collected data on user satisfaction and usability.

Creation of the application

Developed at the Innovation Laboratory of Technology at the *Universidade Christus*, PRESB is a Portuguese-language application compatible with iOS and Android smartphones. When the app is launched, a home screen displaying the logo appears, followed by automatic redirection to the main interface. This screen includes color-coded buttons (gray, green, yellow, orange) labeled 1 through 4, plus a red "MAX" button. At the same time, the smartphone's native camera is activated to provide real-time magnification. Each button applies a preset level of zoom, allowing users to select the magnification that best suits their needs (Figure 1). When the "MAX" option is selected, the app uses the upper limit of the optical–digital zoom available on the device, maintaining a stable frame rate suitable for comfortable near vision reading.

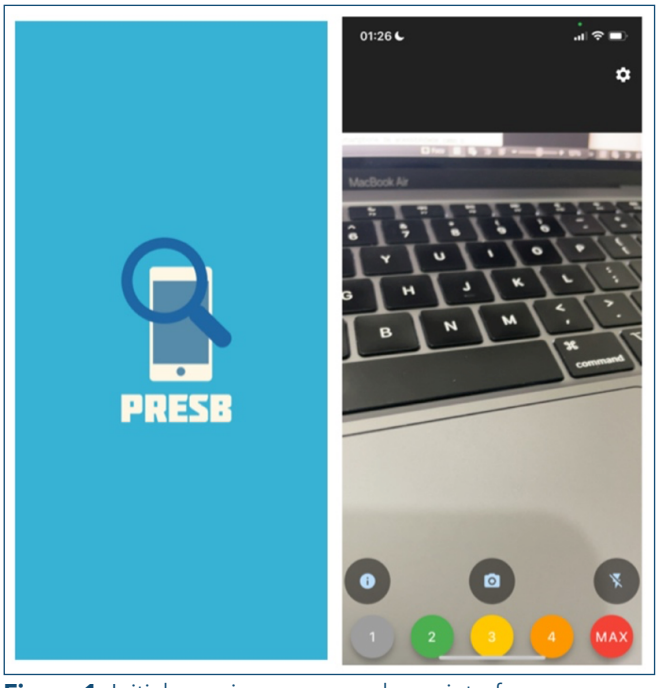

Figure 1. Initial opening screen and user interface.

Additional features include activation of the smartphone's flash for low-light conditions and a central capture button that freezes the on-screen image, allowing the user to inspect it without continuously pointing the camera.

Within the application, a "quick tips" menu offers animated videos: one explains how to set up the

smartphone's accessibility features for users with low vision, and the provides a playful explanation of presbyopia, its main symptoms, and the importance of seeking ophthalmic care when indicated. The "settings" section includes an optional night mode to enhance screen contrast and a "Slice" magnification tool for manual image zoom (Figure 2).

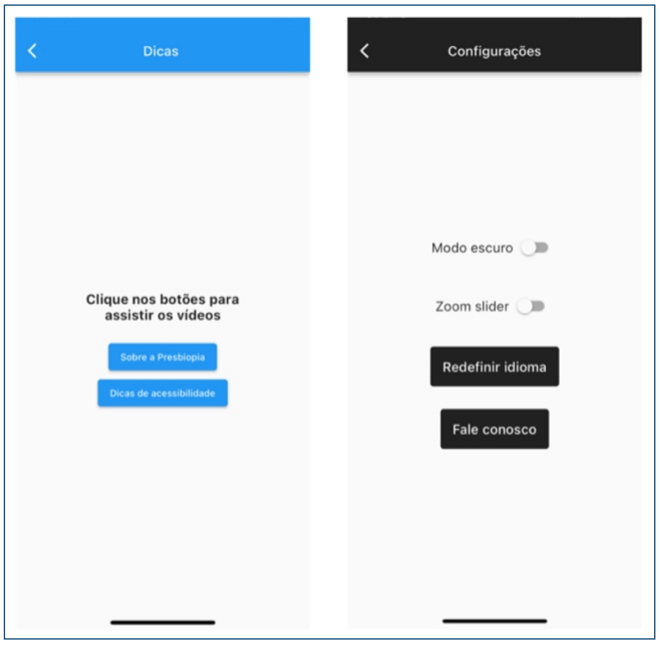

Figure 2. Menus and tools in the PRESB application.

Population, user experience, and application validation

After providing informed consent, participants received a brief explanation of PRESB, including a demonstration of its menus and functions. Eligible volunteers were pseudophakic patients who had undergone bilateral cataract surgery with monofocal intraocular lens implantation in both eyes for emmetropia at *Instituto Cearense de Oftalmologia*; met clinical criteria for presbyopia, defined by age compatible with presbyopia, self-reported difficulty with near tasks, and the need for a near addition on refraction; were literate; and owned a smartphone with an iOS or Android operating system. Participants were eligible if they had best corrected visual acuity (BCVA) better than 0.18 LogMAR in both eyes. Although the target population was composed mainly of patients with senile cataract, some younger pseudophakic individuals (for example, those with early, congenital, or traumatic cataracts) were also included and analyzed within the same group. Exclusion criteria included chronic eye disease with known reduced visual acuity (BCVA worse than 0.40 LogMAR) and illiteracy.

Each participant installed PRESB on their own smartphone, used the app, and then completed the validated Brazilian Portuguese version of the System Usability Scale questionnaire. The System Usability Scale was administered in an interviewer-assisted format to ensure that all items were clearly understood, while preserving the participants' own responses. A profile questionnaire was also administered, collecting data on age, gender, race, education level, familiarity with technology, knowledge about presbyopia, perceived relevance of the educational videos, and free-form comments. Basic clinical data (preoperative and postoperative distance and near visual acuity) were also recorded.

Near reading speed was measured with and without the application using the Minnesota Low Vision Reading Test (MNREAD) chart.[7] Testing was performed at a standard distance of 40 cm under comfortable room lighting, with the participant wearing their usual distance correction when indicated. Reading time and errors were recorded according to the MNREAD protocol, and reading speed was expressed in words per minute. Near reading was first measured without the application and subsequently with PRESB; no randomization of test order was performed.

Application usability was then assessed by the internationally validated System Usability Scale questionnaire, which comprises ten statements rated on a five-point Likert scale (from "strongly disagree" to "strongly agree").

Statistical analysis

Data from both the general survey and the System Usability Scale questionnaire were analyzed using SPSS software (version 20.0 for Windows). Subcategory and overall System Usability Scale scores (ranging from zero to one hundred) were calculated. Mean System Usability Scale scores were compared with demographic variables (age, gender, race, education, technology use, presbyopia knowledge, educational video relevance, and free comments) and with clinical data (preoperative and postoperative visual acuity) using the chi-square test, Fisher's exact test, or the Wilcoxon test, as appropriate. Quantitative variables are presented as mean ± standard deviation.

RESULTS

Sociodemographic profile

Thirty-nine volunteers met the inclusion criteria. Four individuals were excluded (two did not have a

smartphone and two had visual acuity worse than 1.3 LogMAR due to glaucomatous optic neuropathy). Mean age was 63.82 ± 15.43 years (range: 29 to 89). Of the volunteers, 20 (51.3%) were female and 19 (48.7%) were male; 11 (28.2%) self-identified as White, 19 (48.7%) as Brown, and 9 (23.1%) as Black. Regarding education, 4 (10.3%) had not completed primary education, 2 (5.1%) had completed primary education, 6 (15.4%) had not completed secondary education, 11 (28.2%) had completed secondary education, 8 (20.5%) had higher education, and 8 (20.5%) were unable to define their educational level.

When asked whether they regularly used technology, 27 participants (69.2%) answered "yes". Only one participant (2.6%) reported prior knowledge of presbyopia. In addition, 36 individuals (92.3%) considered the educational videos in PRESB to be highly relevant for learning about presbyopia or improving smartphone use, as shown in table 1.

Table 1. Sociodemographic data

	n (%)
Total	39 (100)
Age (63.82 ± 15.43; 29-89)	
Up to 60	15 (38.5)
>60	24 (61.5)
Sex	
Female	20 (51.3)
Male	19 (48.7)
Race	
White	11(28.2)
Brown	19 (48.7)
Black	9 (23.1)
Education Level	
Incomplete elementary school	4 (10.3)
Complete elementary school	2 (5.1)
Incomplete high school	6 (15.4)
Complete high school	11 (28.2)
Higher education	8 (20.5)
I did not know the answer	8 (20.5)
I use of technological tools in everyday life	27 (69.2)
I know what presbyopia is	1 (2.6)
The educational videos were relevant	36 (92.3)

Assessment of pre- and postoperative distance visual acuity

Preoperative and postoperative best-corrected distance visual acuity (LogMAR) were analyzed. Using the Wilcoxon test to compare the change (delta) in visual acuity, a statistically significant difference ($p < 0.001$) was observed between pre- and postoperative values, with a delta of -0.65 ± 0.33 for the right eye and -0.60 ± 0.36 for the left eye. The results are shown in table 2.

Table 2. Statistical analysis of visual acuity data from volunteers in LogMAR

Visual acuity LogMAR	Mean ± SD
Right eye	
Preoperative	0.72 ± 0.37
Postoperative	0.06 ± 0.10
p-value*	< 0,001†
Delta	-0.65 ± 0.33
Left eye	
Preoperative	0.67 ± 0.32
Postoperative	0.07 ± 0.17
p-value*	< 0,001†
Delta	-0.60±0.36

*Wilcoxon test; †value with static significance.

Postoperative near visual acuity

All volunteers were assessed for near visual acuity at least 30 days after bilateral cataract surgery with implantation of a monofocal IOL aimed at emmetropia. Jaeger charts were used to measure near vision without and with PRESB.

According to the chi-square or Fisher's exact test, none of the participants achieved J1 near vision without using PRESB, whereas 28 (71.8%) achieved J1 and 11 (28.2%) achieved J2 with PRESB ($p < 0.001$). These categorical results are summarized in table 3.

Table 3. Near visual acuity with and without the use of PRESB

	n (%)
Near visual acuity without PRESB	
J1	0
J2	0
J3	9 (23.1)
J4	20 (51.3)
J5	9 (23.1)
J6	1 (2.6)
Near visual acuity with PRESB	
J1	28 (71.8)
J2	11 (28.2)
J3	0
J4	0
J5	0
J6	0
p-value*	< 0.001†

* Chi-square test or Fisher's exact test; † value with static significance.

Usability evaluation

All participants responded to the System Usability Scale questionnaire, which presented an average score of 75.31 ± 7.29 (range: 62 to 94), indicating good acceptance of the application by users, and they were also able to evaluate the educational videos (Figure 3). No significant correlations were found between the System Usability Scale scores and demographic variables. Figure 4 illustrates the distribution of System Usability Scale scores.

Participants' comments

Each participant was invited to provide open-ended feedback on PRESB, including their overall experience and

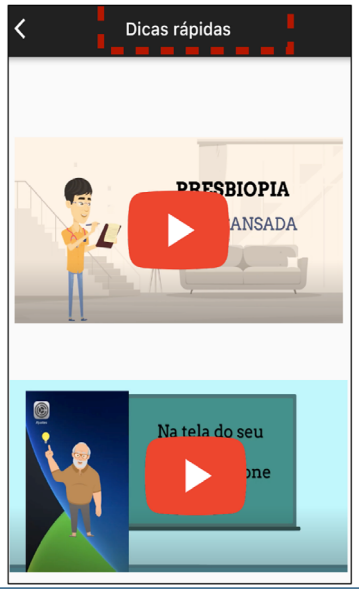

Figure 3. Application interface in "quick tips" with educational videos and information on handling native smartphone tools.

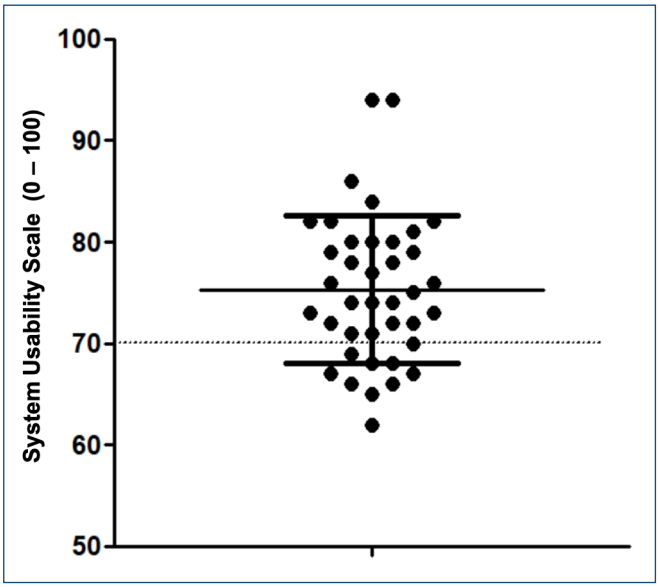

Figure 4. Usability values of the tested sample. Mean of the System Usability Scale of 75.31 ± 7.29 (62-94).

suggestions for improvement. Selected comments are shown in table 4.

Reading speed assessment

Reading speed was evaluated with and without PRESB using the MNREAD chart. Participants read a significantly higher number of words per minute when using the application. The mean reading speed without PRESB was 76.53 ± 31.30 words per minute, increasing to 162.72 ± 21.20 words per minute when the application was used.

Table 4. Excerpts from the main responses of participants regarding their user experience

"I really liked this app; they could have made something so simple sooner"
"I would easily recommend PRESB to a friend"
"Very easy to use"
"I hope this app never disappears"
"PRESB will be my shopping companion"
"If I use this app, I won't need to wear glasses, because I find them quite ugly"
"PRESB should be available for tablets"
"I congratulate the team of doctors who came up with such a cool solution"
"I thought the app could contain more videos talking about other eye diseases, because many times we have eye symptoms, and access to a specialist takes a long time, and with these videos some questions could be solved"

DISCUSSION

Presbyopia is a common refractive condition that usually manifests in the fourth decade of life and progressively worsens during the fifth decade. This decline in near vision occurs when the crystalline lens can no longer become sufficiently spherical because of reduced ciliary muscle contractility and loss of elasticity.[8] A similar effect is observed after cataract surgery with removal of the crystalline lens, particularly when a monofocal IOL is implanted and emmetropia is targeted.

The impact of uncorrected presbyopia on daily activities and overall functional capacity is substantial.[9] Current treatments, such as progressive or bifocal glasses,[10] multifocal IOL implantation at the time of cataract surgery,[11] and refractive surgery,[12] are often effective but may be associated with adaptation difficulties, financial cost, and the need for access to specialized ophthalmic services.

In this pilot, proof-of-concept feasibility and usability study, we focused on a single core feature of the PRESB application, near-image magnification, tested in a specific clinical setting of pseudophakic presbyopes after bilateral cataract surgery. Within this context, PRESB was associated with significantly better unaided near visual acuity and reading speed compared with baseline unaided near vision after monofocal IOL implantation, and it was rated as highly usable by participants (mean System Usability Scale score = 75.31 ± 7.29). Because the main mechanism is optical-digital magnification, an improvement in near performance relative to unaided near vision, it is expected and it should be interpreted as an "aid through enlargement," conceptually closer to a handheld magnifier than to refractive correction. Accordingly, PRESB is intended as an adjunct tool and not as a replacement for conventional near correction. Importantly, we did not compare PRESB with standard care (such as conventional near additions) or with existing smartphone magnifier applications, so the present results should be interpreted as an initial demonstration of feasibility rather than a

comparative effectiveness trial. In particular, the lack of a direct comparison with reading glasses limits any inference about how PRESB performs against the current standard approach for near vision in presbyopia.

Beyond simple magnification, PRESB incorporates educational content, including videos that explain presbyopia and step-by-step instructions for configuring built-in smartphone accessibility features, resources that are not routinely available in similar applications for iOS or Android devices.[13] In the current version, the educational videos are delivered via an online platform and therefore require an internet connection, which may limit access in some real-world contexts. However, this educational component is designed to enhance user understanding and correct use of the tool: patients can view the instructional material when connectivity is available and subsequently retain the guidance for day-to-day use, while the core magnification function remains immediately accessible for rapid, opportunistic near tasks. In addition, native accessibility functions (including built-in magnifiers) already exist on some devices; however, PRESB integrates magnification presets, illumination support, contrast-friendly modes, image capture, and educational guidance within a simplified interface, which may facilitate adoption by older adults and by users who are less familiar with device settings. A practical advantage of PRESB is its usefulness for individuals with presbyopia who do not always have their reading glasses at hand. In everyday situations, such as reading menus with small print in dimly lit restaurants, checking bills or receipts, or examining product labels in supermarkets, the app offers immediate magnification through the smartphone camera. This may help reduce the discomfort or embarrassment that many users feel when they are unable to read important information related to prices or product details, thereby preserving autonomy and confidence in social interactions. Previous studies have shown that uncorrected presbyopia significantly compromises performance in near-vision tasks, reinforcing the importance of accessible interventions.[14] By combining high-contrast magnification presets, a simple, button-based interface and disease-specific educational content, PRESB may be easier for older adults to adopt than manually setting up native accessibility settings.

Some participants reported the impression that the application could replace their reading glasses in daily life. Although this perception illustrates the positive subjective impact of the tool, we emphasize that PRESB is intended as a complementary aid rather than a substitute for comprehensive refractive correction and regular ophthalmic follow-up. Moreover, while the observed differences were statistically significant, clinical relevance should be interpreted in functional terms (e.g., the ability to complete a near task in a real setting), and not solely based on p-values; as such, PRESB may be particularly useful for rapid, opportunistic reading tasks rather than sustained near work.

This study has some limitations. The sample size was relatively small and derived from a single center, which limits generalizability. There were no control group and no direct comparison with standard near corrections or with built-in smartphone magnifiers. The evaluation was short-term and based on a single visit, focused on immediate performance rather than long-term adherence. In addition, the reading tests were always performed in the same order, which may have introduced a learning effect. Finally, the study population consisted of post-cataract pseudophakic patients, so the findings may not directly apply to phakic individuals or to other presbyopic groups.

Near visual acuity was measured using Jaeger charts, an ordinal scale widely used in clinical practice; therefore, variability and dispersion measures derived from ordinal categories should be interpreted cautiously, and future studies should preferentially adopt continuous near-vision metrics when the primary objective is quantitative modeling of variability. In addition, the use of PRESB presupposes access to a smartphone and adequate battery charge, which may limit applicability in some settings. Because the application was developed by the study team, independent external validation will be important to mitigate potential investigator-related bias and to strengthen the evidence base.

Future work should include larger, multicenter, preferably randomized studies to confirm these preliminary findings and to better define the role of PRESB in presbyopia management. Comparisons with standard near additions and with native smartphone magnifier tools will be important to establish relative benefits and potential indications. Long-term studies incorporating real-world usage metrics, such as app analytics and adherence over time, could also help clarify how and when patients actually use the application in their daily lives. Daily-life assessments conducted outside a controlled clinical visit will be particularly valuable to determine sustained usability, situational barriers (e.g., connectivity and battery), and the contexts in which magnification-based assistance is most beneficial.

In summary, PRESB appears to be a viable and potentially useful tool for assisting patients with presbyopia, offering a positive user experience alongside a set of accessibility features. Its integrated educational resources may help users better understand their condition. As a free, complementary option, PRESB has the potential to play a meaningful role in vision care, particularly for individuals who have limited access to more advanced treatment options.[15]

CONCLUSION

The PRESB application proved to be effective and valid in achieving its main objective, as it led to a significant improvement in unaided near visual acuity compared with not using the application. It therefore appears to be a useful adjunct in the daily activities of individuals with presbyopia.

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AUTHORS' CONTRIBUTION

Allan Victor Gonçalves; João Crispim Ribeiro and Daniel Montenegro contributed to the bibliographic survey, writing, revision, and improvement of the statistics. Edgar Marçal contributed to the technical development of the mobile application for smartphones.

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