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Comparative Efficacy of Duochrome Test versus +1 Blur Test in Detecting Refractive Error Across Different Ages

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DECLARATIONS

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ABSTRACT

Background: Refractive errors are common vision problems that require accurate detection for proper correction. The duochrome test and +1.00 blur test are simple subjective methods used to fine-tune refraction. **Objective:** To evaluate the efficacy, accuracy, and reliability of the duochrome test versus the +1 blur test in identifying refractive errors, including myopia and hyperopia, across various ages. **Methodology:** The study was a single-blinded randomized controlled trial. Sample size is 30 with an estimated 10% dropout out patients with refractive error (15 in each group). Data were collected from Eye Professional Clinic within 10 months. Both genders aged between 18 to 60 years old, having refractive error, with no history of prior eye surgery. They had no active eye diseases affecting visual acuity, such as cataracts or retinal disorders and could cooperate with both the duochrome test and the +1 blur test. Individuals with severe visual impairment or neurological disorders affecting vision, patients with nystagmus or any condition that may compromise the reliability of testing. Group A (18-35 years) and group B (36-60 years), both tests were applied. Post-sphere values were taken for the final results. The visual function (VF-14) questionnaire is used to determine the level of functional impairment of vision in patients. Both groups' post-sphere correction values were compared. **Results:** Group A (18-35 years) group mean score of duochrome test score (14.13±1.59) and +1 blur test score (11.73±2.01), post duochrome sphere right eye (-2.0±2.2), post duo-chrome sphere left eye (-2.30±2.39), post +1 blur test sphere right eye (-2.05±2.27), post +1 blur test sphere left eye (-2.31±2.39). Group B (36-60 years) group mean score of duochrome test score (11.60±2.06) and +1 blur test score (11.73±2.01), post duochrome sphere right eye (-2.0±2.2), post duochrome sphere left eye (-2.30±2.39), post +1 blur test sphere right eye (-2.05±2.27), post +1 blur test sphere left eye (-2.31±2.39), p-value is less than 0.05. **Conclusion:** Both the duochrome and +1 blur tests improve refractive error's efficacy, accuracy, and reliability in Group A of young individuals aged 18-35 years as compared to Group B of older adults aged 36-60 years, with the duochrome test showing greater effectiveness.

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INTRODUCTION

Refractive error (RE) is the primary cause of vision impairment globally, with limited access to high-quality treatments in resource-poor settings. Over 65% of people with high RE who could benefit from glasses do not use them. The International Agency for the Prevention of Blindness and the Organization for the Prevention of Blindness prioritize RE treatment, with a worldwide prevalence rate of around 12%.[1] Nearsightedness in Ethiopia is 4%, with a range of 1-5.2% depending on the population. Refractive errors, accounting for over 43% of cases, are a significant cause of visual impairment worldwide. Presbyopia, an age-related refractive error, varies between urban and rural areas and developed and developing countries.[2] Refractive errors, caused by the eye's shape not bending light, can be caused by genetics, factors like prolonged screen time, reading, irregular curvature, myopia, hyperopia, age-related near vision loss, diabetes, cataracts, and eye injuries.[2,3]

The duochrome test is a red-green target-based routine assessment test used in vision testing to refine the final sphere in subjective refraction, aiming to prevent undercorrection and overcorrection. The test presents the patient with black letters or symbols on a red and green background. It capitalizes on the eye's longitudinal chromatic aberration, which causes shorter wavelengths (green) to focus in front of the longer red wavelengths (red). Optimal vision is assumed when the letters or symbols appear equally sharp on both the red and green sides.[4]

The duochrome test uses longitudinal chromatic aberration (LCA) between 400 and 700 nm, providing distinct focus points for different wavelengths. It uses a standard distance visual chart with identical black stimuli on red and green backgrounds (620 nm and 535 nm, respectively) according to British Standard 36682.[5] Two focus points are produced using two wavelengths, located before and after the ideal focal point on the retina in emmetropia (570 nm yellow light). In ametropia, one of the two focal points is closer to the retina, causing background stimuli with the wavelength closest to the retina to stand out more, resulting in hyperopia and myopia.[6] The duochrome test asks the patient to indicate when letters look equally clear on both backgrounds in order to refine the spherical component of refraction. Given the duochrome test's justification, variations in LCA over time may have an impact on the test's reliability. Compared to the duochrome test, LCA is frequently tested in a wider range of wavelengths in the literature, often between 450 and 650 nm.[7]In a more recent study, Tanaka et al. examined color visual acuity in individuals aged 27 to 47 using Landolt rings with dominating wavelengths of 607, 566, 488, and 440 nm on a white backdrop. These writers came to the conclusion that there is a strong positive relationship between age and LCA. This method is predicated on the idea that a subject's capacity to judge focus accuracy is independent of wavelength or age.[8]

The +1.00 blur test is a popular method for verifying spherical correction after subjective refraction. It involves recalculating the distance VA and adding a +1.00DS lens to the distance refractive correction. Visual acuity with +1.00DS better than 6/18 indicates that refractive correction may have been under-plussed or over-minused.[9] The +1.00 blur test is commonly used in pre-presbyopic patients to determine the mean and range of visual angle (VA) levels. Despite its popularity in the UK, the test has received little scientific attention. The VA levels reported using the +1.00DS blur test are likely based on clinical experience, and the test's use is often influenced by factors such as age, pupil size, and refractive error type.[10] In contrast, the comparative efficacy of the duochrome test versus +1 blur test in detecting refractive errors across different ages remains underexplored in current ophthalmic research. While the duochrome test is widely used to refine prescriptions, its standalone effectiveness compared to +1 blur test-based refraction has not been thoroughly investigated.

Limited research directly compares the duochrome test and the +1 blur test for detecting refractive errors in a broad adult population (18-60 years). Most studies focus on individual test accuracy rather than a comparative analysis. Previous studies often examine specific subgroups, such as younger adults or presbyopic individuals, rather than a continuous 18 to 60 years age range. Most previous research lacks randomized participant selection, leading to potential bias. This study aims to fill this gap by employing randomized assignment to ensure unbiased comparisons.[4] The study was designed to evaluate the efficacy, accuracy, and reliability of the duochrome test versus the +1 blur test in identifying refractive errors, including myopia and

hyperopia, across various ages

METHODOLOGY

The study was a single-blinded randomized controlled trial. Sample size is 30 with an estimated 10% dropout out patients with refractive error (15 in each group).[5] A convenient sampling technique was used, and data were collected from Eye Professional Clinic within 10 months**.** Both genders aged between 18 to 60 years old,[11,12] having refractive error,[13] with no history of prior eye surgery.[14] They had no active eye diseases affecting visual acuity, such as cataracts or retinal disorders[15] and can cooperate with both the duochrome test and the +1 blur test.[16] Individuals with severe visual impairment or neurological disorders affecting vision,[9] patients with nystagmus or any condition that may compromise the reliability of testing.[5,9,17]

Group A (18-35 years) and group B (36-60 years), both tests were applied to every patient. Post-sphere values were taken for the final results. The visual function (VF-14) questionnaire is used to determine the level of functional impairment of vision in patients. Both groups' post-sphere correction values were compared.

For the duochrome test, the participant is seated at a standard testing distance (typically 6 meters or 20 feet). A duochrome chart with black letters on a split red-green background is presented. The participant is asked to compare the clarity of letters on both the red and green sides. Lenses are adjusted until the participant reports equal clarity between the two sides, or until the side that appears clearer helps determine the direction of the correction needed (more plus or more minus). The test uses the principle of chromatic aberration, where red (long wavelength) focuses behind the retina and green (short wavelength) in front. If letters on the red side are clearer, this suggests the image is focusing behind the retina, indicating a need for more minus (myopia under correction or hyperopia overcorrection). If letters on the green side are clearer, this suggests the image is focusing in front of the retina, indicating a need for less minus or more plus (myopia overcorrection or hyperopia undercorrection). Participants' refractive error will be identified by the duochrome test and blur 1 in both groups.[4]

For +1 blur test, after determining the subjective refraction, a +1.00 diopter (DS) lens is added to the final prescription. The participant is asked to read the distance VA chart. The expectation is that the visual acuity should drop to 4 lines on the Snellen chart (6/24) when the +1.00 DS lens is added. If VA reduces to 6/24, it indicates that the refraction is not over-minused or over-plussed (proper end point of refraction). If VA remains better than 6/24, it suggests the patient was still accommodating, possibly leading to over-minus (in myopes) or under-plus (in hyperopes), and the refraction should be re-evaluated.[18]

RESULTS

Within-group analysis showed mean comparison: mean of the post right eye post sphere is (-3.02±2.49) and mean of the left. Eye post sphere is (-3.22±2.47), duochrome test score is (12.8±2.2) and + 1 blur test score is (10.66±2.0). The p-value is less than 0.05, which shows there is a significant difference, as shown in Table 1.

Between-group analysis showed mean comparison of the right eye post-sphere and post-left eye post-sphere, duo-chrome test score and post duo-chrome sphere right eye, post duo-chrome sphere left eye, +1 blur test score and post +1 blur test sphere right eye, post +1 blur test sphere left eye, comparative efficacy and post of VF-14 post-test values for both Group A (18-35 years) and Group B (36-60 years) with $p<0.05$, which shows there is a significant difference in Group A duochrome and +1 blur test, but the duochrome test shows greater

Table 1: Paired sample t-test

Within-group Analysis	Mean	S.D	p-value
Post-sphere Right side	-3.02	2.49	0.029
Post-sphere Left side	-3.22	2.47	
Duochrome score	12.86	2.22	0.000
+1 Blur score	10.66	2.08	
Sphere douchrome Right side	-2.98	2.49	0.011
Sphere douchrome Left side	-3.20	2.48	
Sphere +1 blur Right side	-3.00	2.49	0.02
Sphere +1 blur Left side	-3.21	2.47	

Table 2: Independent sample t-test

Between-groups Analysis		Mean	S.D	p-value
Post-sphere Right side	Group A	-2.08	2.29	0.036
	Group B	-3.96	2.40	
Post-sphere Left side	Group A	-2.33	2.39	0.047
	Group B	-4.11	2.29	
Duochrome score	Group A	14.13	1.59	0.001
	Group B	11.60	2.06	
+1 Blur score	Group A	11.73	2.01	0.003
	Group B	9.60	1.59	
Sphere douchrome Right side	Group A	-2.00	2.24	0.028
	Group B	-3.96	2.40	
Sphere douchrome Left side	Group A	-2.30	2.39	0.043
	Group B	-4.11	2.29	
Sphere +1 blur Right side	Group A	-2.05	2.27	0.033
	Group B	-3.96	2.40	
Sphere +1 blur Left side	Group A	-2.31	2.39	0.045
	Group B	-4.11	2.29	
Comparative efficacy	Group A	14.86	2.44	0.015
	Group B	12.4667	2.61	
Post-VF 14	Group A	70.0667	3.71	0.000
	Group B	62.5333	4.50	

improvement in efficacy, accuracy and reliability of refractive errors in young adults between 18-35 years ($p<0.05$), which shows there is a significant difference in Group A duochrome and +1 blur test, but the duochrome test shows greater improvement in efficacy, accuracy and reliability of refractive errors (Table 2).

DISCUSSION

The purpose of our study was to compare the effect of the duo-chrome test versus +1 blur test for detection of refractive error across different ages to improve efficacy, accuracy and reliability of refractive errors. For this purpose, the duo-chrome test, + 1 blur test was used. Both tests were applied to all participants. In addition, subjects completed a post-intervention questionnaire (VF-14) to determine the difference between patients' levels of comfort between the groups. The results of this study have shown that group A (18-35 years) and group B (36-60 years) had a significant difference in post-test values of duo-chrome, and +1 blur paired t-test was applied for within-group analysis. The mean values indicate that there is an increase in duo-chrome scores. The result of this study reveals that there is a significant difference between post-test values of duo-chrome, +1 blur (p-value<0.05) across the group analysis.

An important goal of improve the efficacy, accuracy and reliability of refractive errors across different age groups. This study focused on two tests used to improve efficacy, accuracy and reliability of refractive errors. The results of the current study suggested that duochrome showed significantly better results than the +1 Blur Test.

Between-group analysis showed mean comparison of the right eye post-sphere and post-left. eye post sphere, duo-chrome test score and post duo-chrome sphere right eye, post duo-chrome sphere left eye, +1 blur test score and post +1 blur test sphere right eye, post + 1 blur test sphere left eye, comparative efficacy and post of VF-14 post-test values for both Group A (18-35 years) and Group B (36-60 years). The p-value is less than 0.05, which shows there is a significant difference in Group A duo-chrome and +1 blur test, but the duo-chrome test shows greater improvement in efficacy,

accuracy and reliability of refractive errors in young adults between 18-35 years. The p-value is less than 0.05, which shows there is a significant difference in Group A duochrome and +1 blur test, but the duochrome test shows greater improvement in efficacy, accuracy and reliability of refractive errors in young adults between 18-35 years. These results are consistent with the results of a previous study conducted in 2024 by Riccardo Rolandi et al. to compare ocular defocus curves (DCs) on red, green, and white backgrounds and assess the duochrome test's suitability across age groups.

Both age groups slightly preferred red under white light. The study concluded that the duo-chrome test remains a valid tool for all ages despite minor variations in response. Previous studies' initial finding suggests that the Longitudinal Chromatic Aberration (LCARG) calculated from DCs remains consistent across age groups (21-24 vs 55-66 years) within the 535-610 nm spectral range. The dioptric difference between the two colors used was similar for both younger (YG) and elderly (ELD) groups, at 0.18 ± 0.18 and 0.20 ± 0.16 diopters, respectively. These results align with some previous studies.[5]

Another RCT shows consistency with our results in 2017, conducted by Christopher J. et al. The findings of the present study are further supported by previous research, including a randomized controlled trial conducted by Christopher J. et al., which demonstrated consistency in the clinical value of the Duochrome test. That study originated from a real-world observation by Dr. Rick Savoy, who noted difficulty reading green numerals on fuel price signs at night, while red numerals appeared clearer. This led to a self-diagnosis of night myopia and prompted an investigation into chromatic effects on refraction accuracy.

A study emphasized the principle that the Duochrome test operates by aligning the focal plane of yellow light, representing the dioptric center of the visible spectrum, with the retina, thereby optimizing clarity. This mechanism makes the test highly sensitive for fine-tuning spherical corrections, particularly in patients with active accommodation, such as those in the younger age group (18–35 years) in our study. Their findings reinforced the clinical significance of the Duochrome test in refining optical prescriptions, especially under varying lighting conditions where chromatic aberration becomes more apparent. The consistency between our results and Christopher J. et al.'s trial adds weight to the conclusion that the duochrome test is not only effective but also a reliable tool for achieving more precise refractive endpoints. Particularly in younger individuals with greater accommodative reserves, it enables more accurate discrimination between under- and over-correction compared to the +1.00 D blur test.[16]

CONCLUSION

The study comparing the efficacy of the duo-chrome test versus +1 blur test in detecting refractive error across different ages shows significant improvements in efficacy, accuracy and reliability of refractive errors over time for all participants. Both interventions were effective in improving patient outcomes, but the duo-chrome test is more effective in improving efficacy, accuracy and reliability of refractive errors in different ages.

DECLARATIONS

Consent to participate: Written consent had been obtained from patients. All methods were performed following the relevant guidelines and regulations.
Availability of Data and Materials: Data will be made available upon request. The corresponding author will submit all dataset files.
Competing interests: None
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CONSORT Guidelines: All methods were performed following the relevant guidelines and regulations.

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