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Comparison of monofocal and multifocal contact lenses on binocular distance optical performance in non-presbyopic participants

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Summary
Purpose To compare binocular distance optical performance in non-presbyopic optometry students under different contact lens conditions: no lenses, monofocal lenses, and multifocal lenses.
Methods A total of 20 optometry students (age: 23.00 ± 2.58 years) meeting eligibility criteria were recruited. The study employed a randomized crossover design with two sessions: (1) baseline without contact lenses (W-CL), and (2) experimental where each participant was fitted with monofocal contact lenses (M-CL; Clariti 1-Day) and multifocal contact lenses (MF-CL; Clariti 1-Day Multifocal) in random order, using the permutation method balanced 1:1 across participants within the same session. Optical performance was assessed by measuring binocular distance visual acuity parameters (corrected distance visual acuity [CDVA] and dynamic visual acuity [DVA]) and binocular depth perception parameters (fixation disparity and stereopsis), using the OptoTab POLAR 24″ SMT4V device under standardized conditions.
Results Significant differences in visual acuity parameters (CDVA and DVA) were found across conditions (repeated measures ANOVA, $p < 0.001$), with post hoc analysis showing reduced acuity for MF-CL vs. W-CL and M-CL (Sidak, all $p \leq 0.002$). For both parameters, effect sizes were negligible between W-CL and M-CL (all Cohen's $d = 0.07$–0.09), and small and clinically meaningful when MF-CL was involved (all Cohen's $d = 0.08$–0.17). No significant differences in depth perception parameters (fixation disparity or stereopsis) were found across conditions (all $p \geq 0.103$) with negligible to small effect sizes (Cohen's d, all $p \geq 0.38$).
Conclusion In non-presbyopic participants, MF-CL significantly reduced visual acuity parameters compared to M-CL and W-CL, but not optical performance related to binocular vision.

Keywords Multifocal contact lenses · Corrected distance visual acuity · Dynamic visual acuity · Fixation disparity · Stereopsis

Vergleich von monofokalen und multifokalen Kontaktlinsen bei nichtpresbyopen Teilnehmern hinsichtlich der binokularen optischen Leistung in der Fernsicht

Zusammenfassung
Ziel Vergleich der binokularen optischen Fernleistung bei nichtpresbyopen Studierenden der Optometrie unter verschiedenen Kontaktlinsenbedingungen: ohne Linsen, monofokal und multifokal.
Methoden 20 Studierende der Optometrie (Alter: 23,00 ± 2,58 Jahre), die die Einschlusskriterien erfüllten, wurden rekrutiert. Die Studie verwendete ein randomisiertes Crossover-Design mit 2 Sitzungen: (1) Baseline ohne Kontaktlinsen (W-CL) und (2) experimentell, bei der jeder Teilnehmer sowohl mit monofokalen Kontaktlinsen (M-CL; Clariti 1-Day) als auch mit multifokalen Kontaktlinsen (MF-CL; Clariti 1-Day Multifocal) in zufälliger Reihenfolge ausgestattet wur-

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de, wobei ein Permutationsverfahren angewendet wurde, das 1:1 über die Teilnehmer in derselben Sitzung ausgeglichen war. Die optische Leistung wurde durch Messung binokularer Sehschärfeparameter für die Ferne (korrigierte Fernsehschärfe [CDVA] und dynamische Sehschärfe [DVA]) sowie binokularer Tiefenwahrnehmungsparameter (Fixationsdisparität und Stereopsis) unter Verwendung des Geräts OptoTab POLAR 24″ SMT4V (Fa. Smarthings4vision, Saragossa, Spanien) unter standardisierten Testbedingungen bewertet.

Ergebnisse Signifikante Unterschiede in der Sehschärfe (CDVA und DVA) wurden zwischen den Bedingungen festgestellt (wiederholte ANOVA, $p < 0{,}001$), wobei die Post-hoc-Analyse eine verringerte Sehschärfe für MF-CL im Vergleich zu W-CL und M-CL zeigte (Sidak-Test, alle $p \leq 0{,}002$). Für beide Parameter waren die Effektgrößen zwischen W-CL und M-CL vernachlässigbar (alle: Cohen-d = 0,07–0,09) und klein, aber klinisch bedeutsam, wenn MF-CL involviert war (alle Cohen-d = 0,08–0,17). Es wurden keine signifikanten Unterschiede bei den Tiefenwahrnehmungsparametern (Fixationsdisparität oder Stereopsis) zwischen den Bedingungen gefunden (alle: $p \geq 0{,}103$) mit vernachlässigbaren bis kleinen Effektgrößen (alle Cohen-d: $p \geq 0{,}38$).

Schlussfolgerung Bei nichtpresbyopen Teilnehmern reduzierte MF-CL die Sehschärfe signifikant im Vergleich zu M-CL und W-CL, jedoch nicht die optische Leistung im Zusammenhang mit der binokularen Sehfunktion.

Schlüsselwörter Multifokale Kontaktlinsen · Korrigierte Sehschärfe · Dynamische Sehschärfe · Fixationsdisparation · Stereopsis

Introduction

Binocular vision integrates images from both eyes to produce stereoscopic vision [1]. For this, the visual axes of both eyes must be directed to the same object. In normal binocular vision, small errors of oculomotor and sensory fusion may occur with no symptoms. However, larger errors may produce symptoms in individuals as a result of stress on the vergence and accommodative systems to maintain binocular vision [1]. An example of an activity that could cause stress on the accommodative and vergence systems is the use of electronic devices and near work [1–3]. Recently, the use of digital devices has become an important part of daily life for people of all ages. The use of these devices for prolonged periods commonly causes problems in three areas: visual problems, ocular surface disorders, and asthenopia problems [2, 3].

Using digital devices necessitates the use of vision at short distances, activating accommodation, convergence, and miosis [4, 5]. Socially, an increasing number of people in their 20s and 30s report symptoms associated with accommodative or binocular stress similar to presbyopia after prolonged use of digital devices [4]. These symptoms and signs are more prevalent among university populations, and it has been found that between 10% and 20% of university students report moderate to severe ocular symptoms at the end of the day [6]. In combination with accommodative and binocular stress, individuals may have refractive errors that can be corrected with contact lenses. Usually, contact lens wearers in this population segment generally wear single-vision lenses, needing to use their accommodation for near vision [4]. This can result in accommodative and binocular stress from the use of contact lenses corrected for distance vision [4]. These ocular symptoms can impair visual function, decreasing efficiency and productivity [3].

Monofocal contact lenses (M-CL) and multifocal contact lenses (MF-CL) are both used to correct refractive errors. The former are fitted for the general population, while the latter are commonly reserved for patients with presbyopia [7, 8]. In contrast to single-vision contact lenses, MF-CL have multiple zones of vision, which will depend on their design. These lenses have improved significantly in terms of design and fit [9]: In general, they consist of a variation of concentric powers around a center that will increase or decrease the extent depending on whether the power is low, medium, or high [10, 11]. This center can be center-near, if the addition is in the center of the contact lens, or center-far, if far vision prescription is in the center of the contact lens [10, 11]. Koh et al. [4] showed that the use of low additions in MF-CL decreases the demand for accommodation in near vision. This could lead to a more comfortable near vision, by reducing accommodative and vergence demands while maintaining binocular vision. Nevertheless, the present study was restricted to distance vision parameters to minimize the influence of accommodative variability, environmental factors, and task-dependent visual demands inherent to near vision assessment. This approach aimed to ensure greater experimental control and consistency across testing conditions when comparing the optical performance of different contact lens designs, defined in this study as binocular distance visual acuity (static and dynamic) and binocular vision parameters, including fixation disparity and stereopsis.

Building upon previous findings on near vision, this study specifically hypothesized that MF-CL may alter binocular vision and distance visual acuity parameters in non-presbyopic individuals compared to monofocal lenses and spectacles. The novelty of this research lies in the detailed assessment of binocular function, including stereopsis and fixation disparity, as well as the inclusion of dynamic visual acuity (DVA) measurements, aspects rarely explored in prior studies that mostly rely on static acuity tests. This comprehensive approach aims to provide new insights into how MF-CL designs impact distance vision performance under controlled conditions. It should be noted that this study exclusively evaluated contact lenses, excluding other types of multifocal lenses such as intraocular lenses or spectacles. For this reason, the aim of this study was to compare binocular distance optical performance, defined by binocular visual acuity and depth perception parameters, in non-presbyopic optometry students under different contact lens conditions: no lenses, monofocal, and multifocal.

Methods

Participants

A total of 20 participants were randomly recruited among university optometry students attending the optometry clinic of the center. Eligible participants were required to be between 18 and 35 years old, have a spherical prescription between –0.25 D and –7.00 D in each eye, and have a cylindrical prescription of ≤ 1.00 D and a corrected distance visual acuity (CDVA) of 20/22 or better (≥ 0.1 logMAR) in the worse eye to be enrolled on the study [12–17]. Exclusion criteria comprised a prior diagnosis of ocular infection, trauma disorders, or any ocular or systemic disease that could potentially affect the measurements (glaucoma, scleral or corneal anomalies, dry eye disease, meibomian gland dysfunction, diabetes mellitus, rheumatoid arthritis; [12, 18, 19]). Additionally, patients who had undergone ocular surgery were also excluded from the study. All participants provided signed written informed consent before being included in the study. The study protocol was conducted following the tenets of the Declaration of Helsinki and was approved by the Ethics Committee of the institution.

Study design

Participants attended two separate sessions as part of the study. The study employed a randomized crossover design consisting of two sessions: (1) a baseline session without contact lenses (W-CL), in which participants were tested wearing their spectacle prescription; and (2) an experimental session in which each participant was fitted with M-CL and MF-CL sequentially in random order during the same session.

1. In the first session, participants underwent a battery of pre-study tests, consisting of subjective refraction, keratometry, and horizontal visible iris diameter (HVID; [13, 20]), all performed in the same order as for W-CL. These tests were conducted to verify the inclusion criteria and to obtain the necessary parameters for the potential fitting of contact lenses. Participants who met the inclusion criteria were then scheduled for a second session
2. In the second sessions, the optical performance, defined in this study as two visual acuity parameters (binocular CDVA and DVA) and two depth perception parameters (fixation disparity and stereopsis), was assessed under three conditions: W-CL, M-CL, and MF-CL. Both visual acuity and depth perception parameters were measured binocularly. The order of lens fitting was randomized using a random permutation method balanced 1:1 across participants. The biometric fit of each contact lens was checked with an SL-D2 slit lamp (Topcon Corporation, Tokyo, Japan; [21]). Participants were not aware of the lens that was fitted at each point.

All measurements in both sessions were performed by the same observer on each participant to ensure consistency and minimize interobserver variations [22].

Contact lenses

Two types of daily disposable contact lenses with similar physical characteristics were used in the present study: Clariti 1-Day (Somofilcon A, CooperVision Inc., Pleasanton, CA, USA) and Clariti 1-Day Multifocal (Somofilcon A, CooperVision Inc.; [13, 23]). The specific parameters of the contact lenses are listed in Table 1. To ensure consistency, both eyes of each participant were fitted with the same type of contact lens during each study session. The spherical lens power was adjusted individually based on the spherical equivalent refraction obtained in the first session, following the manufacturer's guidelines. The lens prescriptions were masked to both participants and investigators to maintain blinding during testing. No toric lenses were fitted.

For the Clariti 1-Day Multifocal lenses, a low addition was used for all participants. These MF-CL follow a center-distance design characterized by a progressive radial power profile with no distinct power zones [24]. According to the manufacturer, the addition power for the lenses can be up to +2.25 D. Unlike the high add variants, the low addition lenses exhibit minimal residual spherical aberrations, resulting in a more uniform peripheral power distribution that may facilitate visual adaptation and maintain visual quality.

Table 1 Parameters of contact lenses used in the study.

Commercial name	Clariti 1-Day	Clarity 1-Day Multifocal
Manufacturer	CooperVision	CooperVision
Material	Silicone-hydrogel	Silicone-hydrogel
Name of material (United States)	Somofilcon A	Somofilcon A
Back optic zone radius (mm)	8.60	8.60
Total diameter (mm)	14.10	14.10
Center thickness (mm) at –3.00 D	0.08	0.08
Dk/t value at –3.00 D	86.00	86.00
Water content	56%	56%

Measurement procedures

All visual assessments were performed at distance using the same device, the OptoTab POLAR 24″ SMT4V screen (Smarthings4vision, Zaragoza, Spain; [25–27]) ensuring consistency across all measurements. The device features a polarized screen calibrated internally for testing at a fixed distance of 5 m. Prior to each session, the device calibration was verified to ensure accurate presentation of optotypes at this distance. All visual assessments were performed in the same examination room under standardized lighting conditions. Illumination levels were maintained consistently at 76.6 ± 1.9 lx (measured with the Luxometer PCE-LMD 5; PCE Instruments, Tobarra, Spain) ensuring uniform testing environments across all participants and sessions.

- Binocular visual acuity parameters
  - CDVA: The device displayed randomized letters with decreasing visual acuity levels, and participants were instructed to read the letters on a horizontal line one by one until they hesitated or made an error. The CDVA threshold was determined using a letter-by-letter criterion. Although results were initially recorded in decimal notation, visual acuity is reported here in Snellen notation for means and ranges, with mean and standard deviation (SD) values calculated and presented as geometric means in logMAR units.
  - DVA: The device presented five random letters at each different visual acuity level in decreasing order of difficulty. In all cases, the letters moved from left to right at a predetermined speed of 8.0° per second. Participants were instructed to read the letters on a horizontal line, one by one, until they hesitated to identify a letter or until an error occurred. The DVA threshold was determined using a letter-by-letter criterion. Although results were initially recorded in decimal notation, visual acuity is reported here in Snellen notation for means and ranges, with mean and SD values calculated and presented as geometric means in logMAR units.
- Binocular depth perception parameters
  - Fixation disparity: A pair of polarized glasses were used in distance measurements. First, the participants were shown the optotype to be used without the polarized glasses (a pair of two pencils aligned and in contact through their tips in the center of a circle). In order to calibrate the test, the participant was asked three times if the pencils were aligned or if one had to be moved to achieve alignment. In the case that pencils were not aligned, the participant was asked to indicate which of the pencils should be moved and in which direction to achieve alignment. Once the test was calibrated, the participant was asked to put on the polarizing glasses and to indicate which pencil should be moved and where until the tips of the two pencils were touching.
  - Stereopsis: A pair of polarized glasses were used in distance measurements. Four similar figures were displayed on a digital screen. Among these figures, only one contained a stereoscopic pattern, while the others lacked such a profile. Participants were instructed to sequentially identify the target figure until they hesitated or made an error. The measurement was repeated for each participant three times to check the results; the final level was annotated if the participant reached it or the previous level at which they made an error was noted.

Statistical analysis

Data analysis was conducted using SPSS statistical software v.25.0 for Windows (SPSS Inc., Chicago, IL, USA). The level of statistical significance was set at $p \leq 0.05$. Prior to the analysis, the normal distribution of parameters was verified using the Shapiro–Wilk test [28].

Fixation disparity, CDVA, and DVA showed normal distributions (Shapiro-Wilk test, all $p \geq 0.065$); hence, parametric tests were employed. Data comparisons and differences between results at each time point were evaluated using the ANOVA test for repeated samples, while the Sidak test was used to detect significant pairwise differences [28, 29].

As stereopsis exhibited a non-continuous distribution in all situations (Shapiro–Wilk test: $p \leq 0.012$), differences in this parameter between time points were assessed using the Friedman test, while the Wilcoxon test was utilized to identify significant pairwise differences [28]. To avoid type I errors stemming from multiple comparisons, the statistical significance for the Wilcoxon test was divided by the number of comparisons made to obtain a $p \leq 0.017$ (Bonferroni adjustment; [28, 30]).

Finally, effect sizes were calculated using Cohen's d and Hedges' correction to compare all study parameters under the three conditions studied: W-CL, M-CL, and MF-CL. Effect sizes were interpreted according to conventional thresholds, with values of $d < 0.20$ considered negligible, 0.20–0.49 small, 0.50–0.79 moderate, and ≥ 0.80 large. Effect sizes of small magnitude or greater were considered clinically meaningful. The 95% confidence intervals (CI) were also reported to assess the precision and clinical relevance of the effect sizes [31].

Results

The study sample consisted of 20 participants (10 men and 10 women) with a mean ± SD age of 23.00 ± 2.58 years (range: 20–29 years). Under the W-CL condition, the mean ± SD spherical refractive error was –1.91 ± 1.52 D (range: –5.50—0.25 D), while the mean ± SD cylindrical refractive error was –0.42 ± 0.35 D (range:

Table 2 Descriptive statistics of the study parameters.

	CDVA				DVA				Fixation Disparity (arcminutes [′])		Stereopsis (arcseconds [″])	
	Mean (Snellen)	Range (Snellen)	Mean (logMAR)	SD (logMAR)	Mean (Snellen)	Range (Snellen)	Mean (logMAR)	SD (logMAR)	Mean	SD	Median	IQR
W-CL	20/18	20/15–20/20	–0.057	0.038	20/32	20/23–20/43	0.201	0.069	–2.38	3.21	120	138
M-CL (Clariti 1-Day)	20/18	20/15–20/22	–0.037	0.044	20/31	20/24–20/45	0.187	0.073	–2.61	2.67	120	138
MF-CL (Clariti 1-Day Multifocal)	20/22	20/17–20/31	0.041	0.067	20/37	20/12–20/50	0.268	0.113	–2.18	2.81	189	240.8
p	$p < 0.001$				$p < 0.001$				$p = 0.439$		$p = 0.135$	

Mean and SD are displayed for parametric parameters, median and IQR are displayed for non-parametric parameters; $n = 20$
SD standard deviation, *IQR* interquartile range, *CDVA* corrected distance visual acuity, *DVA* dynamic visual acuity, *W-CL* without contact lenses, *M-CL* monofocal contact lenses, *MF-CL* multifocal contact lenses

–1.00–0.00 D). For the M-CL fitted, the mean ± SD spherical refractive error was –2.14 ± 1.41 D (range: –5.25—0.50 D). Similarly, in the MF-CL fitted, the mean ± SD spherical refractive error was –2.14 ± 1.41 D (range: –5.25—0.50 D).

Binocular visual acuity parameters

Descriptive statistics of the study parameters are presented in Table 2. A significant difference in CDVA and DVA was observed among the three measurements (repeated measures ANOVA, $p < 0.001$; Table 2; Fig. 1). Pairwise comparisons showed no significant difference in CDVA or DVA between the W-CL and the M-CL (Sidak post hoc, $p = 0.177$ and $p = 0.796$, respectively). However, wearing MF-CL resulted in significant differences compared to both the W-CL ($p < 0.001$) and M-CL ($p = 0.002$). Effect size supported these findings: The difference in CDVA between W-CL and M-CL was minimal (Cohen's $d = 0.09$, 95% CI: –0.02–0.90), suggesting no clinical relevance. By contrast, comparisons involving MF-CL showed small-to-moderate

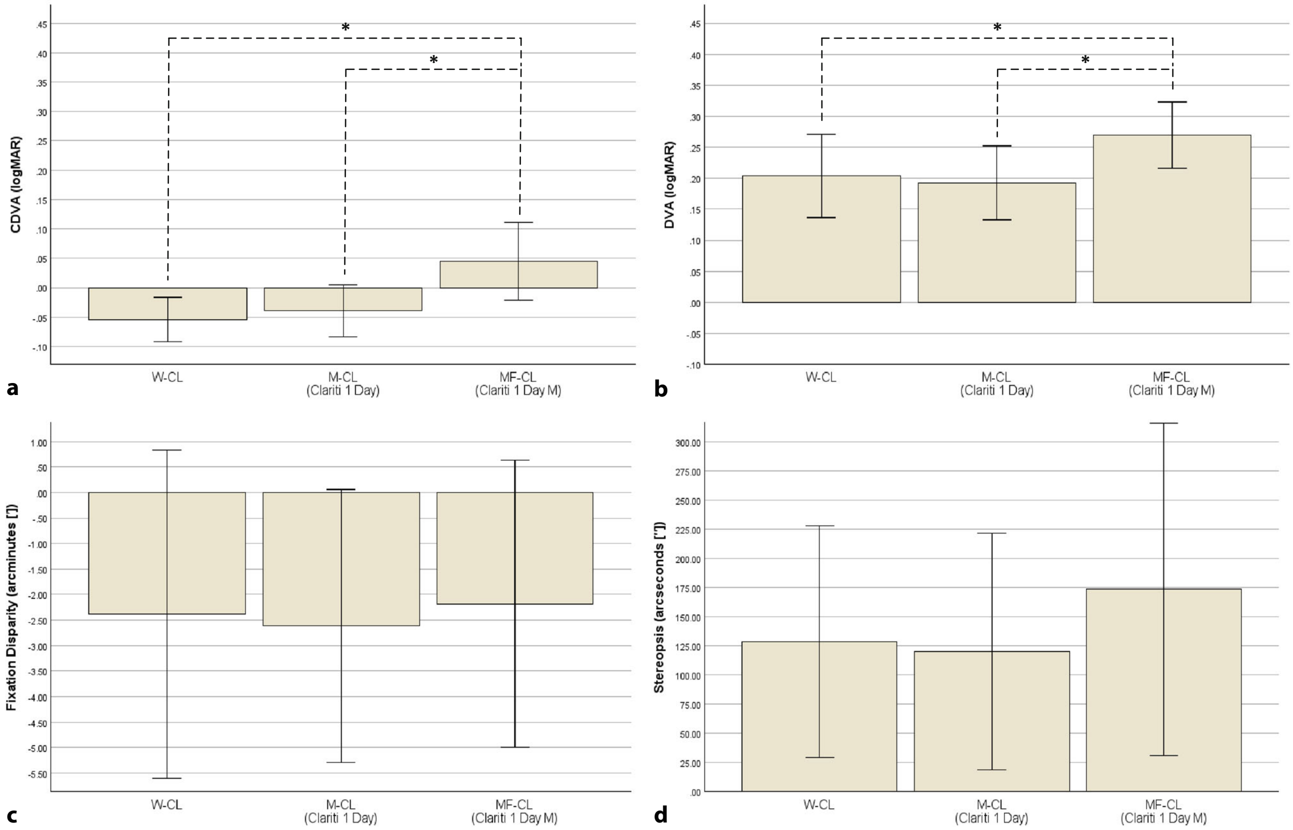

Fig. 1 Histogram representation of the mean values for each study parameter ($n = 20$). Error bars indicate standard deviation (*SD*). *CDVA* corrected distance visual acuity, *DVA* dynamic visual acuity, *W-CL* without contact lenses, *M-CL* monofocal contact lenses, *MF-CL* multifocal contact lenses. (*) Denotes statistically significant differences between paired measures (Sidak post hoc test, $p < 0.05$)

effects (W-CL vs. MF-CL: Cohen's $d = 0.17$, 95% CI: 0.73–1.95; M-CL vs. MF-CL: Cohen's $d = 0.15$, 95% CI: 0.61–1.76), which were considered clinically meaningful according to the predefined effect size thresholds. Similarly, for DVA, the effect size between W-CL and M-CL lens was negligible (Cohen's $d = 0.07$, 95% CI: –0.63–0.26), while comparisons including MF-CL demonstrated small and clinically meaningful effects (W-CL vs. MF-CL: Cohen's $d = 0.10$, 95% CI: 0.36–1.41; M-CL vs. MF-CL: Cohen's $d = 0.08$, 95% CI: 0.69–1.89).

Binocular depth perception parameters

In terms of fixation disparity, no significant difference was found among the three measurements (repeated measures ANOVA, $p = 0.439$; Table 2; Fig. 1). The effect sizes for all comparisons were negligible and their 95% CI included zero (Cohen's $d = 0.13$, 95% CI: –0.31–0.57 for W-CL vs. M-CL; Cohen's $d = -0.18$, 95% CI: –0.62–0.27 for W-CL vs. MF-CL; Cohen's $d = -0.29$, 95% CI: –0.73–0.16 for M-CL vs. MF-CL), indicating no clinically meaningful differences in fixation disparity between any of the conditions according to the predefined effect size criteria. Similarly, there was no significant difference in stereopsis between the three measurements (Friedman test, $p = 0.135$; Table 2; Fig. 1). All effect sizes were negligible to small, and their 95% CI included 0 ($d = 0.11$, 95% CI: –0.33–0.55 for W-CL vs. M-CL; $d = -0.31$, 95% CI: –0.76–0.14 for W-CL vs. MF-CL; $d = -0.38$, 95% CI: –0.83–0.08 for M-CL vs. MF-CL), indicating no clinically relevant differences in stereopsis across conditions.

Discussion

The purpose of this study was to compare visual acuity (CDVA and DVA) and depth perception (fixation disparity and stereopsis) parameters among young non-presbyopic university student contact lens wearers using two different types of contact lens with similar physical characteristics but different optical geometries. The initial aim was to assess whether any visual parameter is altered due to the use of MF-CL. The relevance of the present study lies in the assumption that MF-CL could be used by young people to make near-vision tasks more comfortable than with their eyeglasses or M-CL [4], but MF-CL may disrupt other activities that require adequate visual acuity and depth.

Visual acuity is the capacity of the eye to distinguish shapes and the details of objects at a given distance. In the present study, there was a significant reduction in this parameter when the MF-CL was fitted (Table 1), in accordance with previous reports [10]. On the other hand, DVA is defined as the ability to identify the details of visual targets when there are relative movements between the individual and objects [26]; similar to CDVA, there was an influence of the optical design on the final values provided by the participants. It is important to note that the MF-CL employed were center-near (a higher positive power in the center than in the periphery), making the visual axis match the zone of the contact lens with the higher power, which may explain the results obtained in the visual quality parameters assessed. Previous studies have suggested that when the visual target moves, the effects of retinal motion on speed perception are different depending on the initial target position [32]. It seems that this movement perception on the retina is not affected by the defocus areas in the MF-CL periphery.

The vergence angle between the two visual axes is not always as expected when observing a stationary visual target with both eyes, and vergence errors are common among individuals with normal binocular vision; as a result, the visual axes associated with the centers of the foveolae do not intersect at the fixation point: This means that a fused fixation point is not projected onto the center of the foveola in each eye, usually called "fixation disparity" [33]. However, stereopsis could be defined as the perception of depth produced by the reception in the brain of visual stimuli from both eyes in combination [34]. The distribution of optical power in MF-CL can induce both monocular and binocular defocus, leading to reduced retinal disparity and a decrease in stereoscopic depth perception [35]. Additionally, the disruption caused by MF-CL may introduce visual disturbances, such as halos and glare, which further impede accurate depth perception [36]. The potential impact of MF-CL on stereopsis and depth perception should be considered when prescribing these lenses, especially for individuals engaged in visually demanding activities [37]. In the present study, the sample was composed of participants who generally showed endodisparity with normal stereoscopic values, which was not affected using either type of contact lenses studied. Previous studies have evaluated binocular vergences where M-CL or MF-CL were employed, and in concordance with the present report, those parameters were not affected by the different optical designs [11]. Based on these results, the use of MF-CL may be compensated by neural adaptation where the visual system compensates for the alterations (halos or retinal disparities) introduced by the lenses.

It should be noted that the center-distance design of the MF-CL, characterized by annular power zones with central maximum addition and stepwise decreases peripherally, introduces optical complexities that may influence visual performance [24]. Residual spherical aberrations and the radial power gradient could contribute to variability in adaptation and visual quality among participants. This lens profile might affect binocular vision parameters and DVA by altering the retinal image quality across different pupil sizes and fixation points, which warrants further investigation.

The main strengths of this study lie in the inclusion criteria, which created a homogeneous sample in terms of age, sex, refraction, and demographic characteristics [38]. The study followed a well-structured protocol with clear inclusion and exclusion criteria, ensuring homogeneity among participants and minimizing confounding variables. Furthermore, the study used two lenses with similar physical parameters but differing only in their optical design, which was the main purpose of the study (this approach minimized the influence of other physical parameters over the ocular surface of the lenses on the study outcome). This last point is enhanced by the effect of randomization and masking on participants, reducing potential bias in the results. However, the study was limited by the relatively small sample size, the fact that only healthy participants were included (this issue limits the generalizability of the findings to other populations with different health conditions), and that only parameters involving distance vision were assessed. Although pupil diameter was not directly measured, the controlled lighting conditions aimed to minimize variability related to pupil size. Nevertheless, a limitation of the present study is the lack of direct pupil measurements during testing. Recent evidence indicates that visual performance with center-distance soft MF-CL remains comparable to single vision lenses under smaller pupil conditions, but declines with larger pupils or lower contrast [39]. Therefore, future studies should incorporate pupillometry to better clarify its impact on visual outcomes. Future studies may also perform a follow-up period to assess the potential changes in those parameters over an extended period, since visual perception or binocular capacities may be affected by a neuro-tolerance effect [40].

Conclusion

Overall, this study suggests that multifocal contact lenses (MF-CL) may reduce distance visual acuity compared with both no-contact lens and monofocal contact lens conditions. However, no significant differences were observed in fixation disparity or stereopsis across lens types. Therefore, patients fitted with MF-CL are unlikely to experience any loss of binocular function, regardless of the optical correction, although a slight reduction in visual quality may occur. Although modest, this reduction could be relevant for young adults engaged in visually demanding tasks such as night driving, where optimal distance vision is critical. Accordingly, caution is warranted when prescribing MF-CL to young, non-presbyopic individuals. It is also important to evaluate additional visual parameters to establish the best individualized cost–benefit correction strategy. Future research should include comparisons between healthy controls and individuals with accommodative or binocular anomalies using these optical designs, as well as assess near vision outcomes to better understand the impact of MF-CL on near visual tasks.

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Data Availability The data supporting the findings of this study are not publicly available due to ethical and privacy restrictions.

Declarations

Conflict of interest A. Castro-Giraldez, A. Diaz-Pombo, J. Garcia-Queiruga, H. Pena-Verdeal, M.J. Giraldez, E. Yebra-Pimentel and declare that they have no conflict of interest in the present work and received no specific funding for this work.

Ethical standards All procedures followed were in accordance with the ethical standards of the regional (CEIC2013/360) and the institutional responsible committee on human experimentation and with the Helsinki Declaration of 1964 and its later amendments. Informed consent was obtained from all patients for being included in the study.

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