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Central and peripheral visual performance in myopes: Contact lenses versus spectacles

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ABSTRACT

Purpose: Myopia is known to degrade visual performance with both optical and retinal changes implicated. Whether contact lenses or spectacles provide better visual performance for myopes is still under debate. The purpose of this study was to examine central and peripheral visual function in myopic subjects corrected with contact lenses versus spectacles.
Methods: Size thresholds were measured at 13 locations for 20 myopic subjects (mean spherical equivalent refractive error (SE): -6.43 ± 1.22 D and cylinder power: -0.23 ± 0.22 D) corrected with contact lenses (new etafilcon A contact lens, fitted 15 min prior to measurements) versus spectacles. Measurements were taken at both low ($\delta l/l = 14\%$) and high ($\delta l/l = 100\%$) contrast levels. The data were analysed using one way repeated-measures ANOVA.
Results: Size thresholds increased with eccentricity in a similar manner for both forms of optical correction. Repeated-measures ANOVA showed no statistically significant difference in central and peripheral visual performance between the two forms of correction for both low and high contrast tasks. The outcome remained the same following correction for spectacle magnification.
Conclusion: Eye care practitioners can be confident that modern soft contact lenses do not impair visual performance compared to spectacle lenses for the majority of myopes.

1. Introduction

Myopia is a common refractive condition [1] in which the image of a distant object comes into *focus* anterior to the *retina, resulting in a blurred retinal image*. Myopia affects a significant proportion of individuals in western countries, with a recent study reporting prevalence of 33% in the United States [2]. The prevalence of myopia is increasing dramatically, particularly in East Asia where, for example, around 80% of the young males of Chinese origin in Singapore are now myopic [3].

Axial myopia is primarily the result of elongation of the vitreous chamber [4,5]. It is hypothesised that retinal stretching associated with this elongation leads to reduced retinal sampling density compared to emmetropic eyes [6]. Previous studies employing a range of experimental techniques, suggest that these structural changes have a negative impact on both central and peripheral retinal function in myopes compared to emmetropes [6–10].

Optical correction is by far the most common management option for myopia in the form of single vision spectacle lenses or contact lenses. Both options have advantages and disadvantages: improved spectacle lens designs have led to better cosmesis but there can still be limitation of the visual field associated with the spectacle frame. In highly myopic patients, spectacle lenses significantly minify the retinal image and are associated with prismatic effects, especially in the peripheral visual field [11].

Progress in the management of myopia came with the advent of modern soft and gas permeable contact lenses. Lens designs and materials have improved dramatically over the past decade with the introduction of silicone hydrogel lenses in a range of modalities (daily wear or extended wear, daily disposable versus frequent replacement). Contact lenses pose no limitation on the visual field and also eliminate the effects of peripheral aberrations associated with spectacle lenses. They also remove the social discomfort some associate with spectacles [12]. Additionally, the minification of the retinal image produced by spectacle lenses is greatly reduced with contact lenses [13]. Contact lenses, however, have some drawbacks including greater expense, the need for regular aftercare, discomfort in some cases and the risk of infection especially with the increasing popularity of overnight contact lens wear [14].

With modern optical corrections, patients now have a genuine choice between spectacles and contact lenses, but the question remains, which option provides better visual quality? Despite a range of peer-reviewed publications that consider visual performance with contact lens versus spectacle correction, there is no real consensus on the matter. Some authors report a reduction in visual performance with contact lenses compared to spectacle

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lenses [15–18], whereas others describe no such loss [19–23], or even an improvement in visual performance with contact lenses [24].

Applegate and Massof examined the effect of correction type on the contrast sensitivity (CS) function in three subjects. They found a decrease in CS with soft contact lenses compared to spectacle lenses [15]. A study by Mitra and Lamberts comparing the CS function of 12 myopic subjects (−0.75 D to −6.00 D) wearing spectacles versus soft conventional hydrogel contact lenses, also reported a loss of CS across all spatial frequencies when assessed 30–60 min after contact lens insertion. They attributed the decrease to deposit formation on the lens surface and optical aberrations associated with the contact lenses [16]. Using the Ginsburg's vision contrast test (sine wave gratings), Briggs also reported a reduction in CS function in subjects wearing soft conventional contact lenses, whether clear or tinted, compared to an emmetropic group (no lenses) [18]. A more recent study found significantly poorer low contrast visual acuity with soft conventional hydrogel contact lens wear compared to spectacle wear [25]. None of the above studies appear to have considered the effect of spectacle magnification.

In contrast, Collins and Carney found a significant reduction in CS with spectacles compared to both rigid gas permeable and soft contact lenses for high myopes. No such effect was noted for low myopes. They proposed that this reduction was due to the optical limitations of high negative spectacle lenses, however, it seems that they also failed to adjust their results for spectacle magnification [26].

There are a number of studies that report no difference between the two modes of correction. Bernstein and Brodrick examined CS for 6 spatial frequencies (0.5–16 c/deg), every 2 h following contact lens insertion in a group of nine low myopes. They noted no significant differences between soft contact lenses and the equivalent spectacle correction over the period of a day [19]. Likewise, Nowozyckyj and colleagues, considering 14 myopic participants (−1.00 D to −6.00 D, refractive astigmatism ≤0.12 D), reported the same finding, both over the period of a day and seven weeks later [20]. Looking at 17 myopic subjects, Ng and colleagues [21] also found no significant difference in contrast sensitivity between modes of correction and additionally reported that the level of myopia did not appear to affect contrast thresholds. In a more recently published study, Barth and colleagues evaluated the visual performance of myopic subjects corrected with spectacles and three different brands of conventional hydrogel contact lenses. They also found no difference in visual acuity or contrast sensitivity measurements between spectacles and any of the three types of soft contact lenses [23].

The evidence regarding the effect of contact lenses versus spectacles on visual performance is contradictory, in part due to anomalies in study design. We therefore felt it was appropriate to undertake this study to compare the effect of soft contact lenses and spectacles on the central and peripheral visual function, at both high and low contrast in a group of myopic subjects who were free from ocular disease.

2. Methods

2.1. Scope

We examined the visual performance for the dominant eye of a group of myopes corrected by spectacles (SP) and contact lenses (CL). Assessment of visual performance involved measuring central and peripheral target size thresholds at both high and low contrast, out to ±30° eccentricity (horizontal meridian) and ±25° eccentricity (vertical meridian), using a customised version of the Contrast Acuity Assessment Test [27].

2.2. Subjects

Twenty myopic volunteers were recruited from the University of Bradford student population according to the following inclusion criteria: no history of corneal and ocular surgery; on-axis astigmatism ≤−0.50 D to allow optimal vision with spherical CLs, and no ocular pathology. They ranged in age from 20 to 32 years (mean ± SD, age: 24.9 ± 3.67 years), and subjectively determined refractive errors ranged from −4.88 to −8.75 MSE (mean spherical equivalent refractive error (SE): −6.43 ± 1.22 D and cylinder power: −0.23 ± 0.22 D). Spherical equivalent was defined as sphere plus half negative cylinder. Informed consent was obtained from each subject after the nature of the experimental procedures had been explained. The research followed the tenets of the Declaration of Helsinki and was approved by University of Bradford Research Ethics Committee. To ensure that subjects met the inclusion criteria, their sphero-cylindrical refractive errors were measured by subjective refraction. Best-corrected visual acuities were measured on each participant using a high contrast Bailey-Lovie logMAR acuity chart. They all had visual acuity of 0.00 or better when corrected firstly with spectacles and then contact lenses.

2.3. Apparatus

All experiments were run on the P-SCAN 100 system [28], which allows presentation of visual stimuli at a specified contrast level and target size, on a 21″ high-resolution Sony Trinitron monitor (model 500PS). The luminance of the adapting background was set at 12 cd/m^2. Regular calibration of the luminance characteristics of the stimulus monitor was undertaken using a luminance calibration program (Lumcal) in combination with a Minolta luminance meter (CS-100A). The monitor was allowed to warm up for a minimum of 30 min before each experimental session to ensure a stable luminance output. The test was undertaken in a completely darkened room with the only light originating from the experiment display.

2.4. Experimental design

Size thresholds were determined for a Landolt ring-type target, presented at each of 13 randomly interleaved retinal locations (±30°, ±20°, ±10°, and 0° along the horizontal meridian, and ±25°, ±20°, ±10° along the vertical meridian). The participant was asked to press one of four response buttons to indicate the position of the gap in an obliquely orientated Landolt C ring target (i.e. upper left, upper right, lower left and lower right; four-alternative, forced-choice procedure, 4AFC). Identification of the target orientation requires discrimination of the gap, which was 1/5th of the total ring diameter. The size of the Landolt C target (and hence the gap) was varied using an adaptive staircase method (1up-2down-[30]), based on the responses of the observer. The size threshold (smallest discriminable Landolt C gap) was calculated as the average of 12 out of 16 reversals (initial four reversals discarded). The exposure duration of the target was set at 120 ms (including a rise time of 53 ms) to ensure that performance would not benefit from saccadic eye movements [29].

Measurements were made at high ($L_b - L_t/L_b$ = 100%) and low ($L_b - L_t/L_b$ = 14%) contrast, where L_t and L_b are the luminance of the target and luminance of the background respectively. The viewing distance was 28 cm and *the subject's refractive correction adjusted by +3.00 D for both CLs and SPs* to minimise accommodation fatigue. The only exception was high contrast foveal measurements, which were conducted at a viewing distance of 100 cm with a suitable correction in place, to circumvent the issue of limited screen resolution for the small, central target size. The experiments were performed with a natural pupil. Fixation stability was monitored throughout