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ORIGINAL ARTICLE

Visual Performance with Sport-Tinted Contact Lenses in Natural Sunlight

Graham B. Erickson*, Fraser C. Horn*, Tyler Barney†, Brett Pexton†, and Richard Y. Baird*

ABSTRACT

Purpose. The use of tinted and clear contact lenses (CLs) in all aspects of life is becoming a more popular occurrence, particularly in athletic activities. This study broadens previous research regarding performance-tinted CLs and their effects on measures of visual performance.

Methods. Thirty-three subjects (14 male, 19 female) were fitted with clear B&L Optima 38, 50% visible light transmission Amber and 36% visible light transmission Gray-Green Nike Maxsight CLs in an individualized randomized sequence. Subjects were dark-adapted with welding goggles before testing and in between subtests involving a Bailey-Lovie chart and the Haynes Distance Rock test. The sequence of testing was repeated for each lens modality.

Results. The Amber and Gray-Green lenses enabled subjects to recover vision faster in bright sunlight compared with clear lenses. Also, subjects were able to achieve better visual recognition in bright sunlight when compared with clear lenses. Additionally, the lenses allowed the subjects to alternate fixation between a bright and shaded target at a more rapid rate in bright sunlight as compared with clear lenses. Subjects preferred both the Amber and Gray-Green lenses over clear lenses in the bright and shadowed target conditions.

Conclusions. The results of the current study show that Maxsight Amber and Gray-Green lenses provide better contrast discrimination in bright sunlight, better contrast discrimination when alternating between bright and shaded target conditions, better speed of visual recovery in bright sunlight, and better overall visual performance in bright and shaded target conditions compared with clear lenses.
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Key Words: contact lenses, filters, visual performance, contrast sensitivity, accommodative facility, natural sunlight

Contact lenses (CLs) are often the preferred mode of refractive correction for athletes. It has been reported that 95% of National Collegiate Athletic Association Division I-A athletes, 65% of Division III athletes, and 89% of professional athletes needing vision correction wear CLs.[1] Many athletes who compete in outdoor sports and require vision correction either wear prescription sunglasses or wear non-prescription sunglasses over CLs. Some athletes choose not to wear any tinted eyewear due to frame discomfort, fit, or sports performance concerns. It is not surprising that Athletic Trainers-Certified at 63% of National Collegiate Athletic Association Division I-A, 86% of Division III, and 94% of professional teams have interest in tinted CLs for sports.[1]

*OD, FAAO
†OD
Pacific University College of Optometry, Forest Grove, Oregon (GBE, FCH), Vance AFB, Oklahoma (TB), McGuire AFB, New Jersey (RYB), and Private Practice, Cheyenne, Wyoming (BP).

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There is considerable interest in the potential advantages of CLs containing tints that are engineered for the visual demands of baseball and other sports, commonly referred to as performance tints. CLs with performance tints have been marketed for use in sports for some time: the first tinted rigid gas permeable CL was introduced in 1983.[2] However, the major disadvantage of tinted CLs is that they are more cumbersome than eyewear to change or remove if the environmental conditions change.

The main objective with CL corrections for athletes is to provide an excellent optical image that is stable in all conditions encountered during the sports activity. Excellent visual acuity (VA) is typically a critical factor in sports performance, and measurement of VA through the CLs is a standard part of an assessment.

Measurement of contrast sensitivity function (CSF) has been recommended in athletes because many sports involve visual discrimination tasks in suboptimal lighting due to environmental variability.[3–6] Contrast sensitivity also may be degraded in CL wearers if the lenses are not optimal, even when VA appears acceptable.[7–10] Tinted CLs may improve or degrade CSF under different conditions. The effect of yellow-range tints on contrast sensitivity has been studied extensively, and there has been mixed success in quantifying the perceived improvements in contrast sensitivity.[11–18]

The visible portion of the electromagnetic spectrum comprises wavelengths between approximately 380 and 760 nm. Part of the eye's ability to see artificial (or enhanced) depth is because of the natural chromatic aberration that occurs when different wavelengths refract through the ocular media with different focal points. The difference in focal power between the shorter wavelengths (blue spectrum) and the longer wavelengths (red spectrum) is approximately 2.3 D of focal length.[19] This chromatic aberration results in image blur. Chromatic aberration has been cited as the most significant aberration in the well-corrected human eye,[19,20] and filters that diminish transmission of the short-wavelength (blue) portion of the visible spectrum improve retinal image quality by reducing the amount of chromatic aberration.[21]

Nike Maxsight lenses are commercially available performance-tinted CLs with two tint options, Gray-Green and Amber. The Gray-Green tint is designed for outdoor activities, such as trail running, mountain biking, water sports, and golf. The Amber tint is designed for high-speed ball sports where a ball must be tracked against the background of the playing field or sky, such as soccer, tennis, and baseball. Nike Maxsight lenses claim to offer enhanced visual comfort by reducing brightness and glare throughout the full visual field, while also improving contrast recognition by selectively filtering short-wavelength light.[22] Because both the Amber and Gray-Green tints filter a substantial portion of the short-wavelength light (Fig. 1), a reduction in chromatic aberration may be responsible for improved image clarity with these lenses. A recent study found that

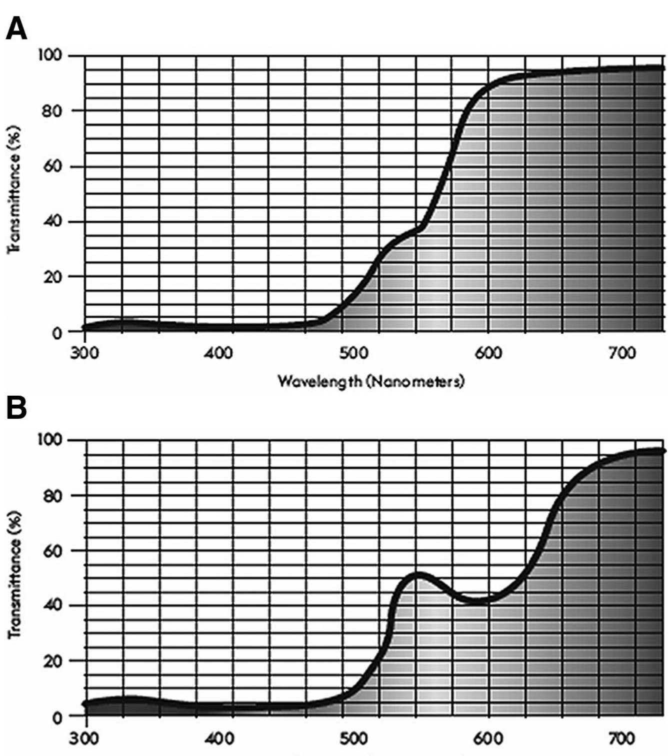

FIGURE 1.
Spectral transmission curves for the Nike MAXSIGHT Amber (A) and Gray-Green (B) tinted CLs.

Nike Maxsight lenses significantly improved CSF in collegiate and professional football athletes.[23] The study cautioned that, while the improvements in contrast sensitivity were statistically significant, the results did not rise to the level of clinical significance. However, this study was performed indoors under "standard room illumination," whereas the Nike Maxsight lenses are designed for use in outdoor sports under natural sunlight.

Another factor to consider is the effect of retinal straylight with Nike Maxsight lenses. Another recent study found that, while the Gray-Green tint resulted in a statistically significant increase in straylight with respect to baseline compared with the Amber tint and a standard Optima 38 clear lens, the authors conclude that those changes are not likely to significantly alter visual function under photopic conditions.[24]

This study investigates the impact of Nike Maxsight CLs on: speed of visual recovery when exposed to bright outdoor conditions; low contrast VA in bright outdoor settings; the ability to adapt to changes between bright and shaded conditions; and visual comfort in bright sunlight. Because artificial lighting conditions are far below the intensity (in candelas per square meter) of natural sunlight, the hypothesis was that purported improvements in visual performance would be revealed in the natural environment.

A number of sport situations contain subtle visual information with varying contrast conditions; therefore an assessment of low contrast VA was included in the visual performance testing. Contrast sensitivity measures the visual system's ability to process spatial or temporal information about objects and their backgrounds under varying lighting conditions.[25] Several investigations have compared CSF in athletes by using gratings of varying spatial frequency.[5,6,26–29] The general results from these studies demonstrate elevated CSF across all spatial frequencies for athletes, although the reliability and validity of the methods used to measure CSF may be questioned. The Maxsight lenses have been shown to improve CSF in indoor conditions; this study measures the effect of performance tinted CLs in natural sunlight to better simulate performance in outdoor sport conditions.

In sports where an athlete may compete for an extended period of time in relatively low light conditions, the transition into bright sunlight can be difficult for recovery of VA and contrast sensitivity. The speed of visual recovery when exposed to bright sunlight was assessed with low contrast VA charts. Recovery of vision when transitioning between shadowed conditions and bright sunlight is a critical element in many sports. Low contrast charts and Haynes Distance Rock charts were used to assess effects on contrast sensitivity and accommodative facility. Additionally, an assessment of accommodation subsystem function is frequently recommended for athletes.[3,4,6,26] The underlying premise is that strength and flexibility in focusing ability provides better stability of visual information to the athlete. A study using the Haynes Distance Rock test presented normative data for a population of elite athletes.[6]

METHODS

Subjects

An Institutional Review Board proposal for the use of human subjects in research was submitted and approved. Thirty-three subjects (14 male, 19 female), ages 19 to 35, were selected from the Pacific University College of Optometry (PUCO) student body and surrounding community to participate in this study. All subjects signed an Informed Consent Form at the time of the initial screening. Subjects were compensated for participating in the study with a pass to the Nike employee store located in Beaverton, Oregon; however, the subjects were not informed of the connection between Nike and the lenses being assessed in the study.

Subjects were required to pass a vision screening for participation in the study. Binocular VAs were measured under normal room illumination with a Snellen chart at 6 m. Subjects were required to wear a clear spherical CL during the initial VA measurement. VA of 20/25 or better was required through the habitual refractive compensation. The habitual refractive compensation was determined by lensometry if the subject wore spectacles, or from the product container or prescription if the subject was a CL wearer. If the subject had a spectacle correction for astigmatism, a spherical equivalent was determined mathematically and the corresponding CLs were fit. VA was always reassessed with each CL modality to ensure that the subject retained VA of 20/25 or better. Fit of the experimental CL was assessed with a biomicroscope to assure an acceptable fit. Subjects could have no history of anterior segment pathology that would contraindicate soft CL wear.

Materials

Subjects were fit with Bausch and Lomb (B&L) Optima 38 clear CLs, Nike Maxsight Amber CLs with 50% visible light transmission (VLT), and Nike Maxsight Gray-Green CLs with 36% VLT. The VLT values represent luminous transmittance levels (see Fig. 1 for spectral transmission curves). The Maxsight lenses were all commercially tinted Optima 38 CLs. All lenses were spherical and had an equivalent base curve of 8.8 mm and diameter of 14.3 mm. Plano lenses were used for subjects with no habitual refractive correction; B&L provided plano Optima 38 lenses for this study.

Procedures

Environmental Conditions

All testing was performed during the hours of 10:00 a.m. to 2:30 p.m. between November 2 and 19, 2005. Weather conditions were bright and sunny, varying from no clouds to thinly scattered high clouds. The illuminance levels on the charts was measured with an RDI-AR823 Wide Range Light Meter (Reliability Direct, League City, TX) and ranged between 80,000 and 100,000 lux in direct sunlight, and 1,000 to 2,000 lux on the shaded charts. The subject was always standing in sunlight; only the charts were adjusted to be in direct sunlight or in shade. Testing was postponed if clouds covered the sun.

The two testing conditions were setup to maximize the exposure to direct sunlight and to simulate shaded conditions. To increase overall luminance of the test areas for bright sunlight, white cotton sheets were used to cover the ground between the subject and chart. The sheets also formed a uniform backdrop for each test area. A second shaded area was constructed from PVC pipe and black felt to prevent direct sunlight from illuminating a chart (Fig. 2). To reduce any light from reflecting into the shaded area, black cloth was placed on the ground between the subject and the chart. The testing setup was rotated approximately every hour to maintain direct illumination from the sun on the test area.

FIGURE 2.
"Shadow Box" created to obstruct direct sunlight from illuminating a chart.

Low contrast VA was always tested first, followed in order by alternating fixation in bright and shadowed conditions at far, and the Haynes Distance Rock test in bright and shadowed conditions. All testing was conducted under binocular viewing conditions.

Fitting and Education

The sequence of CLs for each subject was counter-balanced using a 3 × 3 Latin Square design. Visual acuities were assessed before and after insertion of the CLs to ensure that the experimental lenses did not alter the entering habitual VA. To prepare the subjects to provide feedback on lens performance, each subject was asked to read a questionnaire that they would complete after each CL modality.

Before exiting the building subjects were given the Haynes Distance-Rock test instructions. Each subject was given welding goggles (shade number 10 welding filter; <0.02% luminous transmission) before leaving the building to reduce retinal saturation effects from the sun. The goggles were worn during all non-testing times while outside to prevent light adaptation, including between each test. Each subject wore the welding goggles for approximately 5 min before starting the testing, and for 24 to 58 s between each test.

Low Contrast VA

Low contrast VA was assessed at 4 m with two different test conditions: timed presentation and absolute threshold. Two 10% contrast Bailey-Lovie acuity charts were alternately used during these tests to avoid memorization of the letters.

Timed Presentation. This procedure was designed to assess the ability to recover low contrast VA in bright sunlight following a short period of dark adaptation. Before testing, each subject was read the following instructions:

> When I say "GO," immediately remove your goggles and look at the isolated line of letters directly in front of you.

Please call out the first letter of that line as soon as you can see it. Afterwards immediately put the goggles back on.

The evaluator used a stop watch to time how long, in seconds, it took the subject to call out any letter from an isolated line of five 20/25 letters.

Absolute Threshold. A whole chart, low contrast threshold VA was measured in bright, sunlight. Before testing, each subject was read the following instructions:

> When I say "GO," please remove the goggles and take as much time as you need to call out the lowest line you can see on the chart directly in front of you. After calling out this line, immediately place the goggles back on.

The estimated VA was recorded.

Alternating Between Bright and Shaded Target Conditions

At 4 meters. Two 10% contrast Haynes Distance Rock charts were positioned 4 m in front of the subject; one chart in direct sunlight and the other in the shaded box. The Haynes Distance Rock Test protocol[6] (Appendix A, Supplemental Digital Content 1, http://links.lww.com/A798) was modified to have the subject alternate fixation between the two far charts for 1 min. Before testing, each subject was read the following instructions:

> In front of you there are two charts, one in the sunlight and one in the shadow. This test will be conducted like the example you were shown in the building; however, this time you will be alternating your view between the sunlit and shaded charts. When I say "GO," remove the goggles and call out the first LARGE letter on the top of the sunlit chart, then quickly look to the shaded chart and call out the first LARGE letter on it. Look back at the lit chart and call out the second letter, then back the shaded chart and call out the second letter and so on. Alternate between the charts as quickly as you can while being as accurate as possible. Continue until I say STOP. Then immediately replace the welding goggles.

Similar instructions were read for the smaller letter (20/25) demand. The number of cycles was recorded for each letter size.

Distance Rock. A low contrast Haynes Distance Rock chart was located in the shadow box at 4 m, and a 10% contrast, reduced Haynes Distance Rock chart held at 40 cm in bright sunlight. The Haynes Distance Rock Test protocol (Appendix A, Supplemental Digital Content 1, http://links.lww.com/A798) was followed, except the testing duration was increased to 1 min. Before testing, each subject was read the following instructions:

> In front of you there are two charts, one up close and one in the distance in the shadow. This test will be conducted like the example you were shown in the building. When I say "GO" pull the goggles down around your neck and begin with the larger letters on the near chart, and then alternate between the distance shadowed chart until I say "STOP." Then immediately replace the welding goggles.

Similar instructions were read for the smaller letter (20/25) demand. The number of cycles was recorded for each letter size.

Questionnaire

After testing with each CL modality, subjects completed a questionnaire (Appendix B, Supplemental Digital Content 1, http://links.lww.com/A798) regarding their experience with that CL. After completion of all three CL modalities, each subject was asked to directly compare the performance of each CL on a posttest survey (Appendix C, Supplemental Digital Content 1, http://links.lww.com/A798).

RESULTS

Visual performance data were analyzed using repeated measures analysis of variance. Questionnaire data were analyzed using complex chi-squared analysis.

Visual Performance Data

Timed Presentation

Timed presentation results are shown in Fig. 3. On average Maxsight Amber and Gray-Green lenses provided a significantly

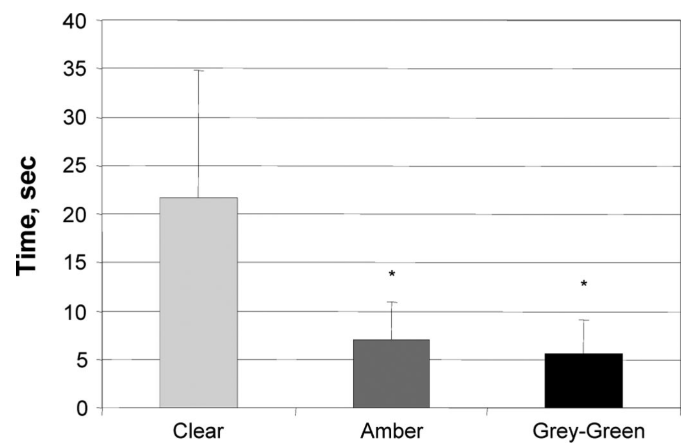

FIGURE 3.
Time for a 20/25 letter to be identified in bright conditions. (*Significance of $p < 0.05$ over clear lenses.)

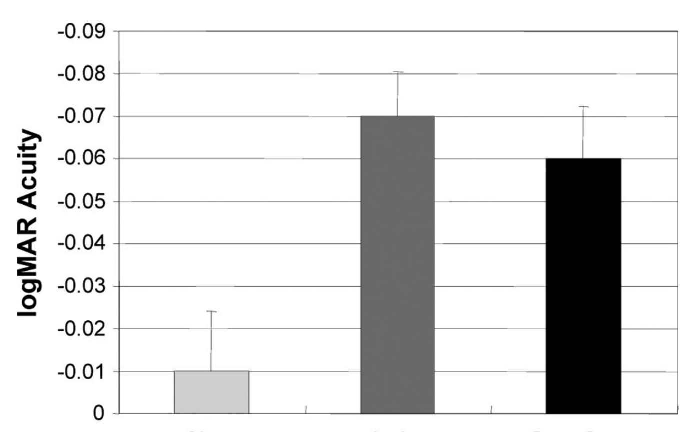

FIGURE 4.
LogMAR VA threshold in bright conditions. (*Significance of $p < 0.05$ over clear lenses.)

quicker recovery time as compared with the clear lens, $F(2,64) = 50.98$, $p < 0.0001$. There was no significant difference between the Amber and Gray-Green lenses.

Absolute Threshold

Absolute threshold low contrast VA results are shown in Fig. 4. On average Maxsight Amber and Gray-Green lenses provided a significant improvement in logMAR VA over clear lenses, $F(2,64) = 16.95$, $p < 0.0001$. There was no significant difference measured between the Amber and Gray-Green lenses.

Alternating Fixation

Results for the alternating fixation between bright and shadowed low contrast 20/80 Distance Rock charts at 4 m are shown in Fig. 5. On average when subjects wore Maxsight Amber and Gray-Green lenses they completed a significantly greater number of cycles between the two charts than with clear lenses, $F(2,64) = 28.14$, $p < 0.0001$. There was no significant difference measured between the Amber and Gray-Green lenses.

Results of alternate fixation between bright and shadowed low contrast 20/25 Distance Rock charts are shown in Fig. 5. On average when subjects wore Maxsight Amber and Gray-Green lenses they completed a significantly greater number of cycles between the two charts than with clear lenses, $F(2,64) = 9.51$, $p < 0.0001$. There was no significant difference measured between the Amber and Gray-Green lenses.

Distance Rock

Results from the distance rock of low contrast 20/80 demand letters are shown in Fig. 5. On average when subjects wore Maxsight Amber and Gray-Green lenses they completed a significantly greater number of cycles between the two charts than with clear lenses, $F(2,64) = 9.49$, $p < 0.0001$. There was no significant difference measured between the Amber and Gray-Green lenses.

Results from the distance rock of low contrast 20/25 letters are shown in Fig. 5. On average when subjects wore Maxsight Amber and

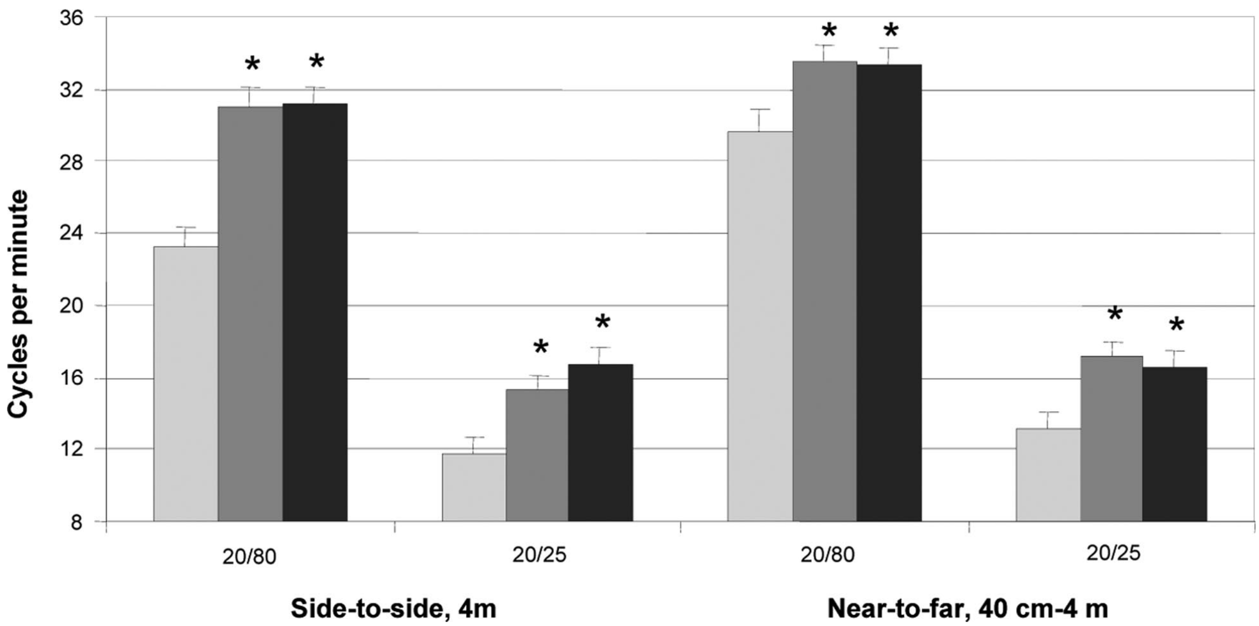

FIGURE 5.
Alternate fixation results, in cycles per minute, for low contrast 20/80 and 20/25 letters in bright and shaded conditions at 4 m (side-to-side) and between 40 cm and 4 m (near-to-far). Standard error bars shown. White columns, clear CLs; gray columns, Maxsight Amber CLs; black columns, Maxsight Gray-Green CLs. *Significance of $p < 0.001$ over clear CLs.

TABLE 1.
Total values from the subjective questionnaire

	Comfort	Obstruct	Glare	Harsh	Shadow	Bright	Stray	Overall
Clear	166	180	99	53	74	65	72	91
Amber	180	184	175	170	161	166	168	168
Grey-Green	180	186	174	178	157	165	174	177
χ^2	0.607	0.323	51.32	97.37	60.70	76.83	82.60	69.41
p	NS	NS	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

The questionnaire used a scale from 1 to 6, with 1 being "strongly agree" and 6 being "strongly disagree." The data below reversed the scale with "strongly agree" receiving a value of 6 and "strongly disagree" a value of 1. Thus, higher values show stronger agreement. Complex chi-squared analysis demonstrates the statistical significance of either tinted lens with respect to the clear lens.

NS, not significant.

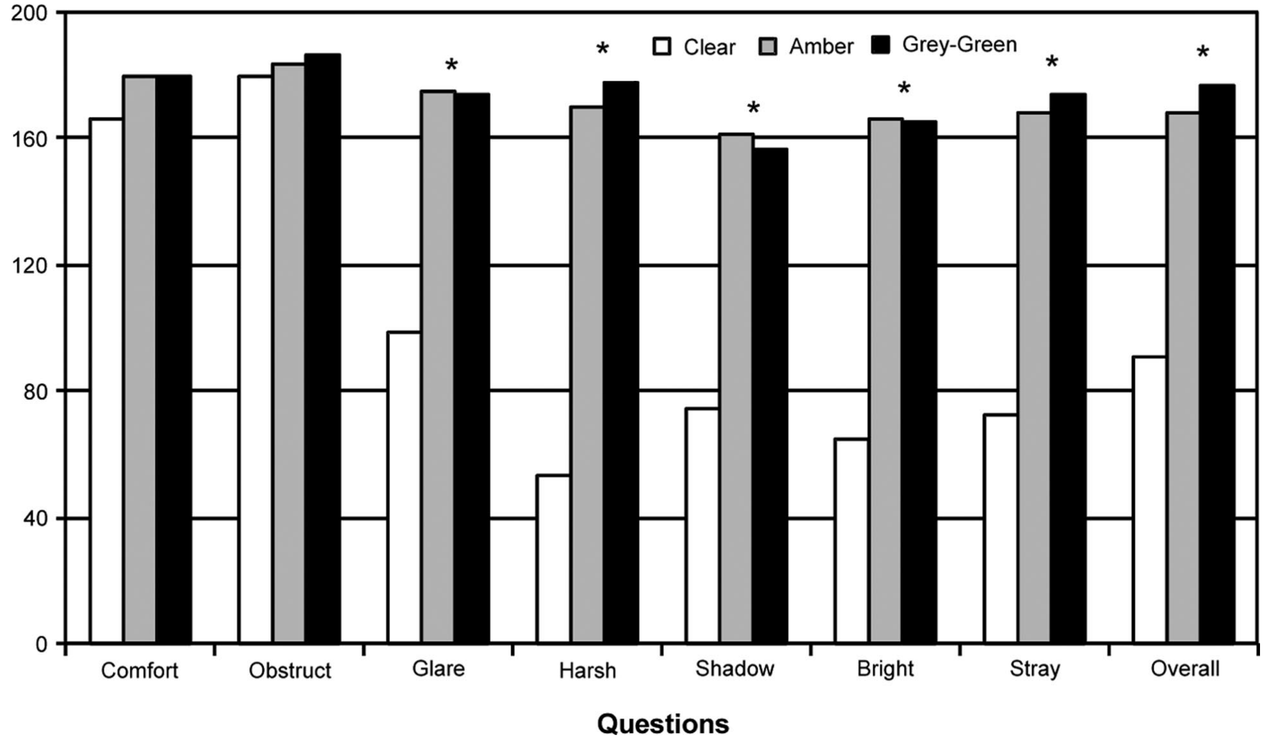

FIGURE 6.
Data from Table 1 is shown graphically; total values from the subjective questionnaire.

Gray-Green lenses they completed a significantly greater number of cycles between the two charts than with clear lenses, $F(2,64) = 8.64$, $p < 0.0001$. There was no significant difference measured between the Amber and Gray-Green lenses.

Questionnaire Data

Subjective responses were obtained to determine if there was a significant difference in physical comfort, visual distortion or obstruction, visual comfort, effects of bright sun, visual transition from bright to shadowed conditions and vice versa, effect of stray light on vision, and overall lens performance (Appendix B, Supplemental Digital Content 1, http://links.lww.com/A798). There was no significant difference between the clear lenses and the Maxsight lenses in physical comfort ($\chi^2 = 8.23$, $p = 0.607$), or visual distortion or obstruction ($\chi^2 = 6.98$, $p = 0.323$). There was a significant difference between the clear lenses and the Maxsight lenses, but no significant difference between the Gray-Green and Amber tints, in each of the remaining subjective responses (Table 1). All the subjective data from all three lenses are compared in Fig. 6.

DISCUSSION
Visual Recovery Speed

The timed presentation procedure was designed to assess the ability to recover low contrast VA in bright sunlight following a short period of dark adaptation. Results showed that when the Maxsight lenses were worn, the subjects improved visual recovery time by an average of 15.52 s. This result is expected since tinted lenses have been shown to aid in recovery of contrast sensitivity and dark adaptation after photoreceptor saturation.[11] Cornsweet summarized Rushton studies showing the effect of cone pigment bleaching on visual recovery.[30] The effect of wearing tinted lenses reduces the proportion of bleached pigment, thereby reducing the time course for light or dark adaptation.

In sports where an athlete may compete for an extended period of time in relatively low light conditions, the transition into bright sunlight can be difficult for recovery of VA and contrast sensitivity. For example, a baseball player may spend considerable time in the dugout before taking the field to bat or field in bright sunlight.

For an athlete who must compete during the twilight transition hours, the exposure to bright sunlight impedes the initial phase of dark adaptation.[31–34] The final level of dark adaptation is elevated, and daily prolonged sun exposure can produce decrements in VA and contrast sensitivity.[32,33,35] The judicious use of sun eyewear during daylight exposure can minimize the impact of bright sunlight on the dark adaptation process and may thereby assist the athlete during the transition to artificial lighting conditions.

Low Contrast VA in Bright Sunlight

Nike Maxsight lenses were found to significantly improve low contrast VA in bright sunlight when compared with clear CLs. Subjects achieved nearly a line improvement in VA while wearing the tinted lenses. Yellow tints have previously been shown to improve the perception of low-contrast contours[12]; this study supports this effect with the Maxsight Amber lens, but also found this result with the Gray-Green lens. The Maxsight Gray-Green tint also reduces transmission of the short-wavelength (blue) portion of the visible light spectrum, thereby improving retinal image quality by reducing the amount of chromatic aberration. If the reduction of chromatic aberration is responsible for significantly improved contrast sensitivity, this may explain why the Gray-Green tint demonstrated similar improvements in low contrast VA. The resulting difference between testing in natural sunlight rather than under artificial lighting conditions magnified earlier effects that were not deemed clinically significant.[23]

A number of sport situations contain subtle visual information with varying contrast conditions. For example, it is essential for a golfer to accurately identify subtle variations in the surface of the green. Enhanced low contrast VA may provide an advantage when judging subtle contours in the terrain, thereby increasing the likelihood of determining an effective line for a stroke.

Alternating Between Bright and Shaded Target Conditions

Visual recovery speed was assessed by challenging the subjects to alternately discriminate low contrast VA targets in bright sunlight and shaded target conditions. The number of completed cycles when looking between a chart in direct sunlight and a chart in a shadow box significantly improved when the subjects wore the Nike Maxsight lenses. This improvement was consistent when the targets were 20/25 letters, 20/80 letters, and when done from near to far with 20/25 and 20/80 letters. Again, based on previous studies of cone pigment bleaching on visual adaptation, this result confirms the effect that filters have on recovery of visual function following exposure to bright sunlight.

Recovery of vision when transitioning between shadowed target conditions and bright sunlight is a critical element in many sports. In soccer, for example, shadows often cover a portion of the pitch. A soccer ball is a high contrast target when stationary, but the graphic pattern has significantly reduced contrast when kicked with a large amount of spin. Because the spin of the ball provides vital clues concerning the flight trajectory of the ball, the ability to discriminate the contrast of the ball pattern is potentially beneficial to the athlete in judging the spin of the ball as it moves between shaded and sunny conditions.

The ability to recover visual function when alternating between shaded and bright target conditions was also assessed with the Haynes Distance Rock Test. One study demonstrated a high correlation between performance on the standard Haynes Distance Rock Test and athletic performance.[6] Similar to the preceding results, this study revealed improved performance with the Maxsight lenses compared with clear CLs in bright sunlight.

Questionnaire Results

Subjects rated Nike Maxsight lenses significantly better in most categories. Subjects did not report any difference in physical comfort or visual distortion between the clear and tinted lenses. Maxsight Amber and Gray-Green lenses were judged to provide superior visual performance in bright and shadowed target conditions. When asked to rate overall performance, subjects preferred the Maxsight lenses compared with clear CLs.

Future Considerations

This study was limited to two commercially available tinted CLs. There was no significant difference between the measured performances of the two tints. A study comparing the visual performance of commercially available tints and an equivalent neutral density filter would help to determine if the visual performance effects are due to the specific wavelength filtration of the tints, or due to the overall reduction of transmitted light. Additionally, it may be that other clear CLs may perform better than the Optima 38 lens. The Optima 38 lens was used for this study to minimize the variables contributing to performance differences, however, other lenses may offer performance advantages such as less retinal straylight.[24] Future studies could also investigate other performance tints to determine if tint color affects specific aspects of visual performance. Of special interest would be the effects of different tints on color contrast; our measurements only assessed variations of black and white. Similarly, tint density could be assessed to determine any potential impact on visual performance. In sports where the bright glare of artificial lighting is a perceived problem, tints designed for use with stadium lighting could be examined.

Future studies could modify the research design by using high-level athletes as subjects, and use actual visual tasks from sports (e.g., judging the spin on a baseball pitch) to assess visual performance. The use of welding goggles to preserve dark adaptation in this study could be also be modified to determine differences in visual performance. This study assessed visual performance with tinted CLs; a similar study could be performed with tinted eyewear. As mentioned previously, contrast sensitivity may be degraded in CL wearers if the lenses are not optimal, and sun eyewear may provide more of a performance advantage. However, the field-of-view aberrations, visual field restriction, optical distortion, frame comfort, frame stability, surface reflections, lens fogging, and precipitation issues found with spectacle lenses can largely be avoided by moving the optics onto the cornea. The combination of these advantages typically elevates the use of CLs to the method of choice for refractive compensation for most athletes.

CONCLUSIONS

The results of this study show that Nike Maxsight CLs improve contrast discrimination and speed of visual recovery in bright sunlight when compared with clear lenses. Maxsight lenses also provided better contrast discrimination when alternating between bright and shaded target conditions. Subjective responses reveal that Maxsight lenses were judged to provide superior visual performance when compared with clear lenses. Visual factors that are critical in sports performance, including subtle contrast discrimination and visual recovery when transitioning between bright and shaded conditions, are enhanced with Maxsight lenses.

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Graham Erickson
Pacific University College of Optometry
2043 College Way
Forest Grove, Oregon 97116
e-mail: ericksog@pacificu.edu