Induced Prismatic Effects in Commercially Available Non-Prescription Golf Sun Eyewear

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ABSTRACT

Background: Visual benefits from sun eyewear are well documented; however, golf has been a sport slow to embrace the use of sunglasses. Sun eyewear can be used to protect the eye and to potentially enhance the golfer’s game during the visually demanding game of golf. This study investigated the amount of induced prism subjectively perceived in four popular brands of commercially available golf sun eyewear.

Methods: Forty subjects evaluated the amount of image jump perceived in four pairs of golf sun eyewear under monocular and binocular conditions. The amount of image jump was assessed in both primary gaze and 30 degrees lateral gaze using a golf ball on a putting green.

Results: Average induced prismatic deviation as reported by the subjects was found to be significant from zero in many of the gaze positions. Of the 12 possible combinations of gaze position and deviation directions, the Bollé sunglasses had significant prismatic image jump in 6, the NYX sunglasses in 4, and the Nike and Oakley sun eyewear both in 2.

Conclusions: Significant amounts of prism were found subjectively in most of the sun eyewear evaluated. It may be beneficial to the golfer to use sun eyewear that induces the least amount of prismatic deviation; however, the impact of this induced prism on golf performance should be assessed in future studies.

KEY WORDS

golf, sun eyewear, prism, depth perception, lateral gaze, vergence

INTRODUCTION

With the high level of public interest in both the game of golf and in products used to enhance performance, golf sun eyewear and its impact on performance should be considered. Golf specific sunglasses are readily available to the golfer. In a survey of pro shops around the nation 52% provided golf sunglasses.1 Currently, many golfers feel that they do not realize a benefit from sun eyewear use during play. Teaching pros have stated that sunglasses can interfere with the accuracy of visual judgment in golf.1 Jim Furyk, a leading golfer on the PGA Tour, has stated in USA Today, “I haven’t found a pair I can be comfortable with and read the greens.”2

Most eyecare practitioners recommend the use of non-prescription sun eyewear for golf and other outdoor activities. Commonly accepted benefits of wearing sun eyewear on the course include the reduction of eye fatigue and squinting, and protection from sun exposure and ocular trauma.3

Sun eyewear may reduce the risk of ocular injury. A 1992 study estimated that 900,000 Americans are visually impaired secondary to trauma, 75% of whom are monocularly blind.4 According to Prevent Blindness America, each year more than 40,000 people are treated for sports-related eye injuries in U.S. emergency rooms, most of which could have been prevented with appropriate protective eyewear.5 Golf accounts for 1.5% to 5.6% of these injuries. Golf related eye injuries result from being struck by a golf club or ball, or getting debris in the eye.5,6 Injuries by club or ball are infrequent but...
severe, and have enucleation rates rivaling air rifle and arrow/dart injuries. A review of the literature reported that golf ball and club induced ocular trauma results in enucleation rates ranging from 37% to 65%. Ruptured globes were also present in 50% to 89% of blunt trauma golf injuries, and create a very poor prognosis for visual recovery. Though golf sun eyewear may help with eye protection, none are approved for impact resistance by the American Society for Testing of Materials (ASTM); the ASTM has not developed a golf-specific eyewear standard for impact resistance. In fact, some sun eyewear have glass or CR-39 lenses that may increase the risk of severe ocular trauma in golf if the lens shatters on impact.

Prolonged exposure to the middle ultraviolet (UVB) waveband has been associated with a variety of ocular problems, including pterygium, pinguecula, cataract and keratopathy. Ultraviolet protection provides patients with decreased risks of cataracts, photokeratitis, corneal burns, anterior uveitis and retinal lesions. The American Optometric Association recommends 99-100% protection from near and middle ultraviolet (UVA, UVB) radiation for sunglasses.

Research on the blue-light hazard, defined by European sunglass standards as 380-500nm, has shown that short wavelength visible light may create deleterious retinal changes, specifically retinal lesions. The most harmful wavelength in the visible spectrum for the production of retinal injury appears to be radiation near 440nm.

Golf sun eyewear may further be used to enhance the golfer’s game by decreasing glare in bright conditions and enhancing contrast while lining up a putt on the green. Eyewear may also provide protection from physical elements such as flying sand and grass. Despite these potential benefits, golf sunglasses may alter visual information that is crucial to the game of golf. Many visual system abilities affect a golfer’s game. Coffey et al. reported that athletes have narrower 6 meter vergence ranges than nonathletes. Coffey et al. found in another study that professional golfers have better visual acuities, contrast sensitivity, and stereopsis than amateurs. Judgment of distance is an intuitively critical skill in golf. Unstable binocular alignment was found to be related to errors in putting alignment in golf.

A recent survey of golfers showed that slightly less than half of the subjects wear sun eyewear while golfing. Of those who wear sun eyewear, slightly over half use their eyewear for all phases of the game. Accordingly, over 75% of golfers are without sun protection during some aspect of their game. Considering the potential for long-term ocular health risks, this figure may be of concern for the eyecare practitioner. Twenty-seven percent of subjects had tried using sunglasses during golf, but had discontinued use for various reasons.

Many golfers choose not to wear sun eyewear due to the possible decrease in visual acuity, contrast sensitivity or color distortion that often occurs with such eyewear. Prismatic effects induced by the lens design of the sun eyewear may also be noticed by golfers. Contributing factors to prismatic effects include the steep front and back lens curves, the tilt of the lens, lens thickness, and manufacturing abnormalities (e.g., induced distortion). Premium sports eyewear was found to have significant amounts of prism in both primary and lateral gaze. Many eyecare practitioners who recommend protective eyewear feel that there are problems with the current selection of protective eyewear on the market. The main areas of concern are typically poor optics, distortion, and poor quality.

Prismatic effects induced by eyewear designs may affect the golfer’s ability to judge depth and location. For example, with yoked horizontal prisms, the image will be displaced laterally, but if the prisms are oriented in opposing horizontal directions both the perceived size and distance of the object will appear to change. Changes in lateral displacement or in apparent size and distance may cause critical errors in golf performance.

The purpose of the present study is to assess the prismatic effects of four popular brands of golf sun eyewear in various positions of gaze. The information from this study may help eye care professionals provide better recommendations to the 15 million core golfers (adults age 18 and over who play eight or more rounds a year) in the U.S.

METHODS
Subjects and Screening
Golfers with handicaps of 10 or below, as calculated by the United States Golf Association’s Golf Handicap Information Network, were recruited from Forest Hills Golf Course in Cornelius, Oregon. There were 40 golfers who met the criteria; 38 male and 2 female. Subjects ranged in age from 18 to 65 years of age with a mean age of 38 years.

Visual acuities were tested on a back-illuminated Snellen Chart (Good-Lite Company, Streamwood, IL), and stereoaucity was tested with the AO Vectographic slide (Bernell Corporation, Mishawaka, IN). All testing was conducted at 20 feet. All subjects had monocular and binocular static visual acuities of 20/25 (6/7.5) or better, and stereaoacuity of 120 seconds of arc or better. Subjects were not permitted to use spectacles to meet the requirements, however contact lens corrections were allowed.

Study Setup
The study was conducted under clear, sunny conditions at Forest Hills Golf Course, which is located approximately 45.5 degrees north latitude. Testing was performed on October 13 and 14, 2001 between the hours of 11:00 am and 6:00 pm. Vertical sun angle was measured using a custom-built goniometer and varied from 37 degrees to 9 degrees above the horizon, with an average of 32 degrees.
On the practice green each subject stood behind a line directly facing a Titleist® Tour Distance 90 golf ball set straight ahead 6 meters. When facing the ball the subject was perpendicular to the sun to reduce glare. Two more Titleist® Tour Distance 90 golf balls were placed 3.43 meters to each side of the middle ball to make an angle of 30 degrees from the line.

Two identical pairs of eyewear marketed for golf use from each of four leading manufacturers were purchased at retail. These eyewear included the Bollé Turbulence with the Cinnamon Tint, Nike Hyperion II Pro Golf Frame with the Nike Golf Tint, the NYX Classic Competition with the Deflector Tint, and the Oakley Golf M-Frame with the Slate Grey Heater lens. For each eyewear the tint selected was the manufacturer’s recommended tint for bright playing conditions. The brand name identifiers on the frame were concealed with tape, and the eyewear was labeled A, B, C, or D on the temples for the study.

**Procedures**

The subjects were given a practice pair of nonprescription sun eyewear and an eye patch to use as an occluder. They were instructed to place the eye patch over their left eye and then position the practice eyewear on their face. In order to familiarize the subject with the image jump motion that they would be looking for during the test, the examiners presented the diagram in Figure 3 and read the following instructions:

> In some sunglasses your view may appear to jump slightly when the lenses are put on. For this study we will be asking you to evaluate any motion seen when the lenses are placed in your view when looking at a golf ball on the green. If the ball moves, please estimate the amount it moves in ball diameters and the direction. If the movement is not straight up, down, left, or right report the motion as between these directions. For example if the ball moved like ball number one in the drawing the motion you would report would be up-right two ball diameters. If it moves like ball number two you would report down and left ½ of a ball diameter. It is important to not tilt the lenses and to place them all the way on when looking for image jump. If they are tilted or not completely on, it may cause movement that is not really in the lens. In order to keep the glasses close to your face please keep the nose pads in contact with your forehead while lifting the glasses up out of your view. It is also important to aim your head straight at the indicated ball when putting on and removing the glasses. In order to familiarize you with the process we will start with one practice pair (subject given practice pair and eye patch).

**Monocular Testing**

The order of eyewear presentation was predetermined using a 4 x 4 latin square design to create the counter-balanced sequences. After receiving the training...
instructions and the first eyewear pair to be evaluated, the subjects were asked to move up to the line facing the golf balls (see Figure 4). The following instructions were read:

The eye patch will now be placed over your left eye so that only your right eye is tested. While standing behind the line point your head at the center ball as if a string was tied between the ball and your nose. Looking at the center golf ball, determine if you see any ball motion when the frame is placed in your view. If motion is seen, estimate the amount and direction.

Maintain your head position towards the center ball. Now look, without moving your head, at the ball on the left and evaluate the motion seen.

Maintain your head position towards the center ball. Now look, without moving your head, at the ball on the right and evaluate the motion seen.

With each of the four pairs of eyewear the subject estimated the amount of ball movement perceived when the eyewear was positioned over the eye. While keeping the subject’s head stationary and pointed at the ball straight ahead, the perceived ball movement was estimated. While maintaining the subject’s head alignment on the ball straight ahead, perceived motion was then evaluated while looking at the ball in right gaze as the eyewear was placed in front of the eyes again. The subject then shifted their gaze to the ball on the left while maintaining their head position and evaluated ball motion. Between each measurement, the eyewear was repositioned to the subject’s forehead and the subjective verbal report was recorded. The amount and direction of movement reported by the subjects was recorded in golf ball diameters. Each subject’s sensitivity to prism induced movement was not determined prior to these measurements.

**Binocular Testing**

The eye patch was removed and subjects were read the following instructions:

This test will be done the same way as with one eye except that we would also like you to determine if you see motion towards or away from you and estimate how many ball diameters it appears to be.

Binocular testing was done with the same procedure as the monocular testing, except that subjects were given the additional instructions of looking for perceived ball
motion towards or away from them. Perceived motion was first evaluated when looking at the ball straight ahead. While maintaining head position straight ahead, the subject then evaluated the perceived motion of the ball on right gaze. Based on the assumption that the frames were symmetrical the ball on the left was not evaluated. The amount and direction of movement reported by the subjects was recorded in golf ball diameters.

According to the PGA, a regulation golf ball is no less than 42.67mm in diameter. At 6.00 m away from the subject, one diameter of movement of the center golf ball is a deviation of $0.711 \Delta$. At 6.93 m away from the subject, the diameter of the golf balls on left and right side represents a deviation of $0.615 \Delta$.

**Results**

Figures 5 through 9 show average monocular and binocular image jump as perceived by the subjects. Image jump was reported along the x, y, and z-axes, corresponding to horizontal, vertical, and depth movement, respectively.

Average monocular perceived image jump in the horizontal direction shown in Figure 5 varied from 0.04 to 0.20 ball diameters in primary gaze and 0.22 to 0.64 ball diameters for either lateral gaze. In primary gaze, due to the large variability in subjective responses for the Oakley and NYX eyewear, only Bollé and Nike eyewear showed image jump that was significantly different from zero. In the lateral gaze direction, the Bollé and NYX eyewear showed significant image jump in both lateral gazes while the Nike and Oakley eyewear showed significant image jump only in temporal gaze.

Average monocular perceived image jump in the vertical direction shown in Figure 6 varied from 0.01 to 0.26 ball diameters in primary gaze and 0.02 to 0.21 ball diameters for either lateral gaze. Due to the large variability in subjective responses for most eyewear, only the NYX eyewear in primary gaze showed a statistically significantly vertical image jump.

Average binocular perceived image jump in the horizontal direction shown in Figure 7 varied from 0.01 to 0.06 ball diameters in primary gaze and 0.23 to 0.64 ball diameters for lateral gaze. While all eyewear showed minimal image jump in primary gaze only the Nike eyewear showed no significant image jump in lateral gaze.

Average binocular perceived image jump in the vertical direction shown in Figure 8 varied from 0.01 to 0.05 ball diameters in primary gaze and 0.01 to 0.17 ball diameters for rightward gaze. Due to the large variability in subjective responses for most eyewear, only Bollé in rightward gaze demonstrated significant vertical image jump.

Average binocular perceived image jump in depth (z-axis) shown in Figure 9 varied from 0.04 to 0.22 ball diameters in primary gaze and 0.05 to 0.23 ball diameters for rightward gaze. Due to the large variability in subjective responses for most eyewear, only the Bollé eyewear in rightward gaze demonstrated significant depth image jump.

Repeated-measures analyses of variance (ANOVAs) were performed on both monocular and binocular
subjective data. The factors for monocular data analysis, shown in Table 1, include eyewear, meridian (horizontal and vertical), and direction of gaze (primary, temporal, and nasal). Factors for binocular data analysis, shown in Table 2, include eyewear, meridian (horizontal, vertical, and depth), and direction of gaze (primary and lateral).

There were significant effects based on eyewear and gaze (p<0.05) angle but no significant effects based on meridian. The only interaction effect that was significant was based on eyewear and gaze. The only significant main effect was based on gaze angle. All of the interaction effects that involve gaze are significant (p<0.01).

**Discussion**

Perceived image jump was reported to varying degrees in all tested eyewear, however the magnitude, direction, and frequency differ between selected brands. The larger the perceived image jump, the more likely golfers will have problems accurately judging the putt. Table 3 presents a composite of significant levels of subjective image jump for all of the 12 elements evaluated. These elements included: three measures of monocular horizontal image jump, three measures of monocular vertical image jump, two measures of binocular horizontal image jump, two measures of binocular vertical image jump and two measures of binocular depth image jump. Overall, Nike and Oakley eyewear resulted in the fewest reports of significant image jump, with two elements each. The NYX and Bolle eyewear induced more frequent reports of subjective image jump, with four and six elements respectively.

When initially reading a putt, a golfer will rely on both central and peripheral visual information. In the putting stance a golfer will move his/her eyes between primary and lateral gaze positions. Accurate and consistent visual information in all relevant gaze positions is crucial to optimal putting performance. The Nike eyewear performed most accurately and consistently in all gaze elements evaluated. When comparing objective measurements of prismatic effects found by Cooper et al. to subjective reports of image jump in this study, the amounts of perceived image jump noticed in some of the eyewear is consistent with the amount of induced prism measured objectively. Specifically, the Nike and Oakley sunglasses had less induced prism than the other eyewear evaluated in the study.

Since only two pairs of eyewear were tested from each manufacturer, it was not possible to account for variability in optical quality. All eyewear tested were purchased from retail outlets just as they would be by a consumer.
Future Studies

Though measures were taken to hide brand identifiers, subjects were still able to identify certain eyewear brands based on their design. This was particularly apparent with the Oakley M-frame, since multiple subjects immediately identified it. This brand recognition may have created some bias to the subject’s responses. Future studies are needed to investigate the effects of induced prism on golf performance to determine if golf sun eyewear provides measurable benefits.

Summary

This study investigated differences in perceived image jump between golf sun eyewear commercially available to the consumer. Overall, Nike eyewear performed best in the subjective measures of optical accuracy as compared to golf specific eyewear from Oakley, Bolle, and NYX. This study demonstrated that low handicap golfers were able to perceive small amounts of prism-induced image jump found in premium sun eyewear designed for golf. Since elite athletes possess superior visual function, it is possible that these small amounts of prismatic effects may have a deleterious effect on golf performance.18-20,26,27

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