

Negligible Impact on Posture From 5-Diopter Vertical Yoked Prisms

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PURPOSE. Yoked prisms are used by some optometrists to adjust posture, but evidence to support this practice is sparse and low level. The aim of this research was to investigate whether vertical yoked prisms have an impact on posture in healthy adults.

METHODS. Posture was assessed objectively in 20 healthy adults, by recording a range of joint angles or body segment locations at the ankle, hip, torso, neck, and head during participant observation of a straight-ahead target, and subsequently with eyes closed. Recording occurred before, during, and after wearing goggles with control plano lenses, and 5-diopter (D) base-up and 5-D base-down yoked prisms. In each viewing condition, the goggles were worn for 30 minutes. Interaction effects of lens/prism condition by time on joint angles and body orientation were determined.

RESULTS. In the eyes-open and eyes-closed conditions, no significant lens/prism \times time interaction effects were found at the torso, neck, hip, or ankle ($P > 0.1$). However, in both eyes-open and eyes-closed conditions a significant lens/prism \times time interaction was found at the head ($P = 0.031$ and 0.006 , respectively), with head extended (tilted backward) by up to 2.5 degrees more while viewing with base-down prisms than with plano lenses.

CONCLUSIONS. In healthy adults, 5-D base-down yoked prisms were not associated with a change in body posture. A small effect on head orientation and not at other locations suggests a minimal effect on posture. Research in a larger sample and in individuals with abnormal posture is needed to verify this.

Keywords: yoked prism, posture, spatial distortion

Yoked prisms are prisms of equal power and equal orientation in front of each eye, such as with their bases up (apices down). In the “base-up” example, the light passing through the prism is deviated toward the base (up) and the perceived image is shifted downward, toward the apex. Because the image shift is identical for each eye, there is no induced diplopia, and the image shift may have the effect of a binocular change in gaze direction and/or an accompanying change in head position to view the target in its shifted position. In addition to an image shift, the prism causes magnification of the image toward the apex, so yoked prism wear is accompanied by displacement and distortion of images in the visual scene.¹

Image shift and distortion affect perceived location and orientation of self and the visual scene, and could potentially be accompanied by compensatory postural changes. The effects of yoked prism on visual perception, head posture, or behavior (e.g., pointing to a target) may be apparent while the prisms are worn or after they have been removed.² The former is a direct effect of the prisms with visual cues. The latter may occur after a period of visuo-motor adaptation, in which case the effect is known as prism adaptation² or an after-effect of the prisms. An after-effect also may occur when visual cues due to the prisms are removed by eye closure or prism removal.

Redding and Wallace³ found a prism-adaptation effect in the form of a head shift in compensation for yoked prism-induced

horizontal shifts of the visual scene. Birnbaum⁴ suggested that the upward image shift created while wearing base-down yoked prisms is accompanied by “upward gaze shift associated with divergence, expanded peripheral awareness, relaxation, outward and backward body thrust, and increased nearpoint working distance” with equal and opposite effects due to base-up yoked prisms. These suggestions were based in part on Kraskin’s⁵ view that “The real value of yoked prism... is the influence on [body] orientation” and that “The specific influence of yoked prisms (and related eye movement) on the pelvis” is a tilt upward or downward with base down or up, respectively, and left or right with base right or left, respectively. Kraskin^{5,6} further proposed a link between yoked prism, posture, and refractive error, suggesting, for example, that the center of gravity shifts forward in myopia and that such a shift could be corrected by yoked prisms.

Based on the theory that a change in posture accompanies a prism-induced gaze shift, yoked prisms are sometimes prescribed for the treatment of postural anomalies,^{4–8} and to adjust posture in individuals with no postural anomaly.^{4–6} Evidence for the effectiveness of yoked prisms as a means of modifying posture has been limited by methodological issues in many of the previous studies. Potential sources of bias in previous studies include partially or entirely subjective assessment of posture and performance, or a lack of masking of participants or researchers.^{9–13}

Gizzi et al.¹⁰ used an objective method (moving platform posturography) to measure posture in healthy individuals without prisms, immediately on wearing 15-diopter (D) base right yoked prisms and after wearing the prisms for 1 hour. Statistically significant shifts in posture toward the prism base (right) were reported at both time points, but multiple comparisons were made with no mention of a correction factor for these. If such a factor were applied, the differences may not have been significant. The authors did note that average changes in posture were less than 1 degree, and that a change of this kind seems unlikely to have a clinically significant impact on patients with significant body posture anomalies.

Despite these findings and the methodological issues noted above, yoked prisms have been proposed as a means of adjusting posture in patients with or without postural anomalies.^{4-6,8,14,15} In a recent case report,¹⁶ vertical yoked prisms were prescribed for an athlete with lower back pain to resolve “anterior visual midline shift syndrome” (in which an object below eye level is perceived to be at eye level). The prisms were prescribed to be worn for daily periods, and a range of therapeutic exercises were also prescribed. The authors state that “The addition of prism glasses was believed to alter the athlete’s vision,” eliminating the midline shift and correcting any postural anomaly. However, any positive change may have been at least partly due to the therapeutic exercises. The authors conclude that further research into the effectiveness of this combined approach is warranted.

As has been noted previously,¹⁷ the use of yoked prisms to adjust posture, without a good evidence base, suggests a need for further research in this area. The aim of the present study was to measure objectively the impact of vertical yoked prism on head and body posture in healthy adults with normal vision. Impact was measured in terms of direct effects (while the lenses were worn and with eyes open) and after-effects (with eyes closed or after prism removal).

METHODS

Twenty participants aged from 19 to 49 (mean 26.4, SD 7.92) years were recruited by invitation from the staff and student population of the School of Optometry and Vision Science, University of New South Wales and Neuroscience Research Australia. All participants had normal vision (Snellen acuity 6/6 or better each eye, no manifest strabismus) and self-reported normal ocular and systemic health, with no postural abnormality. Seventeen of the participants were naive to the possible effects of yoked prisms on posture; three participants were investigators. Our rationale for using healthy subjects was that we were testing the assumption that yoked prisms have an impact on posture in healthy individuals without postural abnormality.⁴⁻⁶

Ethical approval for the study was granted by the University of New South Wales Human Research Ethics Committee, and the study was conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from participants after the nature and possible consequences of participation had been explained.

Participants wore plastic safety goggles (Uvex Safety, Parramatta, Australia) with a clip-in lens housing. Three clip-in frames were made to fit the housing, with 5-prism-D base-up, 5-prism-D base-down, and plano lenses. For simplicity, all three are referred to as “lenses.” Magnification at the center of each lens differed by less than 0.05% across the three lens types, and the lenses had identical base curves. The goggles could be worn over the participants’ habitual distance spectacles, if any (no participants wore multifocal lenses). The order of presentation of the three lens conditions for each participant

was decided arbitrarily by an experimenter just before testing began and therefore was not truly randomized. However, review of the resulting order applied in each case indicated that the conditions were not administered in a consistent order. All participants were masked to the type of lens they were fitted with.

Body segment orientation and joint positions were calculated by using coordinates from active infrared markers tracked in *x*, *y*, and *z* planes using a “CODA” Motion Analysis system (Charnwood Dynamics Ltd., Rothley, UK) at a sampling rate of 200 Hz. Markers were placed on each participant at the following locations (see Fig. 1): fifth metatarsal head of the left foot, lateral malleolus of the left ankle, left femoral epicondyle, left greater trochanter, both posterior superior iliac spine processes, spinal processes of the sixth thoracic and seventh cerebral vertebrae, 2 cm to the left and right of theinion (back of the head), and superior margin of the left orbit. The participant’s task was to stand still for 30 seconds while viewing a cross marked on a wall in the participant’s straight-ahead line of sight, at a distance of 1.40 m. Within each of the three lens conditions, marker coordinates were measured before (PRE, no goggles or lenses; the control condition) lens wear; immediately on lens wear (ON), at 10, 20, and 30 minutes of wearing the lenses; and immediately after lens removal (OFF). A total period of 30 minutes of prism wear was chosen on the basis of previous work^{18,19} in which a significant effect of yoked prism was found after short periods.

At each of these time periods, coordinates were recorded for 30 seconds with eyes open and 30 seconds with eyes closed. The *eyes-closed* condition was included to determine whether any effect found in the *eyes-open* condition was dependent on visual input, or reflected a change in posture independent of visual input, perhaps due to a recalibration of body alignment.²⁰ Between PRE and ON, the participant had eyes closed while the goggles with lenses were put on. The participant was instructed to open his or her eyes at the beginning of recording and to close the eyes 30 seconds after recording began, with recording continuing for a further 30 seconds with eyes closed. Within each lens condition, during the 10-minute periods between measurements, the participant wore the goggles and lenses and was encouraged to undertake a mix of activities, including walking (around the laboratory or along a corridor), reading, and using a computer. Between the three lens conditions, the participant wore no goggles or lenses during a 10-minute “wash-out” period intended to ensure no residual effect of previous lens wear.

To ensure consistent foot position throughout test sessions, before the first recording, each subject was instructed to stand in a comfortable position with bare feet spaced hip-width apart, on a large paper sheet, viewing the target. While in this position, a researcher drew around the subject’s feet and at each recording trial the subject was instructed to place the feet within these outlines.

Analysis

The mean joint angle or segment orientation at each of the five body and head locations was computed from marker positions and averaged over the first 1 and 5 seconds and the full 30-second duration of each recording. Joint angles and segment orientations were defined as follows:

- Ankle angle: acute angle between the foot segment (fifth metatarsal head to lateral malleolus markers) and the leg segment (lateral malleolus and femoral epicondyle).
- Hip angle: acute angle between the thigh (femoral epicondyle to greater trochanter segment) and the pelvis



FIGURE 1. Graphic representing head and body locations of infrared markers used to record location and calculate joint angles and body segment orientations (see Methods for description). Note that due to camera location, leg markers were placed on the left side only. The front head marker was off-centered to the *left*. Gray color of one marker on the head indicates that this marker was on the front of the head.

segment (greater trochanter to left posterior superior iliac spine [PSIS]).

- Neck angle: acute angle between the torso segment (sixth thoracic vertebrae to seventh cerebral vertebrae) and the head segment (seventh cerebral vertebrae and marker to the right of theinion).
- Torso orientation: vector joining the left and right PSIS and the seventh cerebral vertebrae, relative to the vertical.

- Head orientation: vector joining the three head markers, relative to the vertical.

Initially, joint angles and body segment orientation measures were compared between the three time frames of each recording (averaged over 1, 5, and 30 seconds) using a repeated-measures general linear model to look for changes in measurements during the recording (e.g., a change in posture during the first few seconds only).

A small number (32 of 1820, or 1.8%) of data points were missing due to hidden markers or incomplete trials. To avoid the loss of these data (thus reducing our sample) these missing data were estimated using imputation procedures.²¹ We first confirmed that the missing data were “missing completely at random,”²¹ then the missing values were estimated using an established iterative process.²² We conducted two-way repeated-measures ANOVAs on the resulting data set to determine any interaction effects of lens type (plano, prism base up, and prism base down) and time (before, during, and after lens wear) on ankle angle, hip angle, neck angle, torso, and head orientation, with Bonferroni adjustment for multiple comparisons. We were interested in comparing each yoked prism condition with the plano condition. The analysis described above was conducted on data collected while eyes were open and while eyes were closed.

RESULTS

No significant difference was found in any of the joint angle or segment orientation outcome measures between 1-, 5-, and 30-second recording durations ($P > 0.05$), indicating constant joint angles and segment orientations throughout the 30-second recording period. For this reason, data at only one of these recording durations (5 seconds) were used in subsequent analyses.

In the *eyes-open* condition, no significant interaction between time and lens condition was found at the torso, neck, hip, or ankle ($P = 0.36, 0.32, 0.56,$ and 0.52 , respectively), indicating that any effect of 5-D vertical yoked prisms on posture over a 30-minute period is not significantly different from the effect of plano lenses at these locations. However, at the head, a significant interaction between time and lens condition was found ($P = 0.031$). Figure 2 shows head orientation at each time period in the plano, base-up, or base-down lens conditions. Bonferroni-corrected pairwise comparisons showed a difference between plano and base down at 10- (2.2 degrees, $P = 0.009$) and 30-minute periods (2.5 degrees; $P = 0.002$) of lens wear. These differences indicate that at these time periods the head was more extended (chin up and head back) when wearing base-down lenses than wearing plano lenses. No significant difference was found at PRE ($P = 1.0$), ON ($P = 1.0$), or 20-minute periods of lens wear ($P = 0.34$), or when the lenses were removed (OFF; $P = 1.0$). No significant difference was found between plano and base up at any time period ($P > 0.2$).

In the base-down condition, differences over time were found between PRE and 10 minutes (4.1 degrees, $P < 0.001$), PRE and 20 minutes ($P = 0.008$), PRE and 30 minutes (4.3 degrees, $P = 0.001$), ON and 10 minutes (4 degrees, $P < 0.001$), ON and 20 minutes (3.1 degrees, $P = 0.001$), ON and 30 minutes (4.1 degrees, $P < 0.001$), 10 minutes and OFF (2.5 degrees, $P = 0.004$), and between 30 and OFF (2.6 degrees, $P = 0.019$).

Similarly, in the *eyes-closed* condition, no significant lens \times time interaction was found at the torso, neck, hip, or ankle ($P = 0.67, 0.15, 0.11,$ and 0.69 , respectively), but a significant interaction was found at the head ($P = 0.006$; see Fig. 2B). Bonferroni-corrected pairwise comparisons indicated a signif-

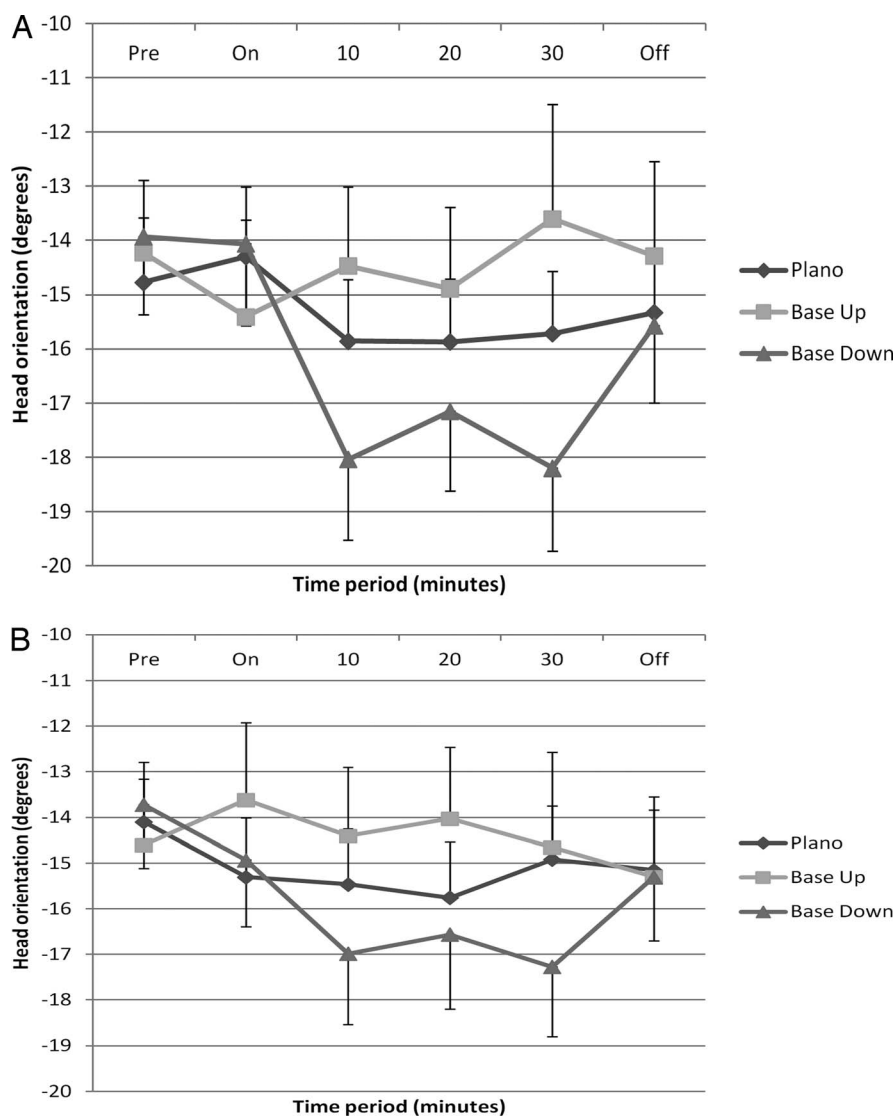


FIGURE 2. Line plots showing mean head orientation in degrees (angle between the vector formed by the three head locations shown in Fig. 1 and vertical) as a function of the period of time before, during, and after yoked prism or plano lens wear with eyes open (A) and eyes closed (B). Error bars indicate SE at each time period and for clarity are shown as positive or negative values, but not both.

icant difference between plano and base-down lenses at 30 minutes of lens wear only (2.4 degrees, $P = 0.01$), with no difference between plano and base-up lenses at any time period ($P > 0.2$). Differences over time during base-down lens wear were found between PRE, 10 (3.3 degrees, $P = 0.01$), 20 (2.8 degrees, $P = 0.02$), and 30 (3.6 degrees, $P < 0.001$) minutes. In addition, head orientation differed between the ON time period (immediately on wearing the prisms) and the 10- and 30-minute time periods (2.0 and 1.6 degrees, respectively; $P = 0.006$ in both cases). Head orientation also differed between the 30-minute and OFF time periods (2.0 degrees, $P = 0.016$).

Head orientation was similar between the PRE and OFF time periods in the eyes-open and eyes-closed conditions ($P > 0.4$), indicating that any effect during lens wear was not sustained after lens removal.

DISCUSSION

Our results indicate that 5-D vertical yoked prisms have no significant impact on posture at the neck, torso, hip, or ankle,

and that 5-D base-down prisms have a significant but not lasting effect on head extension. Sheedy and Parsons¹³ found head extension of 1.15 degrees on average at the end of 2 weeks of 4-D base-down prism wear, compared with baseline measures without prisms at the beginning of this period (detail provided by Sheedy JE, written communication, 2014). Our finding suggests that this effect occurs very soon after lenses are worn and does not require a 2-week adaptation period. Sheedy and Parsons¹³ also found that all but 1 of 24 subjects preferred not to wear the 4-D prisms, and that the 1 subject who accepted this prism reported that it relieved a back problem. This suggests that the prism might have altered body posture, but in the present study no change in body posture was found with either 5-D base-up or -down prisms.

Our sample did not include people with postural abnormalities, and it could be argued that a significant impact on body posture may have been found in subjects with abnormal posture. For example, Wong et al.²³ measured body posture in four young females with abnormal spine curvature, and found significant alterations in spine alignment after 3 minutes' wear with 10-D yoked prisms base up or base down, with opposite

effects on the spine in the two different base directions. No significant effect was found with 5-D yoked prisms in any base direction, suggesting the possibility that stronger prism than the 5 D used in the present study may have yielded a significant impact on body posture. Patient tolerance of a higher prescription, however, is unlikely, given previous findings.¹³

A rationale for the clinical use of vertical yoked prism is that posture is changed in response to image shift or distortion.⁴⁻⁶ The present study adds to previous work in which direct or after-effects of yoked prism on posture have been tested in people without postural abnormalities.^{9,24} Michel et al.²⁴ measured posture by using platform posturography in 14 healthy subjects before and after 20 minutes wearing prisms that induced a 15-degree leftward or rightward visual field shift (equivalent to 27-D yoked prisms base right or left, respectively). They found significant changes in posture after prism adaptation (after-effects), with the body tilted laterally (in the direction of the prism base) and forward (with either prism direction) after the prisms had been worn and then removed. These effects were mainly found in measurements with the eyes closed, and not with eyes open, suggesting that any change in posture due to a prism after-effect is controlled with the help of visual cues received on prism removal. In the present study, a direct effect of base-down prisms on head extension was apparent with eyes open or closed, but was not sustained after lens removal, indicating that the direct effect was maintained without visual cues (eyes closed) and was lost when normal visual cues were available (on removal).

As discussed earlier, Sheedy and Parsons¹⁵ found a small degree of head extension after 2 weeks of 4-D yoked prism base-down wear, suggesting that yoked prisms might have had a greater effect on head and body posture in the present study if they had been worn for a longer period. In a previous study,¹⁸ we found an effect of 5-D base-down yoked prisms on gait after only 7 minutes, which suggests that an effect on posture would be expected within a short period, but it remains possible that we would see an effect after a longer period of prism wear.

It is possible that the small effect of yoked prisms on head extension and lack of effect on body posture found here is due in part to our sample of only 20 participants. However, our *P* values show that any differences in body posture were not close to significance, indicating that much larger samples would be needed to show any effect, and that any such effects would be small. Even the significant differences we found represent changes in head orientation of only a few degrees, with questionable significance for clinical application.

The minimal effect of yoked prism on head extension found in this study does not support the prescription or use of yoked prism to induce postural change in individuals with normal posture. However, further research to test direct effects, after-effects, and tolerance of yoked prisms in a larger sample and in participants with postural anomalies is needed to verify whether their clinical application can be justified.

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