RESEARCH LETTER

Wearable Technology With Head-Mounted Displays and Visual Function

Interest in wearable head-mounted display systems for general consumers is increasing, with multiple models in production.1 However, their effect on vision is largely unknown. Peripheral visual field is a main component of vision and essential for daily activities such as driving, pedestrian safety, and sports.

Conventional spectacle frames can reduce visual field, sometimes causing absolute scotomas (blind spots),2 and head-mounted devices have even more pronounced frames. To quantify their effect on visual function, we compared performance on perimetric visual field tests with a head-mounted device vs regular eyewear.

Methods | Three healthy emmetropic or refractively corrected individuals with 20/20 best-corrected visual acuity and normal baseline visual fields were tested in April 2014. Participants used a wearable device (Google Glass, Google Inc), following manufacturer's instructions, for a 60-minute acclimation period. Participants required minor adjustments to optimize screen visibility. To assess obstruction potential, the display prism's position relative to the right eye pupillary axis was graded as (1) over central pupillary axis; (2) above central pupillary axis but inferior to superior limbus; or (3) above superior limbus.

Immediately thereafter, participants underwent 30-2 and 60-4 threshold perimetric (visual field) testing with the Humphrey Visual Field Analyzer II-750i (Carl Zeiss Meditec). Testing was performed first with the device (with software deactivated to avoid distractions), followed by a control frame of similar color and temple width. The University of California, San Francisco, determined the study was exempt from institutional review board review.

Results | Figure 1 shows the baseline characteristics of participants. Visual field testing demonstrated significant scotomas in all 3 participants while wearing the device (Figure 2; note variations in wearing and head position). In all 3 cases, more than 10° of visual field in the horizontal axis were subtended. Scotoma was absent with control perimetry testing with the regular frame.

For the image analysis, 311 images were found, with 132 eligible for evaluation. The prism covered the pupillary axis in 29.5%, covered the eye but not the axis in 29.5%, and was superior to the limbus in 41%. Therefore, 59% had the prism in a position likely to interfere with vision.

Discussion | To our knowledge, this is the first evaluation of the effect of wearable electronics with head-mounted display on vision. The device created a clinically meaningful visual field obstruction in the upper right quadrant. Defects were induced by the frame hardware design only and were not related to a distracting effect of software-related interference. Image analysis further demonstrated that many people wear the device near or overlapping their pupillary axis, which may induce scotomas and interfere with daily function.

This study is limited by the small number of participants, who may not be representative of all users. Even though the scotomas were easily identifiable, a larger sample is needed to identify factors that influence scotoma.

<table>
<thead>
<tr>
<th>Participant 1</th>
<th>Participant 2</th>
<th>Participant 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>Male</td>
</tr>
<tr>
<td>Race</td>
<td>White</td>
<td>Pacific Islander</td>
</tr>
<tr>
<td>Refraction oculus dexter (OD)</td>
<td>Plano</td>
<td>Plano</td>
</tr>
<tr>
<td>Best corrected visual acuity OD</td>
<td>20/20</td>
<td>20/20</td>
</tr>
<tr>
<td>Pupillary distance, mm</td>
<td>70</td>
<td>62.5</td>
</tr>
<tr>
<td>Wearable device prism position</td>
<td>Prism placed over the central pupillary axis</td>
<td>Prism cleared the central pupillary axis but was inferior to the superior limbus</td>
</tr>
</tbody>
</table>

* Indicates the right eye.
size and depth. The study is also limited by the lack of data on other visual parameters (eg, contrast sensitivity) and functional outcomes (eg, driving ability in a simulated setting).

The image analysis was limited to images posted on the Internet and therefore may not be representative. However, many of the images were created by the manufacturer as the intended mode of wearing the device and were clearly in the pupillary axis, whereas others were above the limbus, suggesting variability in how the device is worn and potentially the magnitude of any resulting scotoma.

Additional studies are needed to understand the effects of these devices on visual function, particularly as their use becomes increasingly common.

Figure 2. Visual Field Testing of 3 Participants

The gray-black areas demonstrate blind spots (scotomas) where the visual field has reduced (darker gray) or no (black) sensitivity to light and visual stimulation. Participant 1 has a pupillary distance of 70 mm and the wearable device scotoma is present in both the 30° and 60° peripheral field test. Participant 2 has a pupillary distance of 62.5 mm and the wearable device scotoma is present in the 30° test but is significantly greater in the 60° test. There is a superior scotoma in the 60° field in the control assessment, likely the effect of the spectacle frame, with an additional temporal scotoma induced by wearable device. Participant 3 has a pupillary distance of 59.5 mm and the wearable device scotoma is present in the 30° test and is significantly greater in the 60° superotemporal quadrant. There is a trace superior defect in the 60° field in the control assessment, likely the effect of the spectacle frame.

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Study concept and design: Ianchulev, Minckler, Stamper, Pamnani, Koo. Acquisition, analysis, or interpretation of data: All authors. Drafting of the manuscript: Ianchulev, Minckler, Hoskins, Stamper, Pamnani, Koo. Critical revision of the manuscript for important intellectual content: Ianchulev, Minckler, Hoskins, Packer, Pamnani, Koo. Administrative, technical, or material support: Ianchulev, Stamper, Pamnani, Koo. Study supervision: Ianchulev, Minckler, Koo.

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Anesthesia Technique and Outcomes After Hip Fracture Surgery

To the Editor Dr Neuman and colleagues\(^{1}\) concluded that although regional anesthesia was associated with shorter hospital stays following hip fracture surgeries than with general anesthesia, there was no significant difference in 30-day mortality.

In their analysis, patients who lived closer to hospitals that specialized in regional anesthesia were matched to patients who lived closer to hospitals that specialized in general anesthesia under the assumptions that patients seek care for hip fractures at hospitals near their homes and that regional anesthesia use varies across hospitals. Although distance is a factor in a patient’s choice of hospital, it is just one of many.\(^{2}\) Without exact patient addresses, Neuman et al\(^{1}\) used the linear distance between the center of the patient’s zip code and the hospital. However, driving distance, hospital reputation, and insurance network participation seem more likely to be associated with a patient’s hospital choice. These assumptions and the inaccuracy of the distance calculations raise concerns about hospital proximity as a strong instrumental variable.\(^{3}\)

Furthermore, if hospital proximity affects mortality through channels other than through the effect of proximity to a regional anesthesia-specialized hospital on the likelihood of receiving regional anesthesia, it is not a valid instrumental variable. Neuman et al matched patients on demographic characteristics and comorbidities,\(^{1}\) but research has shown that people live affects health and mortality in myriad ways that may not have been adequately controlled.\(^{4}\)

Moreover, any patients who received spinal or epidural anesthesia in addition to general anesthesia were grouped with patients who received general anesthesia alone. Therefore, it is likely that the true effect of regional anesthesia on 30-day mortality was biased toward the null.

We performed a similar analysis to that of Neuman et al but excluded patients who received both general and regional anesthesia to directly compare patients for whom either technique was a suitable option.\(^{5}\) Using a propensity score-matched approach, we found that regional anesthesia was associated with a shorter length of stay and an adjusted odds ratio of 0.36 (95% CI, 0.16-0.75) for in-hospital mortality.

Because certain surgical procedures, including hip replacement, can be performed using regional anesthesia as an alternative to general anesthesia, coming to a consensus on the safest anesthetic technique is essential to reduce postoperative complications and mortality.

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