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Variability of Eye Positions with EPS-21 Sun, Wind, and Dust Goggle

by
William E. McLean

Aircrew Health and Performance Division

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Methods for providing advanced spectacle and goggle laser protection for visible lasers include reflective dielectric coatings and holograms, tuned for specific wavelengths. The primary advantage of these methods compared to the current fielded broad band absorptive dyes is the potential for increased visual transmission for a given amount of protection. However, dielectric coatings and holograms are angle and position sensitive such that the locations of the eye positions are critical for the desired protective effects. This study measured the right and left eye positions (lateral (x), vertical (y), and fore-aft (z)) of 20 military subjects fixating straight ahead while wearing an EPS-21 Sun, Wind, and Dust goggle using mechanical methods. The lateral and vertical eye positions were also determined using a reflective method for rapid data acquisition. The reflections from the goggle lens and eyes were captured with a digital camera and analyzed with a computer program. The results showed that the eye positions measured mechanically for this sample varied similarly about the x, y, and z axes.

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The x and y eye positions measured with the reflective technique showed a high correlation with the mechanical method. However, the reflective method with the digital camera took longer than expected to both obtain the images and to analyze the eye positions with a computer program.

Acknowledgements

The author would like to express his appreciation for the assistance of SGT Christopher Kates in recruiting and scheduling subjects, obtaining eye measurements both mechanically and digitally, and analyzing the digital images for the vertical and lateral eye locations. Mr. Phillip Floyd provided instructions and equipment for obtaining and analyzing the digital images. I would also like to thank the USAARL subjects who enthusiastically volunteered to participate in this project.

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Objectives

To determine the central tendencies and variability of the relative eye positions for a small sample of soldiers wearing a developmental sun, wind, and dust goggle, and to correlate mechanical and photographic reflective methods for determining eye positions while wearing a sun, wind, and dust (SWD) goggle.

Military significance

Using holographic and dielectric interference filters to attenuate specific wavelengths requires that the filters be placed within certain tolerances for the x, y, and z (vertical, lateral, and fore-aft) dimensions relative to the eye location to be effective. This type information is critical to the laser protection designers for specific mounting devices such as goggles, spectacles, and visors. For the fielded and near term SWD goggles, there are no adjustments for the x, y, and z components. Therefore, if the designed eye location does not match the user population for the advanced laser protection systems, the user may not be protected for all wavelengths and the cost to the government for a redesign or custom designs could run into the millions of dollars. This study was requested and future field assessments will be conducted for the Military Eyewear Protection System (MEPS) Program.

Background

Class III and IV lasers can cause eye damage. Class III and IV visible and near infrared (IR) lasers are used in fielded military range finders and designators by U.S. and foreign countries. Therefore, all military equipment with visual windows that have been developed in the 1990s such as visors, binoculars, protective masks, goggles, and safety spectacles have been required to provide some type of laser protection. The present fielded laser eye protective filters for visors, goggles, protective mask outserts, and spectacles are based on absorptive dye technology. The dyes attenuate significant amounts of visible light for visible wavelength protection, and may be unusable under low light conditions where the eyes are most susceptible to laser damage. Exposure to sunlight with the dye technology also reduces the effectiveness over time. To provide protection from both visible and near infrared lasers at specific wavelengths, to minimize the effects on both visible transmission and color perception, and to retain adequate protection levels when exposed to solar radiation, technologies other than dyes have been required.

Advanced laser protective technology can attenuate some of the visible lasers with less effect on scotopic transmission by using dielectric and holographic filters. However, these filters are angle sensitive to the transmitted and attenuated wavelengths. This means a very narrow bandwidth can be blocked in the visible transmitted range and still provide sufficient transmission in the other visible wavelengths, but only if the pupils of the eyes are located within the effective area of the holographic design component. When the advanced laser protection filters are incorporated in an optical device such as binoculars, night vision devices, or weapon sights, the laser protective filter can be easily optimized with standard ray trace procedures. With more uncertainty and variability of the eye locations for the protective spectacle or goggles in the vertical, horizontal, and eye relief dimensions, the width of the attenuating wavelengths will have to increase, thereby decreasing the visible transmission and/or decreasing the effectiveness of the laser protection.

A literature review of eye locations relative to spectacles, visors, or goggles only provided information such as the average interpupillary distance (IPD) and the variability between the eyes for female (62.3 mm mean, 3.6 mm standard deviation (SD)) and male (64.7 mm mean, 3.7 mm SD) military personnel (Gordon et al., 1989). Variables that can affect the lateral position of each eye are binocular IPD and the nose location between the eyes (monocular IPD). A survey of infantry troops found the differences in monocular IPD values of 2 millimeters or more for 28 percent of a sample of 828 participants (Walsh, 1989). For a spectacle or goggle without an adjustable nose piece, the vertical location of the eyes relative to the position of the test item will be affected by the shapes and sizes of the facial components, especially the vertical location of the nose relative to the eyes.

To provide an effective holographic component, the vertical and fore-aft locations of the eyes must also be known. The EPS-21 sun, wind, and dust goggle is an Israeli developed item that is being tested as a U.S. replacement for the current SWD goggle. The faceplate is fabricated from polycarbonate and comes in either a clear or neutral tint for sun protection. The EPS-21 design is also being evaluated for advanced laser protective lenses.

Methods

The EPS-21 SWD was used for the eye location measurements for this phase of the study. It is manufactured in only one size. The faceplate has approximately a 5.25 diopter spherical curvature (37-cm radius). By using the reflections from the convex (outer) faceplate surface such as the image of the experimenter at close ranges or small bright light sources at distances with the aid of a magnifying device such as a telescope, the pitch and yaw orientations of the faceplate can be consistently positioned. The wearers of the device (EPS-21) under evaluation were coached on how to turn or pitch their heads and eye fixations for proper alignment. For cylindrical faceplates such as the current SWD, the tilt or pitch can be positioned parallel to a reference plum line and the yaw can be controlled using the reflection technique described for spherical surfaces. With a digital camera and computer program (Adobe Photoshop 4.0), the wearer's pupils were located in vertical and horizontal (x and y) dimensions relative to a fixed point on the goggle. To minimize eye convergence of the participant's pupils and obtain sufficient magnification, the photographs were taken at approximately 12 feet (4 meters). Figure 1 shows the digital camera, telescope, and two flashlights mounted on a tripod.

Figure 1. Digital camera, telescope, and two flashlights.

The *lateral* eye component dimension, the monocular and binocular IPDs were measured for each participant with a commercial pupillometer (Walsh, 1989) (Gordon et al., 1989). The *vertical* location of the eyes were measured using an IPD millimeter ruler by the investigator, locating the participant's eyes relative to a horizontal line drawn on the SWD goggle. The horizontal line was drawn through the lower screw securing the faceplate. Using the reflection of the investigator's eyes from the goggle faceplate, the investigator moved his head until his eyes were aligned with a mid-point horizontal line on the faceplate. Having the participant look into the investigator's eyes separately, the vertical distance from the center of the participants pupils and the horizontal line on the faceplate were measured with a millimeter ruler. Vertical eye position below the horizontal line was recorded as a positive value. Measurements were repeated up to three times for each eye to determine the median value. Figures 2 and 3 show the mechanical methods for obtaining the horizontal and vertical eye positions, respectively.

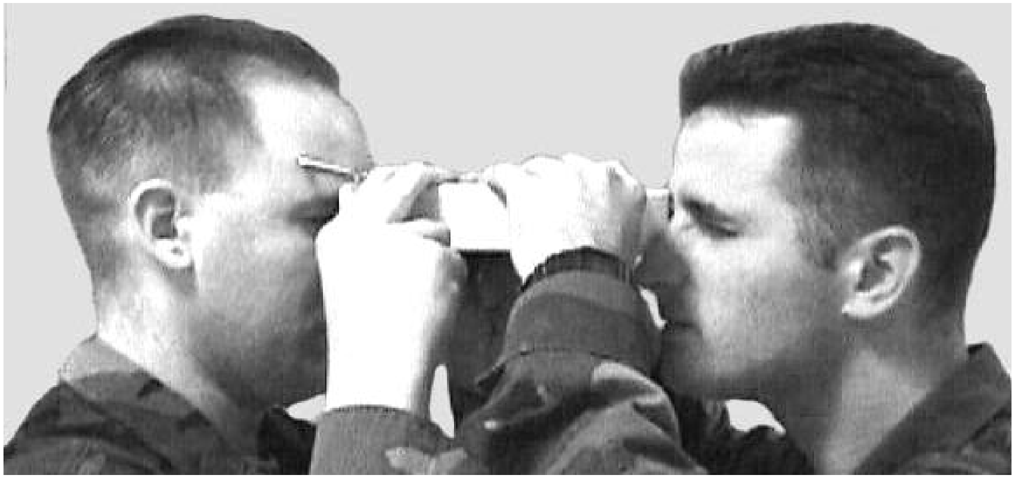

Figure 2. Measurements of the horizontal eye positions (monocular and binocular components) using a pupillometer.

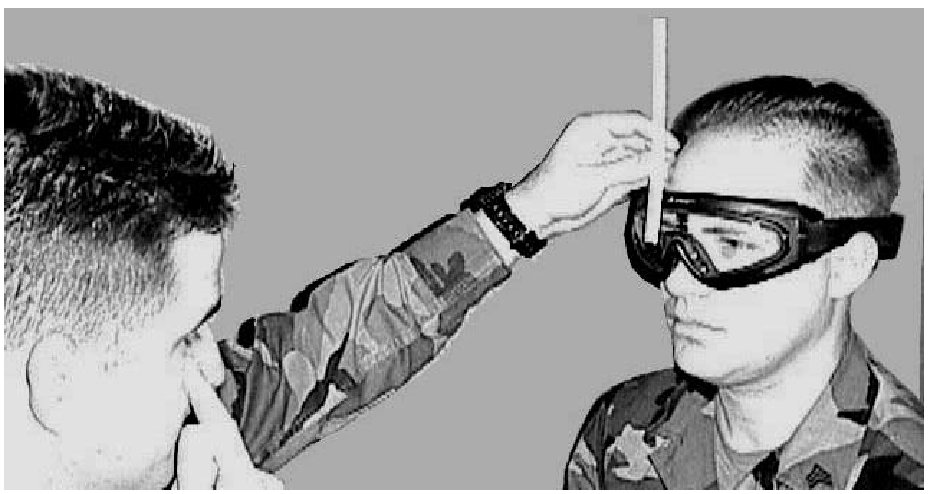

Figure 3. Measurements of the vertical eye positions.

Eye clearances were measured with a translating macroscope (McLean et al., 1995) (Towns and McLean, 1995). The subjects were positioned perpendicular (sideways) to the alignment of the macroscope using a chin and headrest. A measuring caliper with digital output was attached to a precision x-y optical mount and attached to the macroscope. The cross hairs of the macroscope were focused and aligned on the corneal apex of the eye and the scale was set to zero. The macroscope was slowly moved along the subject's line of sight until the center screw of the faceplate was focused and aligned with the vertical component of the cross hairs in the macroscope. The distance was then read from the digital scale. The measurements were repeated three times to determine the median value. The macroscope was moved to the other side of the table to measure both eyes. The macroscope method for a few subjects with deep set eyes was modified by slightly rotating the macroscope on the x-y translating mount to obtain a visible picture of the eye through the goggle. As long as the apex of the cornea and screw were accurately focused and aligned for the two positions, the accuracy of the measurements are retained when the macroscope is slightly yawed and the macroscope movement is parallel to the subject's line of sight (Figure 4).

Figure 4. Measurement of eye clearances using a positioning macroscope.

Subjects

The intended users of laser protection with both spectacles and the advanced SWD goggle are military personnel, primarily ground troops in the Army and Marines. As a pilot and baseline study, we used 20 military volunteers at USAARL for this phase to evaluate the methods described above to measure the eye positions. There were 14 males and 6 females. The sex of the participants was not used for analysis. At a later date, a larger sample of soldiers or marines will participate in a follow-up study using either the photographic reflective or the mechanical methods to determine eye positions. Volunteer consent forms were used for the USAARL participants. Part B of the Volunteer Agreement Affidavit is located at Appendix A.

Results

Mechanical measurements

The eye locations are reported with and without the EPS-21 goggle. Table 1 lists the basic statistics for the binocular and monocular interpupillary distances without the EPS-21 when measured with the pupillometer. The median values for each parameter and subject are located at Appendix B. Measurements are reported in millimeters (mm).

Table 1.
Lateral eye positions *without* EPS-21 goggle.

Statistic	Bino IPD (mm)	Rt IPD (mm)	Lt IPD (mm)
Mean	63.60	32.13	31.50
Standard Deviation (SD)	3.136	1.877	2.351
Median	63	32	31
Minimum	57	28	26
Maximum	69	37	36

Table 2 lists the eye positions when wearing the EPS-21 goggle relative to the lower screw securing the faceplate and located centrally above the nose area. The horizontal measurements were taken with the pupillometer and the vertical measurements with a millimeter ruler using the horizontal line marked on the faceplate. For reference purposes, the vertical dimension of the EPS-21 goggle faceplate at the right and left eye positions for a 64-mm IPD is 48 millimeter. The distance above the horizontal reference line to the upper edge of the faceplate at the 64-mm IPD points is 13 mm, and the distance to the lower edge is 35 mm from the reference line. Note that the minimum vertical height values occurred with one subject and may be an outliner. The next minimum (highest eye location) was +3 mm left eye and +4 mm right eye below the reference line.

Table 2.
Vertical, IPD, and fore-aft relative eye positions *with* EPS-21 goggle.

Statistic	Rt Vert (mm)	Lt Vert (mm)	Rt IPD (mm)	Lt IPD (mm)	Rt Fore-aft (mm)	Lt Fore-aft (mm)
Mean	7.60	7.10	32.40	32.00	29.81	30.10
SD	4.309	3.905	2.458	2.340	3.393	3.817
Median	8	8	33	33	29.35	30.9
Minimum	-6*	-6*	28	26	23.7	22.5
Maximum	12	12	38	35	35	36.7

While wearing the EPS-21 goggle, it was noted that 10 out of the 20 participants (50 percent) experienced fogging of the faceplate. This sometimes made the fore-aft measurements difficult to determine. Table 3 lists the differences in measurements between the right and left eye for IPD, vertical, and fore-aft locations.

Table 3.
Absolute differences between right and left eye locations *with* EPS-21 goggle.

Statistic	|Rt-Lt IPD| (mm)	|Rt-Lt Vert| (mm)	|R-L Fore-aft| (mm)
Mean	0.40	0.50	0.30
SD	3.545	1.000	2.773
Median	0	0	0.35
Maximum	7	3	5.4

Digital camera and computer measurements

The relative eye positions were also measured using the images taken from a digital camera by calculating the vertical and horizontal distances of the subject's pupils from the lower center screw on the faceplate using a computer program. This computer program also permitted the images to be rotated to compensate for any head tilt to one side and improve the vertical eye component accuracy. The vertical dimensions of the goggle above the nose and the horizontal width of the goggle from the central reflections around the faceplate screw were also measured for each subject to determine calibration factors and repeatability. Figure 5 is a sample of the digital images used to determine the vertical and horizontal eye locations. The lower central faceplate screw is located between the two reflections from the flashlights. Also, note the differences in the vertical eye positions between the two subjects. The subject on the viewer's right, had eye positions in the vertical dimension significantly higher than the other subjects.

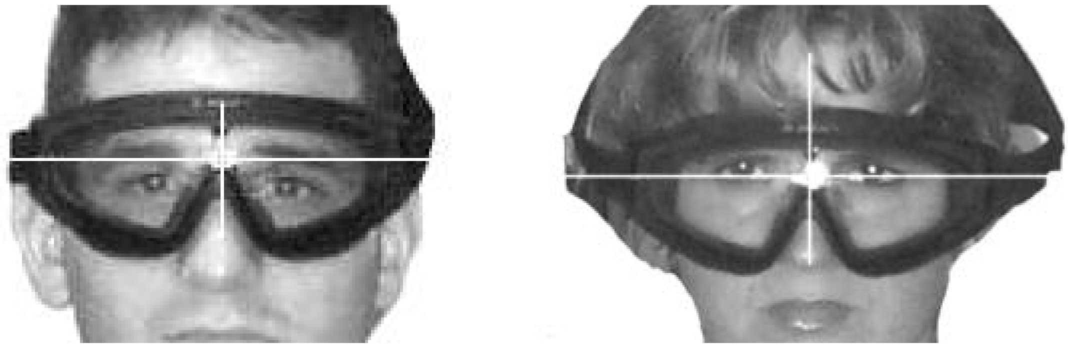

Figure 5. Digital pictures used to measure vertical and horizontal eye locations.

Appendix C lists the relative eye positions and basic statistical information for the 20 participants. Table 4 lists the statistical information on the monocular IPDs and vertical distances from the horizontal reference line on the EPS-21 faceplate lens. The data are reported in millimeters.

Table 4.
Relative eye positions *with* EPS-21 goggle.

Statistic	Rt Vert (mm)	Lt Vert (mm)	Rt IPD (mm)	Lt IPD (mm)	Bino IPD (mm)
Mean	7.62	7.67	31.71	32.69	64.40
SD	4.013	3.469	2.044	2.184	3.665
Median	7.41	7.69	31.85	33.32	63.98
Minimum	-5.49	-3.11	28.74	28.74	57.48
Maximum	12.63	12.45	36.25	35.70	71.39

Table 5 lists the differences in the digital camera measurements between the right and left eye vertical and horizontal eye positions.

Table 5.
Differences between right and left eye locations with EPS-21 goggle

Statistic	Rt-Lt IPD (mm)	Rt-Lt Vert (mm)
Mean	-0.99	-0.05
SD	2.114	1.496
Median	-0.73	0.55
Minimum	-4.58	-3.11
Maximum	3.11	2.38

Figure 6 shows a scatter plot of the eye locations from both the mechanical and digital camera measurement procedures.

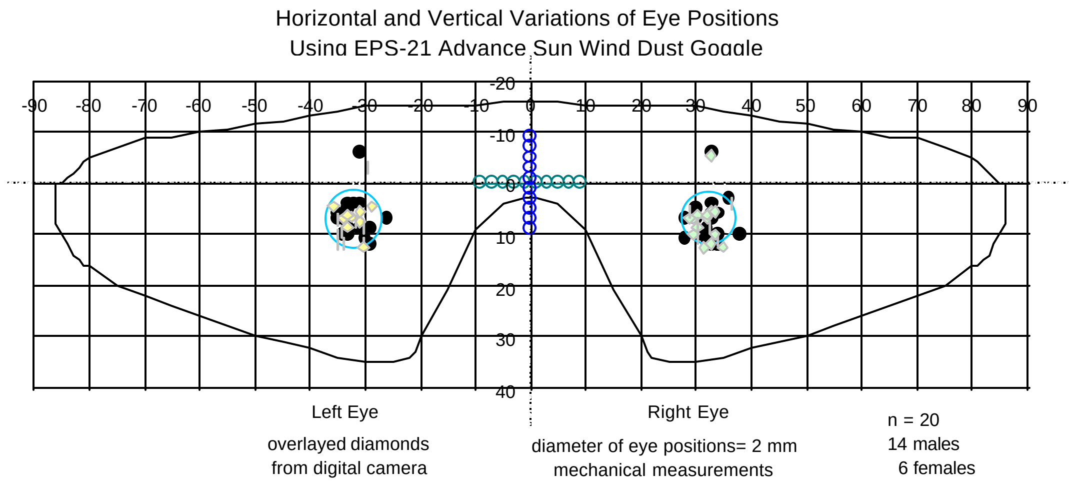

Figure 6. Eye locations measured with digital camera and mechanical methods.

The large circles around the right and left mean eye locations are 10 mm in diameter and equate to approximately 2 standard deviations or the projected 95 percent of the sample population. The circles in the center of the plot that form a cross and the mechanical eye location circles are approximately 2 mm in diameter. The center of the cross is the zero position for the vertical and horizontal measurements. One of the proposed laser protective designs would have required that the eye locations fall within a 2 mm area relative to the laser protection lens location.

The eye location values from the digital camera were very similar to the mechanical measurements, but notable differences occurred between the measuring techniques. Table 6 lists the differences between the mechanical and digital camera measurements. Figure 7 shows a plot of the differences between the mechanical and digital camera measurements for each subject, plotting from the mean locations for each eye. The circles around the means are approximately 2 standard deviations of the measured differences

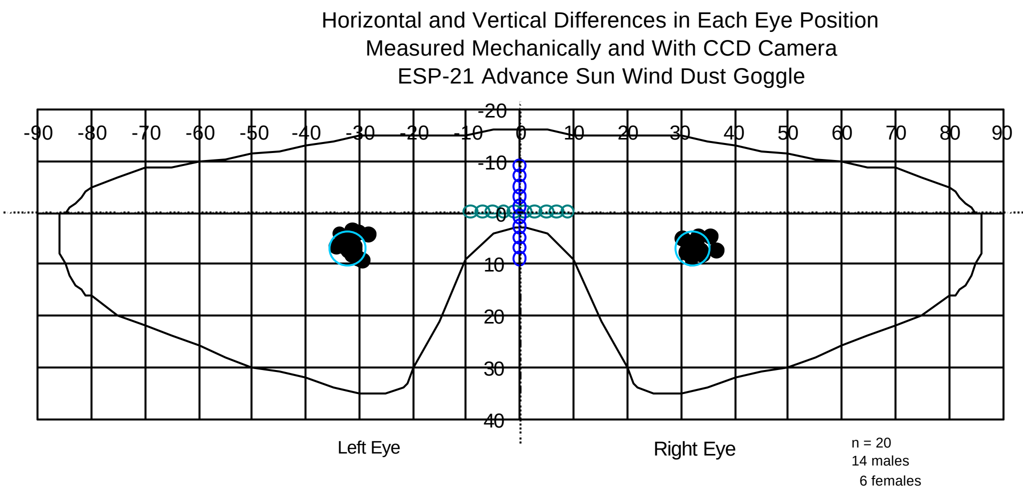

Figure 7. Differences between the mechanical and digital camera measurements.

Table 6.
Differences between mechanical (+) and
digital camera (-) measurements. N = 20.

Statistic	Rt Vert (mm)	Lt Vert (mm)	Rt IPD (mm)	Lt IPD (mm)	Bino IPD (mm)
mean	-0.02	-0.57	0.59	-0.69	0.00
SD	1.287	1.738	1.469	1.406	1.245
median	0.16	-0.35	0.42	-0.77	-0.08
maximum	-2.45	-3.69	4.16	-3.96	2.44

Table 7 lists the correlation coefficients (r squares) and slopes from regression analysis between the mechanical and digital measured values for the IPDs and vertical components.

Table 7.
Correlations (r squared) and slopes between
mechanical and digital measurements.

Mechanical	Digital	r square	slope
IPD right	IPD right	0.644	0.965
IPD left	IPD left	0.654	0.866
IPD binocular	IPD binocular	0.888	0.832
Vertical right	Vertical right	0.911	1.025
Vertical left	Vertical left	0.802	1.008
Vertical right + left	Vertical right + left	0.879	1.041

Multiple regressions and correlations were determined among the vertical, IPD, and fore-aft eye position components, but none showed any meaningful correlations. Figure 8 shows the plots between the monocular IPD values measured with the pupillometer on the goggle and the corresponding eye clearance values measured with the positioning macroscope. The eye clearance values and monocular IPDs are referenced to the lower center screw that secures the goggle faceplate. It appears from Figure 8 that there is little or no relationship between the monocular IPD values and the eye clearances. Similar plots were found for the vertical versus IPD or vertical versus fore-aft positions.

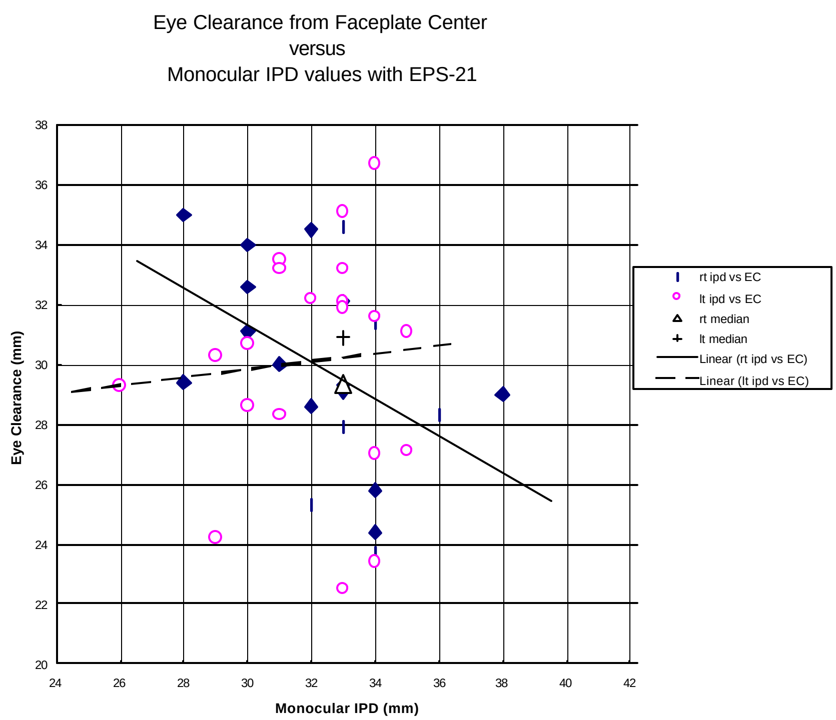

Figure 8. Eye clearance versus monocular IPD values.

Discussion

The two objectives of this study were (1) to determine the central tendencies and variability of the relative eye positions, and (2) to correlate mechanical and photographic reflective methods for determining eye positions from a straight ahead fixation while wearing SWD goggle. These objectives were met, but the information from this study raises several issues and questions for using eye centered laser protection methods.

From this modest size sample (20 subjects) and without considering eye movements, it appears a minimum of a 1000 mm cubic volume (vertical, horizontal and fore-aft eye locations) will be needed to cover approximately 95 percent of the user population. For the one design that required the eye location to be within 2 mm of the eye centered protection point, the number of faceplates or different eye protection cubes to cover this population would be a minimum of 5 x 5 x 5 or 125 different eye centered designed faceplates. If the eye protection volume design is slightly less than 5 mm per dimension, then the number of sizes or eye centered locations would be 3 x 3 x 3 or 27. As the volume of protection increases for the eye centered laser protection methods, the visual transmission may decrease to the point that the holographic and dielectric techniques are no better than the current dye technology.

For the eye centered laser protection methods, it will be important to measure the three dimensional eye locations of each individual user to insure the specific laser protection is adequate. The various methods described in this report for measuring eye locations are fairly repeatable within approximately 2 millimeters. However, all of these methods require several minutes for each individual for all three coordinates (x, y, and z) and will require some training for the measurers.

The Naval Air Warfare Center (NAWC), Patuxent River, Maryland, has developed a computer model to determine the extent of laser protection for eye centered systems, which considers eye position, eye movement, and pupil size. The data from this report will be supplied to NAWC for this model.

The mechanical and digital camera reflection methods for locating the eyes for the horizontal and vertical components correlated fairly well. However, the time to provide an identification marker on the digital picture, to position the subject accurately, and to process the image for each participant took much more time than expected, and would not be practical for a large sample. Also, the digital image from the frontal profile does not provide fore-aft measurements. The mechanical method of measuring the fore-aft eye location with the positioning macroscope also took more time than the other measurements. Other methods of measure the fore-aft eye locations within an enclosed area include a modified slit lamp and parallax ruler techniques. These methods will need to be evaluated before attempting to measure the fore-aft component on a larger group of personnel. As techniques and equipment improve, the reflected image method using a digital camera, recorder and computer may provide the best method to obtain quick and accurate three dimensional eye position data for a large population.

Some questions that have not been addressed by this study are the following:

(1) How repeatable will the soldiers position the protective eye wear on their face between fittings?

(2) How will the attachment or interface to a helmet or headset affect the position relationship between the eyes and laser protection?

(3) How will the user know his eyes are within the safety area of the laser protective system?

(4) The fore-aft eye-positioning device used in this study was a custom designed instrument that is not commercially available. Will a similar device be required for measuring the fore-aft eye locations when the MEPS are fielded?

Conclusions

This study measured the three dimensional central tendencies and variability of the eye positions from a straight ahead fixation relative to the EPS-21 sun, wind, and dust goggle for a sample of 20 soldiers. The vertical, horizontal, and fore-aft eye positions relative to a fixed position on the EPS-21 goggle are independent variables that will need to be determined for each eye for each individual with eye centered type laser protection. The mechanical methods, using the pupillometer for the horizontal and the millimeter ruler and reflections from the faceplate for the vertical components, are reasonably quick, accurate and repeatable for measuring a larger sample size. These methods should also be applicable to any sun, wind, and dust goggle or spectacle for the operational evaluations for the MEPS program. The positioning macroscope method of measuring the fore-aft eye locations in an enclosed area required more time than the other methods of determining the vertical and lateral eye locations. Alternate eye fore-aft position measuring techniques will be evaluated before laser protection operational testing is initiated.

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Appendix A.

Volunteer agreement affidavit, part B.

PART B -- TO BE COMPLETED BY INVESTIGATOR

INSTRUCTIONS FOR ELEMENTS OF INFORMED CONSENT: *(Provide a detailed explanation in accordance with Appendix C, AR 40-38 or AR 70-25.)*

PURPOSE

The purpose of this study is to determine the locations of your eyes relative to the center of the faceplate in the EPS-21 Advanced Sun Wind Dust (ASWD) Goggle. This information will be used in the future protective eyewear designs to provide laser protection.

PROCEDURE

After you have read this consent form and/or have been briefed on this study, you will be asked to sign a group consent form. Your eye positions will be determined using photographic techniques and with optical instrument measurements while wearing the EPS-21 ASWD goggle. At no time will your eyes be touched, irritated, or any discomfort induced.

BENEFITS

You will receive no benefits for participating in this study.

RISKS

There are no known risks associated with photographically or optically determining the eye locations relative to a reference point, or with wearing a SWD goggle.

ADDITIONAL INFORMATION

For the majority of the participants, the procedures should be completed in approximately 20 minutes. You may request to not participate at any time without any fear of retribution. You are not being compared to anyone else. All data and medical information obtained about you as an individual will be considered privileged and held in confidence. You or the measurements obtained will not be reported as an individual, but as a statistical value of the volunteers. However, complete confidentiality cannot be promised, particularly if you are a military service member, because information bearing on your health may be required to be reported to appropriate medical or Command authorities. In addition, applicable regulations note the possibility the U.S. Army Medical Research and Materiel Command (USAMRMC) officials may inspect the records.

Appendix B.

Mechanical measured vertical and horizontal eye location data using pupillometer and millimeter ruler.

Vertical and horizontal eye positions with and without the EPS-21 goggle.
Measured with pupillometer and millimeter ruler for 20 military participants.

		without EPS-21			with EPS-21			
Subject#	Sex	bino IPD	Rt IPD	Lt IPD	Vert Rt*	Vert Lt*	Rt IPD	Lt IPD
1	m	67	33	34	12	10	34	34
2	m	69	33	36	6	6	34	35
3	m	62	32	30	10	9	32	30
4	m	65	31	34	7	7	30	35
5	f	66	33	33	7	7	33	34
6	m	58	28	29	11	11	28	30
7	m	62	31	31	5	5	30	33
8	m	62	31	31	5	4	30	32
9	f	66	33	33	10	9	34	33
10	m	65	32	33	12	10	32	34
11	m	65	32	33	12	9	33	33
12	m	67	37	30	10	9	38	31
13	f	62	34	28	9	9	32	29
14	m	61	29	32	7	6	28	34
15	m	68	34	34	3	4	36	33
16	f	62	32	31	-6*	-6*	33	31
17	f	63	32	31	4	4	33	31
18	m	62	33	30	12	12	34	29
19	m	63	31.5	31	10	10	31	33
20	f	57	31	26	6	7	33	26
mean	**14 m/6 f**	**63.60**	**32.13**	**31.50**	**7.60**	**7.10**	**32.40**	**32.00**
stdev		**3.136**	**1.877**	**2.351**	**4.309**	**3.905**	**2.458**	**2.340**
median	**m**	**63**	**32**	**31**	**8**	**8**	**33**	**33**
min		**57**	**28**	**26**	**-6**	**-6**	**28**	**26**
max		**69**	**37**	**36**	**12**	**12**	**38**	**35**

*Note that negative vertical height values indicate that the eyes are located above the reference line on the SWD.

Fore-aft measurements, determined with positioning macroscope, and fogging.

Subject#	Sex	Rt fore-aft	Lt fore-aft	Rt-Lt fo-aft	fogging*
1	m	23.7	23.4	0.3	0
2	m	31.4	27.1	4.3	0
3	m	25.3	30.7	-5.4	0
4	m	31.1	31.1	0	0
5	f	29.3	27	2.3	0
6	m	29.4	28.6	0.8	1
7	m	34	32.1	1.9	0
8	m	32.6	32.2	0.4	1
9	f	24.4	22.5	1.9	1
10	m	34.5	36.7	-2.2	1
11	m	32.1	33.2	-1.1	0
12	m	29	33.5	-4.5	0
13	f	28.6	30.3	-1.7	0
14	m	35	31.6	3.4	0
15	m	28.3	31.9	-3.6	1
16	f	34.6	33.2	1.4	1
17	f	29.1	28.3	0.8	1
18	m	25.8	24.2	1.6	1
19	m	30	35.1	-5.1	1
20	f	27.9	29.3	-1.4	1
mean	**14 m/6 f**	**29.81**	**30.10**	**-0.30**	**0.50**
stdev		**3.393**	**3.817**	**2.773**	
median	**m**	**29.35**	**30.9**	**0.35**	
min		**23.7**	**22.5**	**-5.4**	
max		**35**	**36.7**	**4.3**	

*Note: Fogging is indicated with a value of 1 and no fogging with a value of 0.

Appendix C.

Computed vertical and horizontal locations of the eyes using digital camera and light reflections.

Computed vertical and horizontal locations of the eyes using digital camera and light reflections.

		Summary Sheet of Digital Camera Measurements				
Subject#	Sex	bino IPD	Rt IPD	Lt IPD	Vert Rt*	Vert Lt*
1	m	68.1	33.9	34.2	11.2	9.5
2	m	68.3	32.6	35.7	5.5	4.6
3	m	61.1	30.2	30.9	8.6	7.7
4	m	63.5	29.5	34.0	7.0	7.7
5	f	67.4	33.3	34.0	5.5	7.0
6	m	59.7	29.5	30.2	10.1	11.7
7	m	61.1	30.2	30.9	6.2	5.5
8	m	64.4	31.9	32.6	7.0	6.6
9	f	67.4	32.4	35.0	8.8	7.1
10	m	66.5	31.5	35.0	12.6	10.3
11	m	66.6	33.3	33.3	10.1	8.6
12	m	69.7	34.8	35.0	12.4	11.7
13	f	60.4	30.2	30.2	7.9	8.8
14	m	62.1	28.7	33.3	7.0	6.2
15	m	71.4	36.2	35.1	4.0	7.1
16	f	62.1	32.6	29.5	-5.5	-3.1
17	f	63.7	31.9	31.9	6.2	7.7
18	m	62.8	32.6	30.2	11.7	12.4
19	m	64.3	30.2	34.0	10.8	11.7
20	f	57.5	28.7	28.7	5.5	4.6
mean	**14 m/6 f**	**64.40**	**31.71**	**32.69**	**7.62**	**7.67**
stdev		**3.665**	**2.044**	**2.184**	**4.013**	**3.469**
median	**m**	**63.98**	**31.85**	**33.32**	**7.41**	**7.69**
min		**57.48**	**28.74**	**28.74**	**-5.49**	**-3.11**
max		**71.39**	**36.25**	**35.70**	**12.63**	**12.45**

*Note that negative vertical height values indicate that the eyes are located above the reference line on the SWD.