Do Women and Myopes Have Larger Pupils?

Ronald Jones

It is commonly reported that the pupils of women are larger than those of men and the pupils of myopes larger than those of emmetropes. However, these reports are not supported by experimental procedures using objective measurements, controlled conditions, and adequate numbers of subjects. In this report the open-loop pupil size was measured objectively using dynamic infrared pupillometry in a sample of 48 subjects. Subjects were balanced for age and equally divided between emmetropes and myopes, males and females. The results did not support the contention that females have larger pupils than males or that physiologic myopes have larger pupils than emmetropes. Invest Ophthalmol Vis Sci 31:1413-1415, 1990

The size of the normal pupil is influenced by the intensity of retinal illumination, proximity of the stimulus, and emotional state of the individual. Pupil diameter varies between 8 mm when fully dark-adapted to a minimum of 2 mm when the eye is light-adapted to moderate photopic luminances. The normal pupil has been shown to be relatively miotic in the elderly, but other influences on the pupil are not well established. It has been variously reported that the pupils of women are larger than those of men and the pupils of myopes larger than those of emmetropes or hyperopes, but such reports do not appear to have been documented by studies with objective measurements, controlled conditions and adequate numbers of subjects to consider them resolved. It is the purpose of this report to determine the pupil size in samples that are balanced for sex, age, and refractive error in order to evaluate these claims.

The pupillary light reflex is controlled by a negative feedback system that continually adjusts pupil size in response to changes in retinal illumination. The pupillary light feedback loop can be "opened" by preventing changes in pupil size from affecting retinal illumination. This is achieved by placing an aperture in front of the eye that is smaller than the natural pupil. Artificial pupils of approximately 0.5 mm also increase ocular depth of focus to the extent that accommodation is made ineffective. When viewing through a monocular pinhole, accommodation and convergence assume their resting states and the pupil is open-loop. The pupils were measured under such conditions in order to minimize any effects of external stimuli on pupil size differences between males and females, myopes and emmetropes.

Materials and Methods. The optical system is illustrated in Figure 1. The light source was an incandescent projection lamp (approximate color temperature 3200°K). Identical lenses L3, L2, and L1 were separated by twice their focal lengths, and the focal point of L1 was coincident with the entrance pupil of the left eye. An aperture stop was imaged by L1 and L2 onto the pupil of the left eye to form a 0.5-mm exit pupil for the viewing system. The fixation target consisted of a Maltese cross that was positioned coincident with the subject's far point to assure that the pinhole provided similar depth of focus for subjects with all refractive errors. The target was 5° in diameter and provided a background retinal illuminance of 2.5 X 10^4 trolands. This photopic light level was chosen after pilot experiments indicated that it provided an intermediate pupil response size, thus assuring that the pupil response was not saturated.

The right eye was occluded with an infrared transmitting filter (Wratten no. 87; Kodak, Rochester, NY). An infrared sensitive MOS video camera monitored the right eye through the filter and provided a highly magnified video image to a dynamic pupillometer (model RK-416; ISCAN, Cambridge, MA). The pupillometer was connected by digital interface (Base-Board; TECMAR, Cleveland, OH) to a microcomputer (model 5150; IBM, Armonk, NY). The pupillometer was calibrated with a series of artificial apertures that were placed in the plane of the pupil. A least-squares linear regression of the pupillometer output against aperture diameter was used to obtain coefficients for subsequent scaling of the pupil diameter by the computer. The pupillometer resolution was 0.05 mm.

Subjects: Subjects ranged in age from 18 to 26 yr and had normal binocular vision as indicated by 20/20 or better corrected monocular visual acuities, 20° stereothreshold and ability to fuse at distance through loose prisms of 4A base-in and 6A base-out. Refractive error was determined by autorefraction or lensometry of the subject's spectacle lenses. Informed consent was obtained from each subject prior to testing. A total of 48 subjects, equally divided between males and females, simple myopes (-1.50 to -3.50 D) and emmetropes (+0.75 to +0.25 D) were tested in these experiments. Preliminary experiments with the pupillometer indicated a standard deviation of pupil measurement of 0.25 mm. The precision was limited by the presence of normal pupil oscillations.
Selection of subjects was continued until a minimum of 12 subjects was obtained in each of the four categories. Subjects were then matched in priority of refractive error, sex, and age. Ties were resolved by random selection. (A total sample of 72 subjects was tested in order to obtain the balanced test sample).

**Procedure:** Data collection consisted of computer-controlled trials in which pupillary responses were measured while accommodation, convergence, and the pupil were open-loop. Subjects were positioned in the apparatus with a dental impression bite-bar and were light-adapted to the fixation target for 3 min prior to stimulus presentation. The computer warned the subject of the beginning of a presentation with an audible tone so that blinks could be minimized. Then a 5-sec sampling period was initiated in which pupil size was measured at 60 sample/sec. The average and standard deviation of the pupil diameter over the 5-sec period were computed and stored on disk. Data samples taken during blinks or eye movements greater than several degrees were eliminated from the sample. Such artifacts were detected with circuitry provided by the pupillometer and signaled to the computer. Each measurement was repeated at least once and the results of the separate trials were averaged.

**Results.** The mean values of pupil size and their standard errors obtained for subjects in each of the four measurement groups are presented in Table 1. Two-way analysis of variance was used to evaluate the effect of gender and refractive error on pupil size; this statistical analysis is presented in Table 2. The results indicate that there were no significant differences in the pupil sizes between myopes and emmetropes or between males and females. The mean size of the pupil for the entire group of subjects was 5.71 mm (SE=0.12) for the open-loop conditions of the experiment (retinal illuminance was $2.5 \times 10^4$ trolands).

**Discussion.** The results do not support the contention that females have larger pupils than males or that myopes have larger pupils than emmetropes. The

![Fig. 1. Schematic of the apparatus used to measure pupil size and to open the accommodation, convergence, and pupillary loops. L₁–L₄, lenses 1–4.](http://iovs.arvojournals.org/pdfaccess.ashx?url=/data/journals/iovs/933157/)
conditions of these experiments were designed to free the pupil of influences from accommodation and convergence by opening these oculomotor control loops. Since the pupil also was open-loop, constant retinal illuminance was maintained for the experiments, and the results permit comparison of pupil sizes under controlled stimulus conditions. The relatively large number of subjects (48) and the balanced design were employed to circumvent bias due to individual differences in the level of arousal. Further, the use of a simple fixation target should have eliminated any gender-dependent emotional factors associated with the visual context of the stimulus.  

The dependence of the pupil size on gender or refractive error has yet to be determined by experiments in which the influence of accommodation, convergence, and luminance is systematically varied. The current results permit only the conclusion that the pupil size is not dependent on gender or refractive error in the absence of external oculomotor stimuli. However, these results do cast doubt on the validity of reports that are based on uncontrolled or unspecified stimulus conditions. It seems unlikely that the results for gender would differ for closed-loop conditions. On the other hand, it is reasonable to expect that uncorrected myopes will have a larger pupil at near than will emmetropes, when accommodation is closed-loop. This difference occurs because emmetropes will be required to accommodate more than will myopes, and the synkinesis between accommodation and the pupil will result in relatively greater pupillary constriction. Such pupillary size differences lack physiologic significance and are simply artifacts resulting from uncontrolled differences in accommodation between the two groups. Nevertheless, these differences may account for the widely held clinical impression that myopes have larger pupils than emmetropes or hyperopes.  

These results do not allow conclusions about pupil size in high or pathologic myopia, since physiologic myopes were selected for this test sample. Physiologic myopia is defined by Curtin as the refractive condition in which the apparently random combination of normal optical components renders the eye myopic. The etiology of this group of myopes is probably different than that of pathologic myopia, which is accompanied by significant structural changes in the eye.  

The results also suggest that the mean open-loop pupil diameter (5.71 mm) is greater than that of the closed-loop pupil, which is approximately 2.0 mm in diameter at an equivalent retinal illuminance and field size. Palmer reported that opening the pupillary loop results in a significantly larger pupil than when the same light flux passes through the natural pupil. However, opening and closing the pupillary feedback loop with pinholes concomitantly affects accommodative feedback. Therefore, this pupil size difference cannot be attributed only to the action of pupillary feedback. Further investigation will be required to resolve this issue.

Key words: pupil, myopia, gender, near response, physiologic myopia

From Ohio State University, College of Optometry, Columbus, Ohio. Supported by grant EY-06577 from the National Eye Institute, National Institutes of Health, Bethesda, Maryland. Submitted for publication: May 30, 1989; accepted October 4, 1989. Reprint Requests: Dr. Ronald Jones, The Ohio State University, College of Optometry, 338 West Tenth Avenue, Columbus, OH 43210.

References