induced myopia. Anomalous patterned visual experience during development apparently disrupts emmetropization—the process by which a maturational interdependence among the various ocular components normally results in a distribution of refractive error that is leptokurtic in the region of emmetropia. Although no single theory regarding the mechanism responsible for emmetropization has achieved universal acceptance, the present study is unique in suggesting that emmetropization is dependent on normal visual stimulation during development.

We are indebted to E. Tamler, R. Litwin, A. Jampolsky, and C. Hoyt for allowing us access to their patient records and for helpful discussions at the beginning of this study. We thank C. Nicholson for typing and editing the manuscript.

From the School of Optometry, University of California, Berkeley. Supported in part by a research fellowship from the Alfred P. Sloan Foundation, a research grant from the National Institutes of Health (EY 02193), and a National Institutes of Health Biomedical Sciences Research Grant (RR 07006) to R. C. Van Sluyters. Submitted for publication Oct. 1, 1980. Reprint requests: Dr. R. C. Van Sluyters, School of Optometry, University of California, Berkeley, Calif. 94720.

Key words: refractive error, visual deprivation, emmetropization, myopia

REFERENCES


The relation between the intraocular pressure (IOP) at which the pulsating vascular tree (PVT) entoptic phenomenon is first observed and the ophthalmic artery diastolic pressure measured by ophthalmoscopic examination of the central retinal artery was determined in 25 normal volunteers. The PVT entoptic phenomenon consists in perceiving black stripes in the shape of branches of a tree appearing and disappearing synchronously with each heartbeat when the intraocular pressure is increased. The average IOP at which the entoptic phenomenon was first observed was 31.4 ± 7.5 mm Hg, and the average ophthalmic artery diastolic pressure was 51.8 ± 7.5 mm Hg. The correlation coefficient between both sets of numbers was r = 0.97 (p < 0.01). These results show that the ophthalmic artery diastolic pressure can be measured accurately with the perception of the PVT phenomenon as an end point. Because the perception of the phenomenon is not disturbed by ocular media opacities, this method enables the determination of the ophthalmic artery diastolic pressure in eyes where an ophthalmoscopic examination is not possible.

Measurement of the ophthalmic artery pressure by direct observation of the collapse of the central retinal artery is of aid in the diagnosis of carotid artery occlusive disease. In eyes with opaque media, however, ophthalmoscopic observation of the retinal arteries is not possible. In such eyes, an alternative monitoring system independent of the ability to visualize the retinal vessels is needed.

The entoptic phenomenon of the pulsating vascular tree (PVT), which is not affected by ocular media opacities, allows the ophthalmic artery diastolic pressure to be determined when ophthalmoscopic examination is not possible.

The perception of black stripes in the shape of...
tree branches appearing and disappearing synchronously with each heartbeat is characteristic of the PVT phenomenon. These stripes, which extend from the optic nervehead toward the macula, are produced by a moving shadow cast on the retina when the retinal arteries expand and contract as a pulse wave is transmitted along them. The stripes are not seen at normal intraocular pressure (IOP) but become visible with increased IOP or after strenuous physical effort. This phenomenon can be vividly observed if the retina is illuminated by deep blue light. At this wavelength, the contrast between the illuminated part of the retina and the portion that is in the shadow of the large vessels is very high because of the strong absorption of the blue light by the blood.

In this communication, we show that the IOP at which perception of the PVT phenomenon first occurs (IOP_{PVT}) corresponds closely to the ophthalmic artery diastolic pressure (OADP) determined by ophthalmoscopic observation.

**Materials and methods.** The IOP at which perception of the PVT first occurs and the OADP determined by ophthalmoscopic observation were investigated in 25 eyes of 25 volunteers whose ages ranged from 25 to 63 years. All subjects had vision of 20/60 or better. Brachial artery blood pressure was determined by sphygmomanometry with the subjects sitting.

In a preliminary experiment, each subject was first made aware of the phenomenon. As he looked into a blue field entoptoscope (Model BFE 100; Medical Instrument Research Associates), an instrument that diffusely illuminates approximately 25° of the retina at 430 nm, the IOP was raised and lowered several times by finger pressure gently applied to the eye until the PVT phenomenon was clearly recognized. The phenomenon was considered as correctly perceived when the subject identified the temporal-to-nasal extension of the stripes.

Fifteen minutes later, 2 drops of 0.5% proparacaine hydrochloride (Alcaine; Alcon Laboratories) were applied. The IOP was slowly increased by means of a Langham pressure cup (Digilab) placed on the temporal sclera until the subject reported the first perception of the PVT. When this occurred, the IOP was measured with a pneumotonometer (Model 30R; Digilab), calibrated as indicated by Langham and To mey, and documented as IOP_{PVT}. The IOP was then lowered to approximately 20 mm Hg. After 30 sec it was slowly increased under direct ophthalmoscopy until the first collapse of the central retinal artery was detected. This IOP was documented as OADP.

The reproducibility of the difference OADP – IOP_{PVT} was determined from measurements in three subjects on three different days. The subjects were also asked to compare the minimum intensity of blue field light needed to perceive the PVT phenomenon with the minimum intensity at which the blue field entoptic phenomenon was observed. The blue field entoptic phenomenon is the perception of leukocytes moving in one's own retinal capillaries.

**Results and discussion.** Fig. 1 shows the relationship between OADP and IOP at which perception of the PVT entoptic phenomenon first occurs (IOP_{PVT}) from measurements in 25 eyes. Correlation coefficient is \( r = 0.97 \) (\( p < 0.01 \)). The 45° line corresponds to values of IOP_{PVT} equal to OADP.

Average IOP_{PVT} was 51.4 ± 7.5 mm Hg and average OADP was 51.8 ± 7.5 mm Hg. Average pressure difference (OADP – IOP_{PVT}) was 0.44 ± 1.78. No statistically significant difference was found between both sets of data.

Average ratio between OADP and mean brachial artery diastolic pressure was 0.69. In each of the three subjects tested for reproducibility of OADP and IOP_{PVT}, the values of OADP and OADP – IOP_{PVT} did not differ by more than 3 mm Hg.

The results demonstrate that OADP can be measured accurately by the perception of the PVT phenomenon.
phenomenon as an end point. We investigated the feasibility of determining ophthalmic artery systolic pressure by the IOP at which the PVT phenomenon first disappears. We found that this was not possible; the PVT phenomenon ceased to be perceived at IOP levels below systolic pressure.

This technique can be applied only to cooperative subjects with good peripheral visual field function. The central visual acuity of the subjects is not important because the phenomenon is perceived by the retinal photoreceptors underlying the major retinal arteries. Because the phenomenon is seen when the retina is diffusely illuminated, the presence of such light-diffusing opacities as cataracts, corneal opacities, or vitreous hemorrhage does not affect the perception of the phenomenon if enough light reaches the retina. The minimal retinal irradiance needed to elicit the perception of the PVT phenomenon was found to be the same as that needed for first perceiving the leukocytes in the macular retinal capillaries. For this reason, a blue field entoptoscope can provide enough light for the PVT phenomenon to be perceived even in the presence of dense media opacities.

From the Department of Ophthalmology, University of Pennsylvania School of Medicine and the Scheie Eye Institute, Philadelphia, Pa. This work was supported by National Institutes of Health grant EY0-3398 and Research Career Development Award EY0-0120 (C. E. Riva) from the National Eye Institute, an unrestricted grant from Research to Prevent Blindness, Inc., New York, and the Charles E. Goetz Teaching and Research Fund. Submitted for publication Nov. 18, 1980. Reprint requests: Dr. Charles Riva, Scheie Eye Institute, Myrin Circle, 51 N. 39th St., Philadelphia, Pa. 19104. *On leave from The Eye Department, Beilinson Medical Center, University of Tel-Aviv, Israel.

Key words: ophthalmic artery pressure, ophthalmodynamometry, entoptic phenomenon, intraocular pressure, ocular media opacities

REFERENCES