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Where the iris ends and the pupil begins

Abstract

Specially trained police officers known as Drug Recognition Experts (DRE) use pupil size to determine the type of substance a suspect drug user has taken. The DRE's use a defined program for evaluating pupil sizes. Part of the program consists of taking pupil measurements in standard room illumination as well as in dark room conditions. Three different methods of pupil measurement are taken in the dark room. These measurements are taken with a direct, diffuse, and shielded penlight. The dark room measurements can be difficult to obtain, especially in people with dark iridis. An ultraviolet light source may aid in the measurement of dark irides by causing the lens to fluoresce, thereby silhouetting the pupil. To determine if the UV light source would affect the pupil size differently than the penlight, the two methods were compared. These comparisons were made with the same DRE officer measuring the same subject during two separate sessions. There was no significant difference in pupil sizes between the UV light source and the DRE standard program of pupil measuring. The data collected was also used to determine if the DRE officers are reliable and consistent when evaluating pupils. The DRE officers were accurate to within 0.5mm between the two pupil measurements taken on the same individual at different times. The DRE program has pre-determined pupil size limits for passing and failing suspects. It was found that the upper limit of what the DRE protocol accepts as normal pupil size be raised from 6.5mm to 8.5mm.

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WHERE THE IRIS ENDS AND PUPIL BEGINS

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Kevin Osborne was born and raised in Calgary, Alberta, Canada. He graduated from the University of Alberta with a Bachelor of Arts with Honors. After graduating he plans on practicing in the USA. Kevin is married and has a two-year-old son.

Heidi Boersma is a native Oregonian. She attended the University of Oregon where she studied General Science. Before entering optometry school, Heidi spent three years working for a local optometrist. Upon graduation Heidi would like to practice optometry in the Portland area.

Christy Lighthouse is a native of Nevada. She received her bachelor's in Health Sciences at the University of Nevada Reno. She decided to enter into the field of optometry because she wanted to help people and be involved in her community. She plans to practice in Nevada.

Kirsten Marie Guidon was born in Victoria, British Columbia in Canada, and was raised in Merritt, British Columbia. She returned to Victoria in 1991, where she attended the University of Victoria and graduated in 1995 with a Bachelor of Science, with distinction, in Psychology. Professional interests include ocular health and disease and providing eyecare and vision services in underprivileged areas. As an optometry student, Kirsten has been to the orphanages in Sibiu, Romania and the coastal city of Salinas, Ecuador on eyecare missions. While at Pacific University, Kirsten was active in the Student Optometric Association, serving as secretary in 1997-1998, and chairperson for Save Your Vision Week 1998. She has also served as Class Historian for the Class of 1999. Professional goals include private practice, additional eyecare missions, and the promotion of the profession of optometry.

ABSTRACT

Specially trained police officers known as Drug Recognition Experts (DRE) use pupil size to determine the type of substance a suspect drug user has taken. The DRE's use a defined program for evaluating pupil sizes. Part of the program consists of taking pupil measurements in standard room illumination as well as in dark room conditions. Three different methods of pupil measurement are taken in the dark room. These measurements are taken with a direct, diffuse, and shielded penlight. The dark room measurements can be difficult to obtain, especially in people with dark iridis. An ultraviolet light source may aid in the measurement of dark irides by causing the lens to fluoresce, thereby silhouetting the pupil.

To determine if the UV light source would affect the pupil size differently than the penlight, the two methods were compared. These comparisons were made with the same DRE officer measuring the same subject during two separate sessions. There was no significant difference in pupil sizes between the UV light source and the DRE standard program of pupil measuring.

The data collected was also used to determine if the DRE officers are reliable and consistent when evaluating pupils. The DRE officers were accurate to within 0.5mm between the two pupil measurements taken on the same individual at different times.

The DRE program has pre-determined pupil size limits for passing and failing suspects. It was found that the upper limit of what the DRE protocol accepts as normal pupil size be raised from 6.5mm to 8.5mm.

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INTRODUCTION

Many states in the country have police officers who are specially trained to recognize signs and symptoms of drug use. Police officers who graduate from the program are termed Drug Recognition Experts (DRE's). DRE training includes 72 hours of formal classroom education, a certification phase requiring the officers to examine a minimum of six drug-intoxicated subjects, assist in 6 more, and take a comprehensive exam.

DRE's are not required to examine every impaired driving case. They are only needed when the suspected impaired driver has a blood alcohol level that does not justify his/her behavior. It is the DRE's responsibility to determine which class or classes of drugs the suspect is under the influence of. In order to accomplish this, the officers use a twelve-step evaluation process.

The twelve-step program consists of the following areas: 1. determination of blood alcohol concentration, 2. interview of the arresting officer, 3. preliminary examination, 4. eye examination (eye movements, presence of nystagmus, etc.), 5. divided attention/psycho physical tests, 6. vital signs, 7. dark-room examination, 8. check for muscle tone, 9. injection sites, 10. suspects statement, 11. opinion of the evaluator, 12. toxicological examination.

Pupil sizes are affected by not only light, proximity, and psychogenic responses, but also chemical substance taken into the body. For example, narcotic analgesics such as heroin, cause the pupils to constrict to as small as 3.0 mm in the dark. CNS stimulants such as cocaine, however, cause the pupils to dilate. The purpose of the DRE dark-room examination is to obtain accurate pupil measurements that can be used as evidence to support suspected drug use.

First pupil sizes are measured in standard room illumination, then the suspect waits in total darkness for 90 seconds. After the pupils adjust to the dark, the officer measures them again using as little light as possible. To minimize light levels, the officer places a thumb over the penlight and holds it up to the suspect's eye. The

Figure 1



pupils are also evaluated with two additional methods - indirect, in which the penlight is held tangent to the eye, and direct, in which the penlight is shined straight into the eye. Measurements are obtained using a 3 X 5 inch card consisting of circles measuring in diameters of 1.0 to 9.0 mm in 0.5 mm steps. This card is held against the subject's face next to the eye and the officer compares the pupil to the pre-measured circles.

Since the testimony by the DRE is usually sufficient to establish the suspect's intoxication status, the accuracy of estimating pupil size is important. Measuring pupils accurately using minimal light can be challenging especially for individuals with dark irides. One method of overcoming this is to darken the room and illuminate the subject's eyes with ultraviolet (UV) light (Figure 1). The human lens is partially composed of protein fibers and amino acid residues such as tryptophan. When these molecules absorb high energy photons, such as UV light, they are raised to an excited but short-lived energy state. This energy is then dissipated by the release of lower energy quanta which are seen as visible blue light. The pupil is then silhouetted by the fluorescing lens creating a contrast easily detected by the evaluating officer.

This study addresses three goals. The main goal is to compare pupil diameter measured using the standard DRE shielded penlight method to the UV light method and to account for any differences detected. Secondary goals are to establish normative data for pupil sizes as measured using DRE protocols and to evaluate the test-retest reliability of the DRE officers' pupil size measurements.

SUBJECTS

The 78 subjects who participated in this study were professional students at Pacific University College of Optometry and police officers. The age, sex, race and iris color were recorded for each subject. The subjects' age range was from 22 to 48 years with a mean age of 27.9 years (s.d. = 5.3; 65% were male). Ninety-four percent of the subjects identified themselves as caucasian, 4% were asian and 2% were hispanic. No subjects identified themselves as being black. Thirty-three percent of the subjects had blue colored

irides and 26% had brown irides. Due to the fact that the subjects were either optometry students or police officers, there was an extremely low probability of recreational drug use on the day of the experiment. In fact, no subjects reported the use of alcohol, recreational drugs or medication that day with the exception of aspirin and birth control pills. All subjects gave informed consent for participation in the project.

It should be noted that all the subjects were calm and relaxed during the testing. They were familiar with the building in which the pupil measurements were taken as well as comfortable with the DRE officers and testing techniques used.

METHODS

Each subject was assigned a subject number as well as a group number. Pupil size measurements for the right eye only were obtained during two different sessions, each of which began with a standard room illumination measurement followed by a 90 second dark adaptation period. Each group of subjects was randomly assigned to the DREs for their first measurement session. In one session, three different pupil measurements using an incandescent penlight were taken according to current DRE protocol. In another session, an ultraviolet light was used to measure pupil sizes.

Two methods were used to evaluate each subject's pupil size: the penlight method and the ultraviolet light method. The penlight method consisted of three different techniques that are currently used by DREs to measure pupil size. For the shielded penlight method, the DRE placed his finger directly over the penlight. The luminance of the shielded penlight was 25 cd/m². With the indirect penlight method, the DRE held the penlight tangent to the front of the eye and measured the pupil. The direct penlight technique is one in which the penlight was held straight in front of the eye and the pupil measured.

The ultraviolet light method consisted of a single pupil measurement obtained with a small, battery-powered UV source (D & T Lite™ IU series, multipurpose lamp; 4 watt, 6 inch UV bulb; 4-AA batteries). The UV bulb was covered in black construction paper with

a 6.0 mm round aperture at the center of the bulb to limit the amount of UV exposure. The UV light source was placed below the subject's eye, at the level of the lid margin, with the aperture placed directly below the pupil. The UV lamps gave an average luminance of 21.1 cd/m².

RESULTS

A. SHIELDED PENLIGHT LIGHT METHOD VERSUS ULTRAVIOLET LIGHT METHOD

1. Total Group Comparison

The mean pupil size as measured by the UV light for all subjects was 7.24 mm (s.d. 1.14; Figure 2). This measurement is only 0.3 mm smaller than the mean pupil size as measured with the shielded penlight method (7.54 mm, s.d. 1.09). A paired t-test was used to determine whether there was a significant difference in pupillary diameter as measured by the shielded penlight versus the UV light method. The paired t-test ($p < 0.05$) revealed there was a significant difference in pupil size between the two methods.

2. Iris Color

Subjects with blue and brown irides were then considered separately. A t-test was conducted on the mean pupil sizes from these groups. When comparing the measurements of the shielded penlight method and UV light method for the blue-eyed subjects, there was a significant difference in pupil size ($p < 0.05$). No significant difference was revealed in brown-eyed subjects ($p > 0.05$).

3. Age Groups

Subjects were further divided into three groups based on age (Figure 2) and individual t-tests were conducted. For the 20-24 year olds, there was no significant difference ($p > 0.05$) in pupil size between the shielded penlight and UV light methods. There was, however, a significant difference ($p < 0.05$) between the two methods for the other age groups.

B. DRE PUPIL SIZE CRITERIA

The majority of pupil sizes which fell above the established DRE norms were measured by the covered penlight method (77%), and the diffuse penlight method (50%). The pupil sizes which fell below the DRE norms were measured by the direct penlight method (4%).

C. DRE OFFICER TEST-RETEST RELIABILITY

The mean pupillary diameter in standard room illumination for the 78 subjects as measured in Sessions 1 and 2 were 5.46 mm (s.d. 1.16) and 5.43 mm (s.d. 1.12) respectively. A comparison of the two standard room illumination pupil measurements produced a test-retest reliability coefficient of 0.911. The linearity of this relationship is verified by the scattergram in Figure 3. A paired t-test revealed that there was not a significant difference ($p > 0.05$) between the two standard room illumination measurements.

DISCUSSION

A. SHIELDED PENLIGHT LIGHT METHOD VERSUS ULTRAVIOLET LIGHT METHOD

There was no significant difference in pupil sizes between the DRE standard shielded penlight method and the UV light method when testing young individuals (20-24 years old) with dark irides. In a follow-up questionnaire, 71% of the participating DRE officers preferred the UV light over the covered penlight method for measuring pupil sizes on such individuals. All of the DRE officers suggested a brighter UV light would have made measurements easier. Although a brighter UV source (manifested as a larger aperture in the black paper) would have possibly made pupil testing easier, the many pre-test experiments demonstrated that any increase in the 6 mm aperture would adversely affected pupil size.

B. SUGGESTED PUPIL SIZE LIMITS

Pupil size measurements provide an objective way of establishing evidence of the presence or absence of specific

Figure 2 - Histogram of Mean Pupil Diameter of Shielded Penlight and UV Light Methods Versus Age

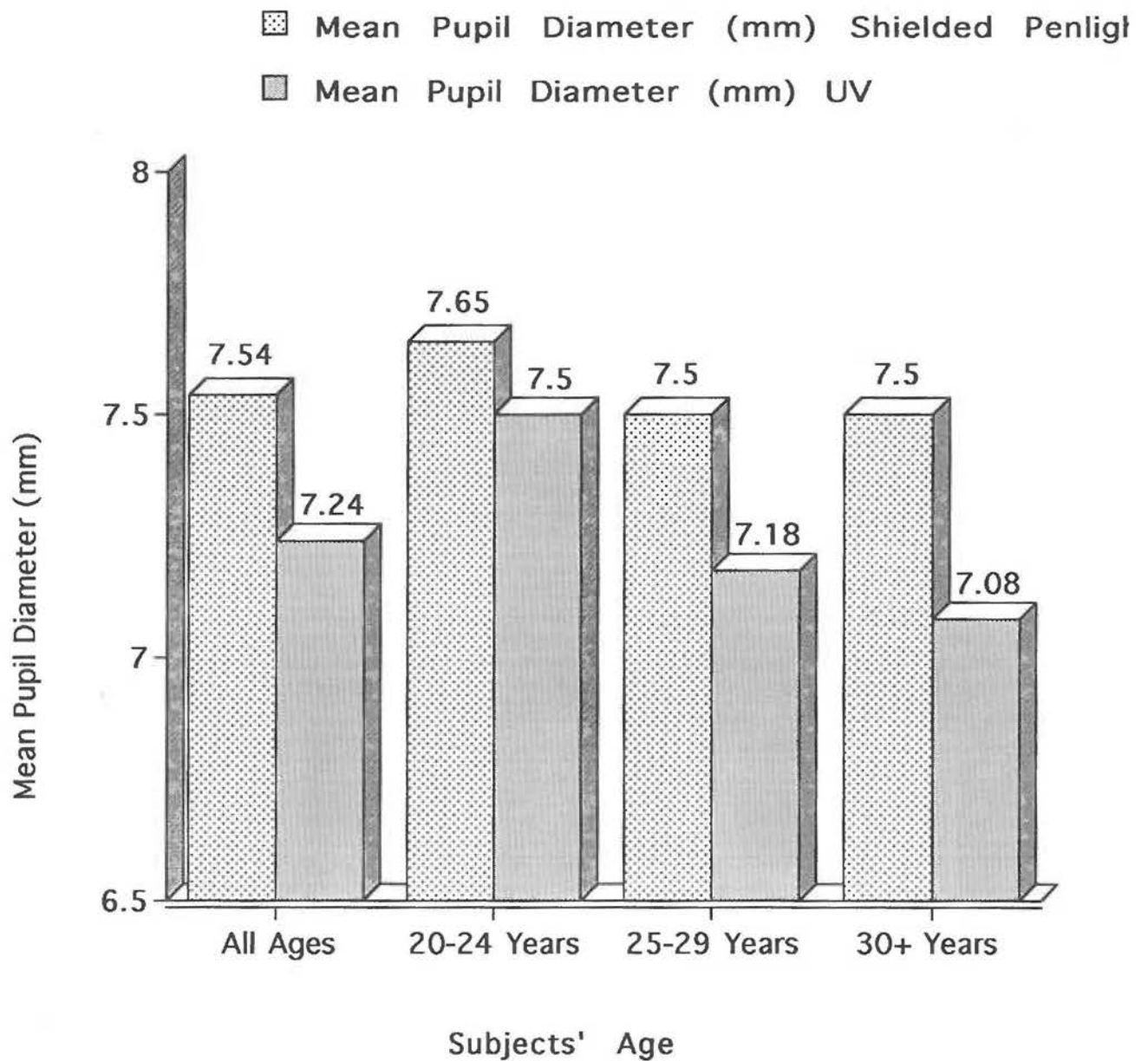
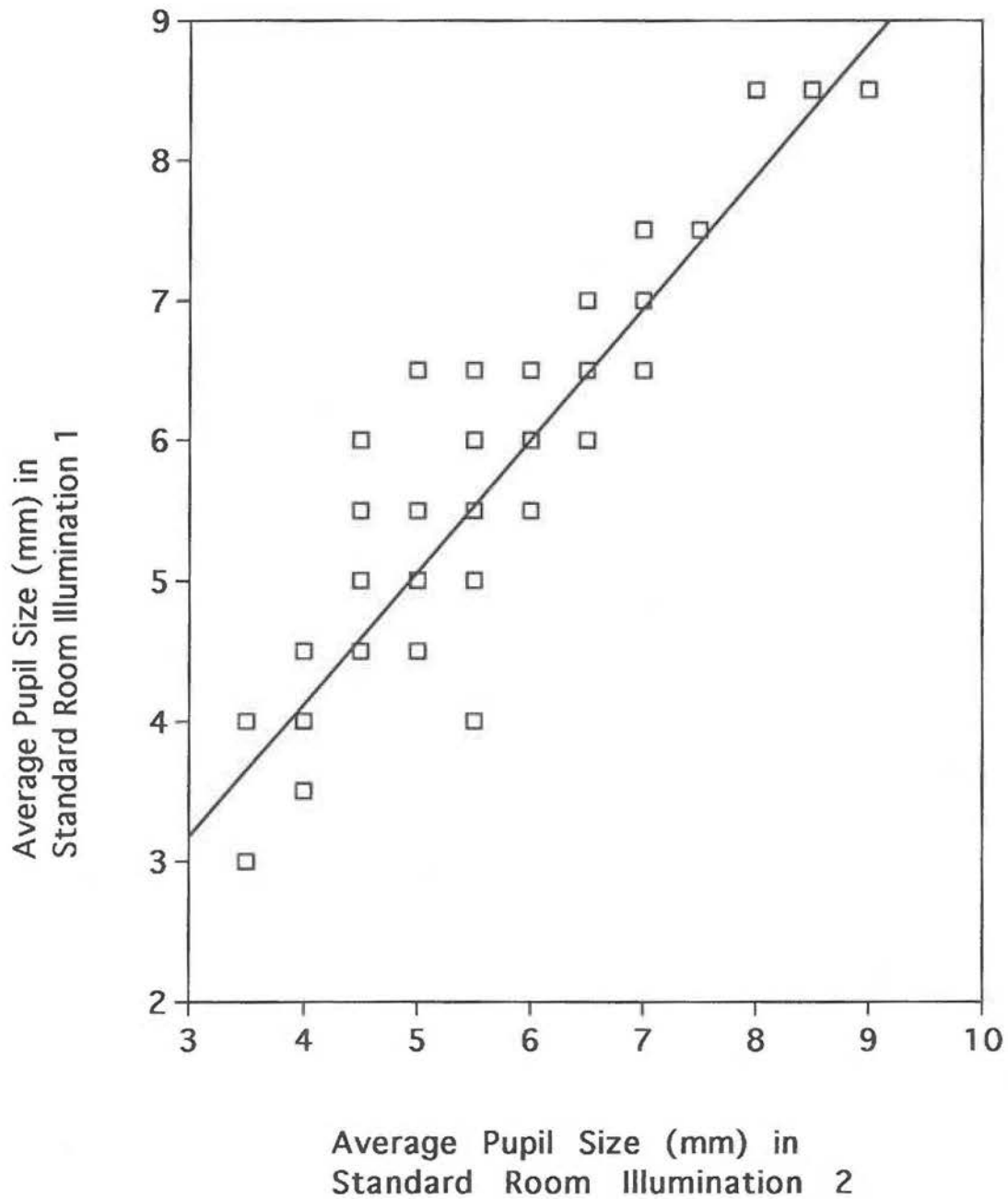


Figure 3 - Scatterplot



categories of drugs. The DRE protocols define abnormal pupil sizes as those less than 3.0 mm or more than 6.5 mm for any of the pupil measurement conditions. Using the shielded penlight method, 77% of the subject population fell above the DRE definition of normal pupil size and failed the test, even though they reported no use of alcohol, recreational drugs or medication the day of the tests. To correct for this large number of false positives, it is suggested that the upper limit of what the DRE protocol deems as "normal" be raised to at least 8.5 mm to give a pass rate of 81% for the current DRE protocol (Figure 5).

The DRE criteria for pupil sizes do not take into consideration the age of the subject. Medical literature has shown that the maximal pupillary diameter is reached in adolescence (midteens) and progressively decreases until about the age of sixty when it levels off (ADLER p. 329). The mean pupil sizes of the subject population also decreased with increasing age (Figure 6). Furthermore, this decrease in pupil size with age is independent of gender, refraction, iris color and illuminance level. This suggests that the DRE criteria for pupil size should be modified to take age into consideration.

C. DRE OFFICER TEST-RETEST RELIABILITY

The high positive coefficient of reliability (0.911) between the two standard room illumination pupil measurements indicates that the DRE officers are reliable and consistent when evaluating pupils. Figure 4 reveals that 94% of the standard room illumination measurements taken at different intervals on the same individual were within 0.5mm on either side of each other.

CONCLUSION

Although not applicable for every subject, the ultraviolet light would indeed be useful in determining pupil sizes for young subjects with dark irides. This experiment revealed that changes in pupil diameter, when measured with ultraviolet light as compared with the standard penlight, were neither statistically or clinically significant in subjects with dark irides. It was also shown that the

DRE range of "normal" pupil sizes was too narrow. While the lower limit was adequate, the upper limit of 6.5 mm was set too low. This study suggests that the upper limit of what the DRE protocol deems as "normal" be raised to at least 8.5 mm to give a pass rate of 81% for the current DRE protocol.

Figure 4 - Frequency Histogram of the Difference in Pupil Size Between Two Standard Room Illumination Pupil Measurements

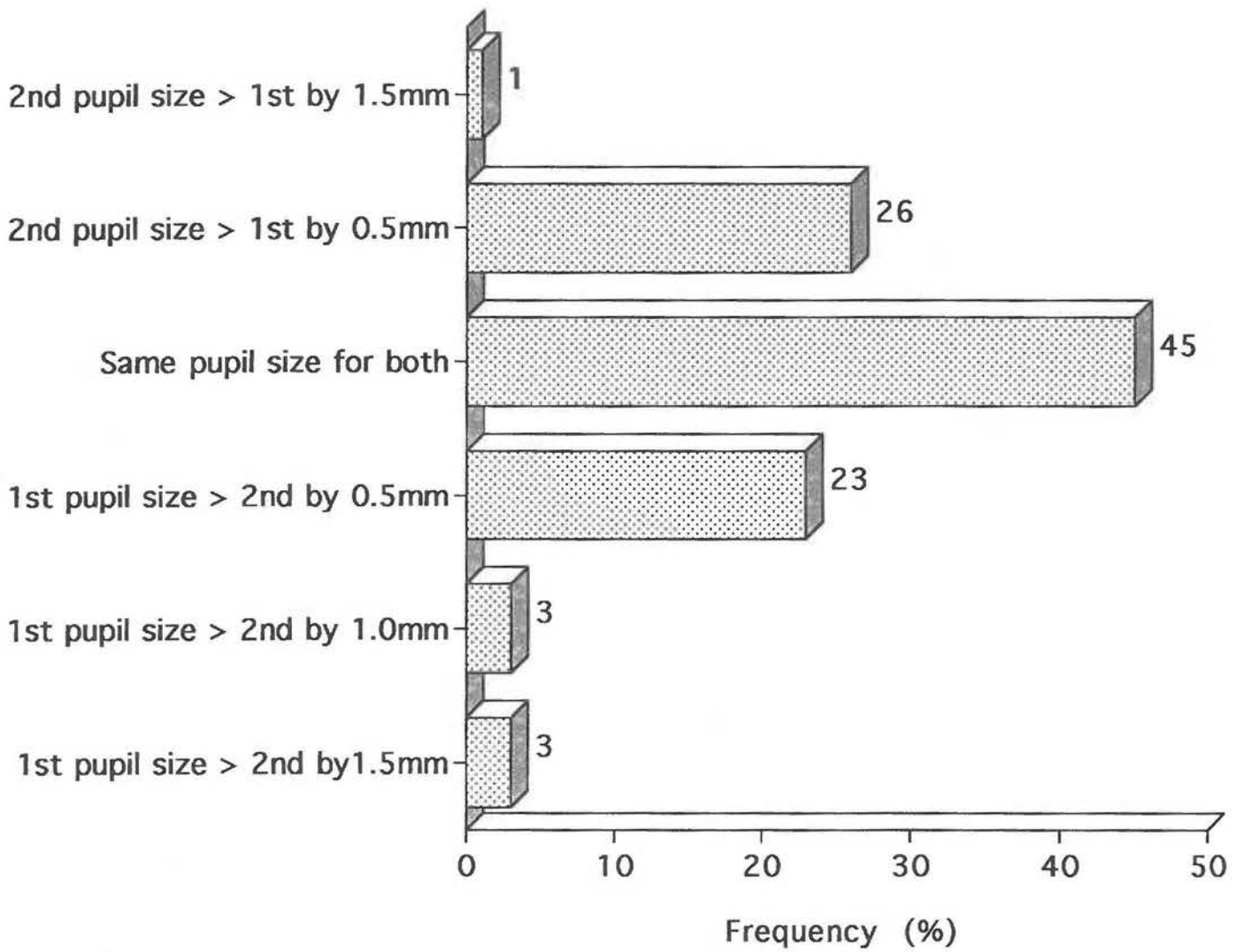


Figure 5 - Histogram of Upper Limit of Pupil Size Versus Pass Rate for DRE Protocol

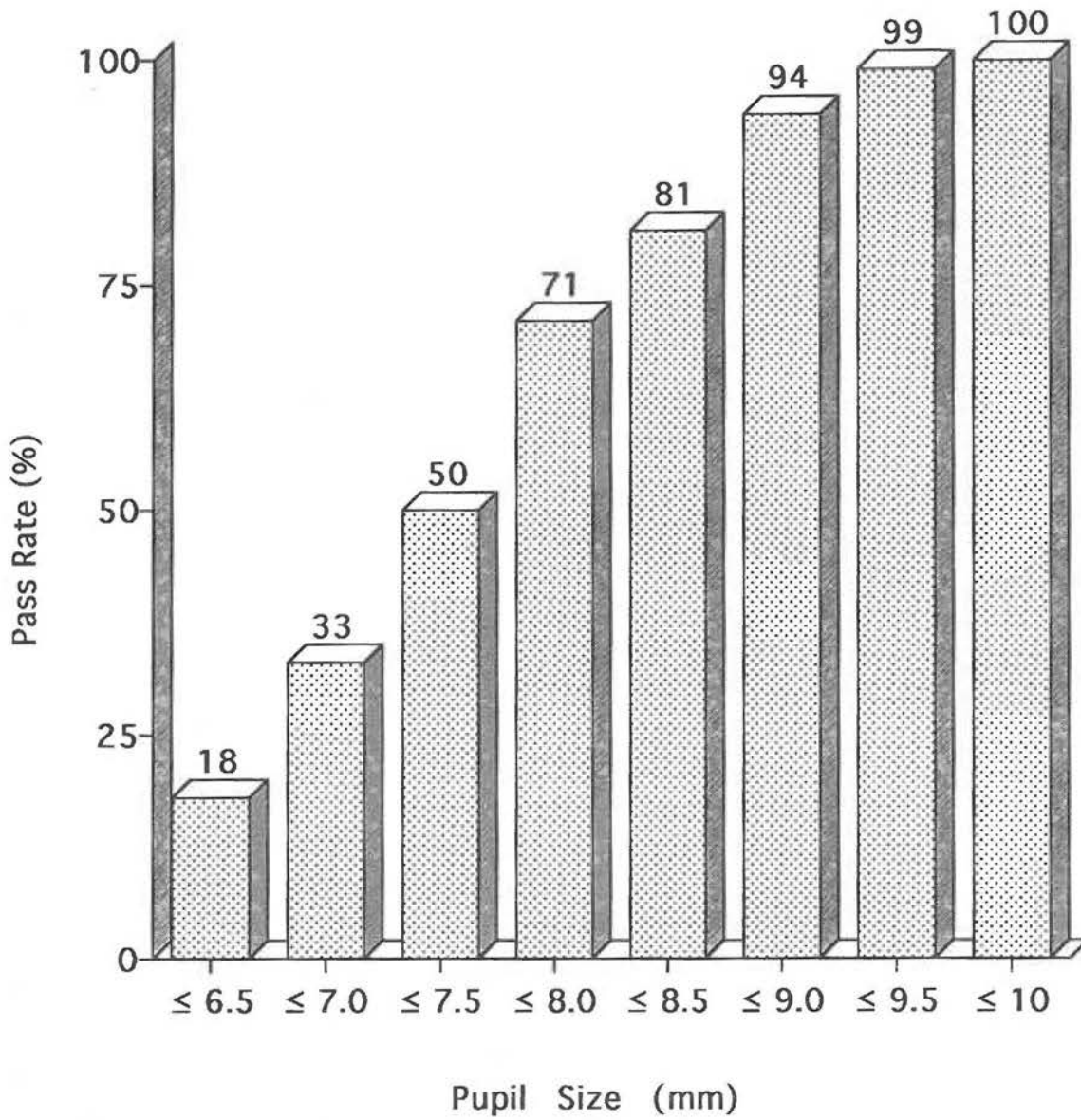


Figure 6 - Scatterplot of Mean Pupil Size in Standard Room Illumination Versus Age

□ Mean Pupil Diameter in mm

