

USE OF THE EYECHECK™ PUPILLOMETER FOR THE DETECTION OF FATIGUE DO TO SLEEP DEPRIVATION.

This document was prepared by Dr. Jack E. Richman of the New England College of Optometry, Boston MA. Through a contract with the Illinois State Police and is submitted to the General Assembly of the State of Illinois pursuant to Public Act 91-0881 to amend the Illinois State Motor Vehicle Code by changing Section 11-501.5.

1. FATIGUE

Goal:

To determine the capability of the EyeCheck™ pupillometer to discriminate and identify fatigue and sleep deprived impaired subjects from normal (non impaired).

1.1 Subjects

To establish the effect of lack of sleep and related fatigue on behavior of the pupil, forty eight volunteer subjects were recruited from Illinois State Police Academy. Each was screened for any medical conditions, eye abnormalities, had reportedly not been awake greater than ten hours, and were reportedly free of any pharmacological agents. This was confirmed with urinalysis employing a comprehensive drug screen, which complies with Federal (SAMHSA) regulations.

There were 83% males and 17% females ranging in age from 21-40 years of age with a mean and median age of 28 years of age. Consent to participate in pupillometry was obtained from each subject after the nature of the procedure had been explained fully.

1.2 Method

All the subjects were instructed to sleep at home for the entire night. Upon awakening they were instructed to avoid alcohol, caffeine and strenuous physical activity, which are known to alter papillary activity.

Each subject agreed to remain wake for a twenty-four hour period in which their pupils would be assessed five times every six hours. This provided a baseline (alert, non sleep

deprived) pupil activity profile, then one at six hours, twelve hours, eighteen hours, and finally twenty-four of wakefulness.

Subjects were seated with the pupillometer in a relatively quiet darkened room. Since previous studies have shown that when alert subjects sit in a darkened environment, their pupils remain dilated and relatively stable in size and fluctuation. Drifts toward smaller pupil diameter (miosis) occurs more in fatigued versus alert persons. Fluctuations and change in pupil size is also consistently reported. When these changes are monitored, changes in alertness can be measured. Based on this approach, the examiner followed the instructions for administration of the EyeCheck™. The subjects were allowed to dark adapt for 90 seconds before pupil diameter was continuously measured for a period of eight minutes. The pupil size was sampled continuously each tenth of a second and measured to a hundredth of a millimeter in size.

Once this data was collected on the subject, an analysis was performed on the data by the EyeCheck™ pupillometer and the accompanying laptop computer and software.

If pupil size decreases while variability increases, then we may be able to identify pupillary criterion that can identify sleepiness and reduced alertness. These oscillations had a tendency to increase during the 10-minute duration of the test, while the subject was sitting in the dark quiet examination room.

1.3 Results: Cumulative Miosis. In this investigation, the CM value for all subjects was compared in the alert stage (Normative value) with the CM value after 18 hours of sleep deprivation. A paired t-test indicated that there was a significant difference between the alert and sleep deprived conditions ($p < .01$). The sensitivity was 81.82% and

the specificity was 94.29%. The positive predictive value, i.e., does a randomly selected subject from the population actually have the problem, was 93.10% . The negative predictive value, i.e., does a randomly selected subject from the population not exhibit problem, was 84.62%. This indicates that the EyeCheck™ pupillometer, using this parameter as a physiological objective measure, evaluation identified reduced alertness as a product of sleepiness and fatigue.

Our results, like those of other investigators, demonstrated that pupillary parameters such as changes in pupil size and fluctuations can identify sleepiness and reduced alertness