

Reproducibility and Normative Values of the Parameters of a New Hand-Held Digital Pupillometer

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Abstract

We evaluated the intra-examiner reproducibility and determined the standard values of pupil parameters using the PLR-3000 pupillometer (NeuroOptics Inc). Generally good reproducibility was obtained, except for the T75 parameter. The standard values may be useful to distinguish various neurological abnormalities in clinical practice.

Keywords: Hand-held digital pupillometer; Reproducibility; Normative value; Parameter

(CV) and the normal ranges were analyzed with a 95% confidence interval (CI) as the normative values of the parameters.

Introduction

Evaluation of pupil size and the pupil light response are important parts of the ophthalmologic examination for detecting several neurological and ocular abnormalities [1]. Our research findings suggest that colored-light pupil response can be a novel tool to differentiate between outer and inner retinal diseases [2]. In contrast, these evaluations require special devices and technical expertise; and a longtime (almost 20 minutes) is required to make the necessary measurements, due to having to adapt the eye in a dark room.

The recent development of a hand-held digital pupillometer (PLR-3000 pupillometer; NeuroOptics Inc., Irvine, CA, USA) has allowed a more rapid and reproducible method to measure pupil size and pupil light response without having to rely on the dark adaptation. However, the determination of the normative values of healthy subjects remains unknown. We, therefore, evaluated the intra-examiner reproducibility and determined the normative values of pupil parameters.

Material and Methods

The PLR-3000 pupillometer is focused on the pupil, and then a white light of 180 μ W intensity at the duration of 0.8 second is flashed into the pupil. In accordance with the algorithm, the pupil parameters, such as size, latency, constriction velocity, and dilatation velocity are automatically calculated (Figure 1).

We examined 30 eyes of healthy subjects ranging in age from 21 to 23 years. Study protocol was approved by the Institutional Ethics Committee of Kitasato University (2016-G023B). This study followed the tenets of the Declaration of Helsinki for research involving human subjects, and written informed consent was obtained.

Pupil recordings were performed from 10 AM to 2 PM in a quiet room with controlled lighting. Pupil parameters were evaluated twice at 1-minute intervals by an experienced examiner (KA). The intra-examiner reproducibility was examined by the coefficient of variation

Results

Table 1 summarizes the mean CVs and the normative values with the normal range determined by the 95% CI of the parameters. The mean CVs for two repeated values determined by the same examiner were 6.0% for the initial pupil size (INIT)-parameter, 4.8% for the minimum pupil size at the end of light stimulus (END)-, 4.7% for the percentage of pupil constriction (DELTA)-, 9.5% for the latency time before onset of pupil constriction (LAT)-, 10.3% for the average pupil constriction velocity (ACV)-, 7.4% for the maximum pupil constriction velocity (MCV)-, 6.6% for the average pupil dilation velocity (ADV)-, 13.7% for the time 75% recovery from the minimum pupil size (T75)-parameter. The reproducibility of the T75 parameter was considerably lower than that for the other parameters.

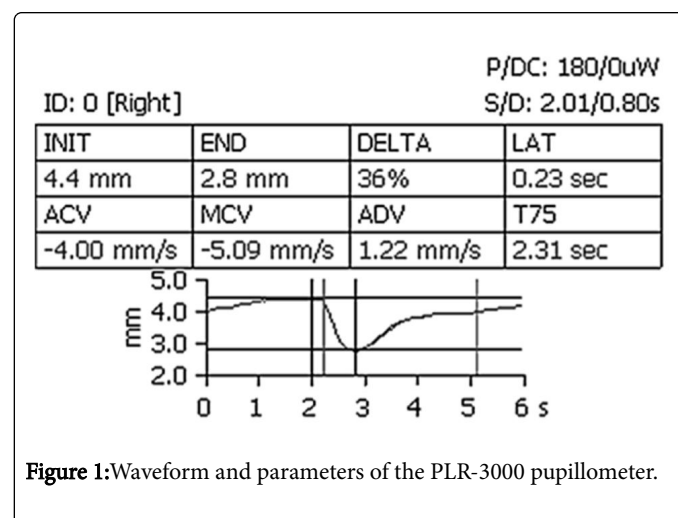


Figure 1: Waveform and parameters of the PLR-3000 pupillometer.

Discussion

In the present study, the parameters had generally good reproducibility. Recently, a novel study on the usefulness of a similar

device, i.e., the NPi-100 (NeuroOptics Inc.) was reported by Zhao et al. [3]. They concluded that the NPi-100 has a high inter-device reliability by two examiners measuring the same patient. Our findings strongly supported this previous report.

Pupil parameters	Reproducibility (CV)		Normative values	
	Mean	SD	Mean	95% CI
INIT: maximum size before light stimulus (mm)	6.0	5.0	5.0	4.7-5.3
END: minimum size after light stimulus (mm)	4.8	3.6	2.9	2.8-3.0
DELTA: percentage of constriction (%)	4.7	4.0	40.1	37.6-42.6
LAT: latency time before onset of constriction (sec)	9.5	11.6	0.21	0.20-0.22
ACV: average constriction velocity (mm/sec)	10.3	9.2	3.3	3.0-3.6
MCV: maximum constriction velocity (mm/sec)	7.4	7.8	5.0	4.6-5.4
ADV: average dilation velocity (mm/sec)	6.6	8.0	1.5	1.4-1.6
T75: time at 75% recovery (sec)	13.7	10.1	1.36	1.16-1.56

CV: Coefficient of Variation; SD: Standard Deviation; CI: Confidence Interval

Table 1: Reproducibility and normative values of pupil parameters.

DELTA and LAT parameters reflect the inability of the visual afferent systems. ACV, MCV and ADV, T75 derive exclusively from the parasympathetic and sympathetic nerves, respectively [4]. Intra-examiner reproducibility of the T75 parameter, which means the times to pupil recovery were lower than those in the other parameters. The problem is that the current settings of the device must not give the

pupil enough time to recover 75%. The solution is to make the light stimulus less bright and shorter time so that the pupil has enough time to recover. There should be done in another settings menu or should be at least a 5-minute interval of between the light stimuli [5]. Moreover, the normative values can be used as “reference values” because the values of people in their thirties or older remain unknown. In the future, these evaluations should be included to confirm this limitation.

Consequently, for the PLR-3000 pupillometer, normative values may be useful to distinguish various neurological abnormalities, such as optic neuritis, pupil-affecting or -sparing oculomotor nerve palsies, Horner’s syndrome, and Adie’s tonic pupil in clinical practice.

Conflicts of Interest/Disclosures

The authors report no conflicts of interest and have no proprietary interest in any of the materials mentioned in this article.

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