Journal of Optometry (2017) xxx, xxx–xxx

Journal of Optometry

www.journalofoptometry.org

ORIGINAL ARTICLE

Influence of refractive error on pupillary dynamics in the normal and mild traumatic brain injury (mTBI) populations

James Q. Truong, Nabin R. Joshi*, Kenneth J. Ciuffreda

SUNY College of Optometry, Department of Biological and Vision Sciences, 33 West 42nd Street, New York, NY 10036, USA

Received 23 July 2016; accepted 13 December 2016

KEYWORDS
Pupil light reflex (PLR);
Refractive error;
Myopia;
Mild traumatic brain injury (mTBI);
Infrared pupillometry

Abstract
Purpose: There have been several studies investigating static, baseline pupil diameter in visually-normal individuals across refractive error. However, none have assessed the dynamic pupillary light reflex (PLR). In the present study, both static and dynamic pupillary parameters of the PLR were assessed in both the visually-normal (VN) and the mild traumatic brain injury (mTBI) populations and compared as a function of refractive error.
Methods: The VN population comprised 40 adults (22–56 years of age), while the mTBI population comprised 32 adults (21–60 years of age) over a range of refractive errors (−9.00 D to +1.25 D). Seven pupillary parameters (baseline static diameter, latency, amplitude, and peak and average constriction and dilation velocities) were assessed and compared under four white-light stimulus conditions (dim pulse, dim step, bright pulse, and bright step). The Neuroptics, infrared, DP-2000 binocular pupillometer (30 Hz sampling rate; 0.05 mm resolution) was used in the monocular (right eye) stimulation mode.
Results: For the majority of pupillary parameters and stimulus conditions, a Gaussian distribution best fit the data, with the apex centered in the low myopic range (−2.3 to −4.9D). Responsivity was reduced to either side of the apex.
Conclusions: Over a range of dynamic and static pupillary parameters, the PLR was influenced by refractive error in both populations. In cases of high refractive error, the PLR parameters may need to be compensated for this factor for proper categorization and diagnosis.

* Corresponding author at: SUNY College of Optometry, Department of Biological and Vision Sciences, 33 West 42nd Street, New York, NY 10036, USA.
E-mail address: njoshi@sunyopt.edu (N.R. Joshi).

http://dx.doi.org/10.1016/j.optom.2016.12.005

Please cite this article in press as: Truong JQ, et al. Influence of refractive error on pupillary dynamics in the normal and mild traumatic brain injury (mTBI) populations. *J Optom.* (2017), http://dx.doi.org/10.1016/j.optom.2016.12.005

PALABRAS CLAVE
Reflejo pupilar a la luz (RPL);
Error refractivo;
Miopía;
Lesión cerebral traumática leve (mTBI);
Pupilometría por infrarrojos

Influencia del error refractivo sobre la dinámica pupilar en las poblaciones normales y las afectadas de lesiones cerebrales traumáticas leves (mTBI)

Resumen
Objetivo: Existen diversos estudios que han investigado el diámetro pupilar estático y basal en individuos con visión normal en todo el espectro de errores refractivos. Sin embargo, ninguno de ellos ha evaluado el reflejo dinámico pupilar a la luz (RPL). En el presente estudio, se evaluaron tanto los parámetros pupilares estáticos como los dinámicos en poblaciones con visión normal (VN) y en las afectadas de lesiones cerebrales traumáticas leves (mTBI), comparándolos en función del error refractivo.
Métodos: La población VN incluyó a 40 adultos (de 22 a 56 años de edad), mientras que el grupo de mTBI incluyó a 32 adultos (de 21 a 60 años de edad) para un rango de errores refractivos (de -9D a + 1,25D). Se valoraron siete parámetros pupilares (diámetro estático basal, latencia, amplitud, constricción máxima y media, y velocidades de dilatación), comparándose bajo cuatro situaciones de estímulo con luz blanca (pulso tenue, punto tenue, pulso brillante, y punto brillante). Se utilizó el pupilómetro binocular con infrarrojos DP-200 de Neuroptics (30 Hz de muestreo; 0,05 mm de resolución) en el modo de estimulación monocular (ojo derecho).
Resultados: Para la mayoría de los parámetros pupilares y situaciones de estímulo, los datos se ajustaron a una distribución gausiana, centrándose el ápex en el rango miópico bajo (−2,3 to −4,9D). La respuesta se redujo a ambos extremos del ápex.
Conclusiones: Para un rango de parámetros pupilares dinámicos y estáticos, el RPL se vio influenciado por el error refractivo en ambas poblaciones. En casos de error refractivo elevado, los parámetros de RPL pueden necesitar compensarse por este factor, para su debida categorización y diagnóstico.

Introduction

The technology to assess and quantify human pupillary response dynamics, such as the pupillary light reflex (PLR), has greater resolution and precision than ever before.[1,2] Hence, there are many pupillometric studies which have investigated ways to exploit pupillary dynamics as a potential, objective diagnostic tool, as well as a possible biomarker for a variety of clinical conditions, such as glaucoma,[3,4] amblyopia,[5] and mild traumatic brain injury (mTBI).[2,6,7]

However, underlying all clinical conditions are basic physiological and biological factors that may influence the PLR. These must first be elucidated, and then perhaps factored in for a clearer and more accurate understanding of the findings, and in addition, their possible basic and clinical ramifications. For example, it is well known that the steady-state, baseline pupillary diameter progressively decreases with age.[8,9] Another factor that is germane to the present study is that of refractive error (RE), which has been investigated in a few studies, but only with regard to steady-state (i.e., static), baseline pupillary diameter, with equivocal findings.[10–13] Some studies found a significant relation with refractive error,[10,11] while others[12,13] did not. However, dynamic pupillary parameters, such as peak constriction velocity and latency, have never been studied as a function of refractive error. This may be important, as this factor may have to be taken into account in its quantification and diagnostic categorization of 'normal versus abnormal'.

The present study was part of a larger investigation of pupillary responsivity in mild traumatic brain injury (mTBI), in which the static and dynamic responses have been found to be reduced, slowed, and delayed, as well as symmetrical between the two eyes.[1,2,6,7] mTBI is caused by a ''bump, blow, or jolt to the head, or a penetrating head injury, that disrupts normal function of the brain''.[1] This may result in a constellation of sensory, motor, perceptual, cognitive, linguistic, and behavioral problems[1] of a non-visual (e.g., disrupted sleep, nausea, confusion, etc.) and visual (e.g., vergence dysfunction, photosensitivity, visual motion sensitivity, etc.) nature, including adversely affecting the pupillary system (i.e., the pupillary light reflex, PLR).[1,2,6,7]

Thus, the purpose of the present investigation was to answer the following important basic and clinical question, that is, ''What influence does refractive error have, if any, on dynamic pupillary responsivity''. Furthermore, if there is an effect of refractive error on pupillary dynamics, does that effect also apply to the mTBI population, whose pupillary dynamics have been shown through objectively-based, infrared pupillometry to be adversely affected by the mTBI, i.e., slowed and delayed, and having a smaller baseline diameter.[2,6,7] This information is critical in the differential diagnosis between the two populations, as detailed in the Discussion section.

Please cite this article in press as: Truong JQ, et al. Influence of refractive error on pupillary dynamics in the normal and mild traumatic brain injury (mTBI) populations. *J Optom.* (2017), http://dx.doi.org/10.1016/j.optom.2016.12.005