Digital asthenopia: blue-blocking lenses and + 0,40D additional power in the near zone, for eye strain, accommodation and convergence functions

Astenopia digital: avaliação de lentes com filtro de luz azul e poder adicional de +0,40D na zona de perto, para fadiga visual e nas funções de convergência e acomodação

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ABSTRACT

Purpose: Evaluate blue-violet light filter and additional power of +0.40 D in the near zone ophthalmic lenses, on convergence, accommodative functions, and symptoms of digital asthenopia (DA).

Methods: Randomized study in cross-over design conducted on 49 volunteers (age, 29 ± 5.5 years; male: female, 18:31). Each subject wore test (+0.40 D in the near zone) and control lenses (regular single vision) for 4 weeks in randomized order. Both lenses had a selective blue-violet light filter. A baseline measurement was taken with the subjects' current updated glasses. Accommodation amplitude (AA) and near point of convergence (NPC) were measured binocularly with the RAF ruler. DA was evaluated by a questionnaire.

Results: No significant difference (p=.52) was found for AA comparing baseline (11.50±1.88 D), test (11.61± 1.62 D), and control SV lenses (11.88±1.50 D). No significant difference was found for NPC (p=.94), between baseline (6.50 ± 2.89cm), test (6.71± 3.49) and control SV lenses (6.82± 3.50 cm). No significant difference was found comparing test and control SV lenses in symptoms of DA (p=0.20).

Conclusions: The +0.40 D lenses have no negative impact on convergence or loss of accommodation power. The +0.40 D and control SV lenses had a similar impact on attenuating symptoms of DA.

RESUMO

Objetivo: Avaliar os efeitos do uso de lentes oftálmicas com filtro seletivo de luz azul-violeta, sem e com poder adicional de + 0,4D na zona de perto nas funções de acomodação e convergência e para sintomas de astenopia digital (AD).

Métodos: Ensaio clínico controlado, randomizado e mascarado, com 49 voluntários (idade, 29 ± 5,5 anos; masculino: feminino, 18: 31). Cada participante usou lentes de teste (+0,40 D na zona de perto) e controle (visão simples), por 4 semanas de forma randomizada. Ambas as lentes tinham filtro seletivo de luz azul-violeta. A medição inicial (baseline) foi feita com os óculos atualizados de cada participante. A amplitude de acomodação (AA) e o ponto de convergência próximo (PPC) foram medidos binocularmente com a régua RAF. A AD foi avaliada por um questionário.

Resultados: Não houve diferença estatisticamente significante (p=0,52) para as medidas de AA comparando as lentes baseline (11,50±1,88 D), teste (11,61±1,62 D) e controle VS (11,88±1,50 D). Nenhuma diferença significativa foi encontrada para a medida do PPC (p=0,94), entre as lentes baseline (6,50 ± 2,89cm), teste (6,71±3,49) e controle VS (6,82±3,50 cm). Nenhuma diferença significativa foi encontrada comparando lentes teste de VS e controle nos sintomas de AD (p=0,20).

Conclusões: As lentes com +0,40 D não têm impacto negativo na convergência ou na perda de acomodação. As lentes +0,40 D e controle VS, tiveram impacto semelhante na redução dos sintomas de AD.

INTRODUCTION

The ubiquitous use of technology and increasing exposure to modern lighting sources that emit relatively higher amounts of blue light than traditional light sources (e.g. light-emitting diodes – LEDs), has raised questions concerning the potential adverse effects of excessive exposure to short-wavelength visible light.[1] Developments in digital technology have led to an explosion in the use of electronic devices – computers, tablets, smartphones, or e-books – there is an increased effort for near vision, and all this entails: increased accommodation/convergence, increased visual attention, and decreased blinking with dry eye symptoms.[2] If this effort is pronounced and/or maintained failure of the adaptation mechanisms might occur, with the exhaustion of the ocular muscles (intrinsic and extrinsic muscles) and subsequent visual fatigue leading to the inability to accomplish the tasks that were intended.[2-4] On screens, characters are becoming smaller and more pixelated.[5] Eyes are exposed to the brightness of our screens for a longer time.[6,7] Symptoms related to digital asthenopia, such as sore eyes, eye fatigue, headaches, blurred vision, and dry eye, have been reported to affect up to 90% of computer users.[3] However, given the multifactorial nature of digital asthenopia, the relative contribution of blue light to digital asthenopia is difficult to ascertain.[8] In response, lenses with additional power in the near zone have been developed to relieve accommodative effort and improve performance in activities that require frequent use of near vision closely, as with users of digital screens.[9,10]

The purpose of the present study was to conduct a wearer test survey of users to evaluate the performance of blue – blocking and an additional power of +0.40 D in the near zone ophthalmic lenses and an anti-reflective coating directly on users and to determine their impact on the accommodation and convergence functions and in symptoms of digital asthenopia when using digital devices.

METHODS

This randomized study in cross-over design followed the tenets of the Declaration of Helsinki and was approved by the Research Ethics Committee of the Faculty of Medicine, *Universidade de São Paulo (USP), São Paulo (SP), Brazil* (CAAE: 87584318.1.3001.0065; October 16, 2018). Written Informed Consent was obtained from participants before their enrollment. The ophthalmic evaluation included slit-lamp microscopy, cover and cover-uncover tests, non-contact intraocular pressure measurement, ocular refraction under cycloplegia, corrected distance visual acuity, and indirect fundoscopy. The inclusion criteria were: healthy adults aged 20 to 39 years who spend more than 4 hours daily working on a video display terminal, and refractive errors with spherical components between ±4D and cylindrical between ±2.00D. The exclusion criteria were: active condition of an allergic, inflammatory, or infectious nature, on the ocular surface; users of medications that influence the vision and/or muscle function; contact lens wearers; strabismus and/or amblyopia; and anisometropia greater than 1.50D. Forty-nine eligible volunteers were recruited. Each subject wore test lenses (+0.40D in the near zone) and control single vision lenses, both lenses with a blue-violet blocking light filter and an anti-reflective coating, for 4 weeks each in randomized order. The subjects did not have a choice of frames: there was a model for men and another for women. Wearers were not aware of the benefits of the lenses or the name of the manufacturer to avoid introducing bias into their perception of the tested equipment. Accommodation amplitude and near point of convergence were measured binocularly using the push-up technique with the royal air force (RAF) ruler. An average of three measurements was taken for the analysis. Digital asthenopia was evaluated using a modified version of the questionnaire developed by Ames et al.[11] (Table 1). This questionnaire consisted of ten questions related to asthenopia graded on a scale from zero to six, with zero defined as none and six as most severe; a score of 60 corresponds to the most severe asthenopia. A baseline measurement was taken with the subjects' current updated glasses and then after wearing either the test lenses or control lenses. Statistical analyses were performed using R Studio Program ver. 1.2.5001 (RStudio, Boston, MA, United States). Repeated measures analysis of variance (Anova) was used to compare the accommodation amplitude and near point of convergence measurements after wearing the test lenses, control lenses, and baseline. Since the assumption of normality was rejected (Shapiro-Wilk test), comparisons of both lenses concerning asthenopia scores were made with the non-parametric Wilcoxon test and p-values less than 0.05 were considered statistically significant.

Table 1. Astenopia questionnaire form

Symptom	None	Slight	Moderate	Severe
Tired eye	0	1.2	3.4	5.6
Sore/aching eye	0	1.2	3.4	5.6
Irritated eye	0	1.2	3.4	5.6
Watery eye	0	1.2	3.4	5.6
Dry eye	0	1.2	3.4	5.6
Eyestrain	0	1.2	3.4	5.6
Hot/burning eye	0	1.2	3.4	5.6
Blurred vision	0	1.2	3.4	5.6
Difficulty in focusing	0	1.2	3.4	5.6
Visual discomfort	0	1.2	3.4	5.6

Source: modified from the original version proposed by Ames et al.[11]

RESULTS

The mean age of the participants was 29.07±5.5 years (20 to 39 years), being 31 (63%) females. Concerning the educational level, 45 (92%) were college or above. Thirty-six (73%) subjects reported three or more digital devices viewed simultaneously in daily life, while 42 (86%) reported everyday computer use for more than 6 hours.

No significant difference (p=0.52) was found for accommodation amplitude at baseline (11.50±1.88D) and after 4 weeks of wearing +0.40D lenses (11.61±1.62D) or control lenses (11.88±1.50D). Similarly, the changes in near point of convergence, between baseline (6.50±2.89cm) and measurement 4 weeks later wearing +0.40 D lens (6.71±3.49) or control lenses (6.82±3.50cm) were statistically insignificant (p=0.94) (Table 2).

Table 2. Accommodation amplitude and near point of convergence: baseline measurement was taken with the subjects' updated current glasses. Other measurements were taken after wearing the control lenses or +0.40D in the near zone (n=49)

Measurements	At baseline current lenses	Control lenses	+0.40 in the near zone lenses	p-value*
AA, D	11.50±1.88	11.88±1.50	11.61±1.62	0.52
NPC, cm	6.50±2.89	6.82±3.50	6.71±3.49	0.94

Results presented as mean ± standard deviation.
* Analysis of variances for repeated measures.
AA: accommodation amplitude; NPC near point of convergence.

The total asthenopia score for digital asthenopia at baseline was 17.61±5.51 considering a maximum possible score of 60. In relation to baseline, after 4 weeks of wearing test lenses (+0.40D in the near zone) and controls, both lenses attenuated significantly digital asthenopia symptoms (p=0,000 and p=0,03, respectively). However, the comparison between the test lenses and controls did not reveal significant differences in the values of the total asthenopia scores (p=0.20) and between the mean scores of each of the symptoms of digital asthenopia (Table 3).

Table 3. Changes in asthenopia questionnaire responses after 4 weeks of control lenses or +0.40D in the near zone lenses wearing (n=49)

Symptom	Control lenses	+0.40D in the near zone lenses	p-value*
Tired eye	2.22±1.12	2.10±1.46	0.64
Sore/aching eye	1.22±1.19	1.22±1.31	0.86
Irritated eye	1.36±1.36	1.34±1.46	0.77
Watery eye	1.10±1.43	1.14 ±1.48	0.83
Dryness	1.12±1.37	1.04± 1.25	0.94
Eye strain	2.34±1.76	1.85±1.84	0.17
Hot/burning eye	0.46±0.79	0.55±1.10	0.83
Blurred vision	0.98±1.29	0.65±1.07	0.15
Difficulty in focusing	1.57±1.36	1.41±1.42	0.47
Visual discomfort	1.37±1.53	1.20±1.58	0.56
Total	13.78±7,51	12.53±10.28	0.20

* Wilcoxon test.
Results presented as mean ± standard deviation.

DISCUSSION

This study included healthy adult volunteers 20 to 39 years old engaged in 4 or more hours of daily near work computer screen watching. Eighty-five percent (85%) of them reported daily computer use for more than 6 hours. Previous studies have shown that computer use for more than 4 hours at a time can increase eye discomfort substantially.[12,13] Digital asthenopia is a multifactorial condition with several potential contributory causes, such as uncorrected refractive error, oculomotor diseases, tear abnormalities, and/or musculoskeletal problems.[2-4,6,14]

With the use of lenses with additional power in the near zone to relieve symptoms of digital asthenopia, one of the questions is how these lenses would affect or not the wearer's binocular vision. Accommodation amplitude and near point of convergence were measured before (baseline measurement was taken with the subject's updated current glasses) and after wearing +0.40D lens and control lenses for 4 weeks each in randomized order. There were no significant differences in accommodation amplitude and NPC between measurement baseline with their current glasses and after 4 weeks of wearing +0.40D lenses or control lenses. These results reaffirmed that the use of +0.40 D lenses for 4 weeks has no negative impact on convergence, "lazy accommodation" or loss of accommodation power.[15,16]

Concerning the total asthenopia score baseline taken with the subject's updated current glasses, it was significantly attenuated after 4 weeks of wearing control single vision lenses or +0.40D lenses, each in randomized order.[17,18] There is currently a relative paucity of clinical evidence to support many claims surrounding the deleterious effects of blue-light exposure.[19] Although ocular discomfort symptoms have been long associated with computer and video display terminal use,[20,21] the relative contribution of blue light per se (rather than other potential causative factors, such as binocular vision anomalies, postural factors, and/or tear film dysfunction) remains unclear.[19] However, in this investigation, the subjects had their refractive errors properly corrected and did not present oculomotor diseases or accommodative or converge problems.

On digital screens, the characters are getting smaller and more pixelated, and the eyes are constantly more exposed to the bright light.[5,22] The rationale for claims that blue-light filtering lenses attenuate digital asthenopia is based upon the premise that modern digital devices that emit relatively higher amounts of blue light are frequently being used for several hours per day and many device users experience ocular discomfort.[19,22,23] Given that there is a correlation between discomfort glare sensitivity and brightness sensitivity with blue LEDs,[24] a potential mechanism may involve a reduction in discomfort glare from a LED-backlit display.[19,24] The two lenses tested presented a filter against blue-violet light and an anti-reflective coating. Spectacle blue-violet light filtering lenses reduce screen brightness,[25] block harmful blue light,[26,27] and do not significantly affect visual performance.[22] This selective blue-violet filter present in the tested and control lenses reduces the quantity of blue-violet light (415nm to 455nm) reaching the eye by 20% and allows beneficial light to pass through (visible light, including blue-turquoise).[25] Lenses with more than 70% of blue-light transmission do not significantly affect contrast sensitivity, color vision, and visual performance.[22]

However, the comparison between +0.40D lenses and control lenses did not reveal significant differences in the values of the total asthenopia scores (p-value = 0.20) and between the mean scores of each of the symptoms of digital asthenopia. This knowledge can inform clinical practice guidelines relating to the prescription of selective blue-violet light filtering spectacle lenses with an anti-reflexive coating to attenuate symptoms of digital asthenopia.

One limitation of this study was the evaluation of digital asthenopia using a questionnaire since the responses are somewhat subjective and can be affected by responders' daily physical and mental conditions.[28]

CONCLUSION

The +0.40 D lenses have no negative impact on convergence, or loss of accommodation power. The +0.40 D and control SV lenses had a similar impact on attenuating symptoms of DA.

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