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NARRATIVE LITERATURE REVIEW

Time outdoors, exposure to violet light and prevention of myopia in children

Tempo em ambiente externo, exposição à luz violeta e prevenção da miopia em crianças

Tiempo en ambiente externo, exposición a la luz violeta y prevención de la miopía en niños

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ABSTRACT
Prevalence of myopia is increasing worldwide. Epidemiological evidence suggests that children who spent more time outdoor are less likely to be or become myopic. It has been suggested that the mechanism of the protective effect of time outdoors involves light-stimulated released of dopamine from the retina, since increase of dopamine inhibits eye growth. On the other hand, too, it has been suggested that the absence of light violet (LV) in our industrialized world is a major contributing factor responsible for the recent epidemic increase in myopia. However, there is a lack of convincing evidence that the LV, in fact, suppressed myopia progression.

Keywords: Myopia; Environment; Illuminance; Dopamina; Violet Light.

RESUMO
A prevalência de miopia está aumentando em todo o mundo. Evidências epidemiológicas sugerem que as crianças que dispensam mais tempo em ambientes externos ou ao ar livre são menos propensas a se tornarem míopes. Tem sido sugerido que o efeito protetor do tempo dispensado em ambiente externo envolve a liberação estimulada por luz de dopamina pela retina, uma vez que a dopamina inibe o crescimento ocular. Por outro lado, foi sugerido que a ausência da luz violeta (LV) em nosso mundo industrializado é o principal fator responsável pelo incremento atual da miopia. No entanto, faltam evidências convincentes de que a LV, de fato, previne a progressão da miopia.

Palavras-chave: Miopia; Ambiente Externo; Iluminação; Dopamina; Luz Violeta.

RESUMEN
El predominio de miopía se está incrementando en todo el mundo. Evidencias epidemiológicas sugieren que los niños que pasan más tiempo en ambientes externos o al aire libre son menos propensos a volverse miopes. Se ha sugerido que el efecto protector del tiempo dispensado en ambiente externo involucra la liberación estimulada por luz de dopamina por la retina, una vez que la dopamina inhibe el crecimiento ocular. Por otro lado, se ha sugerido que la ausencia de la luz violeta (LV) en nuestro mundo industrializado es el principal factor responsable del incremento actual de la miopía. Sin embargo, faltan evidencias convincentes de que la LV, de hecho, previene la progresión de la miopía.

Palabras Clave: Miopía; Ambiente Externo; Iluminación; Dopamina; Luz Violeta.

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1. MYOPIA

Myopia is commonly considered a benign disorder because vision can be corrected with glasses, contact lenses, and refractive surgery[1]. We are currently experiencing a disconcerting surge in the prevalence of myopia in East Asia, with 80%-90% of university students suffering from myopia, of whom 20% or more already manifest pathological myopia[1-4]. The increased prevalence of myopia in this part of the world has been associated with the increase in educational pressure and lifestyle changes, including less time spent outdoors[2-6]. The same phenomenon has been observed in other parts of the world, but to a lesser extent[7].

One of the side effects of this epidemic is the substantial increase in the number of people with pathological myopia and therefore liable to develop various eye conditions that may lead to vision loss or irreversible blindness8 which, unfortunately, cannot be prevented by vision correction[9]. The prevalence of low vision attributable to pathological myopia is 0.2%-1.4% in Asian populations[9].

The increased prevalence of myopia worldwide has been generating significant demands on public health and arousing considerable interest in the adoption of interventions to prevent its onset or control its progression in school-age children. Studies have so far focused on the optical properties of the eye, the use of pharmacological agents and the modification of environmental factors[10]. The use of corrective lenses has not been particularly effective at controlling the progression of myopia[11]. The topical application of 0.01% atropine seems to be the most promising intervention at present, but its widespread use is limited by side effects and compliance issues[12].

2. OUTDOOR ENVIRONMENT

Epidemiological studies suggest that increased time spent outdoors is associated with a lower risk of myopia progression in children and adolescents[6,10,13-15]. There is evidence that it also exerts protective action against the progression of myopia in children who are already myopic[9,16].

Studies in animal models (in chicks, treeshrews, and monkeys) suggest that eyes exposed to high levels of illumination (1,000-10,000 lux) remain more hypermetropic than eyes exposed to lower levels of illumination (500 lux). This refractive difference results from the fact that eyes submitted to higher levels of illumination remain hypermetropic with stable refraction, whereas those exposed to lower levels of illumination present deviations towards emmetropia[17].

Most of the studies that evaluated the mechanism of emmetropization in animal models (in chicks, treeshrews, and monkeys) of myopia triggered by visual deprivation and/or negative lenses used very low levels of illumination (100-500 lux). The exposure of these animals to higher levels of illumination (15,000-28,000 lux) reduced the rate of progression of myopia caused by visual deprivation, negative lenses or both[17].

Several mechanisms have been suggested to explain the protective effect of the outdoor environment against the progression of myopia in children. There seems to be no doubt that the role played by very close objects, small pupils, and elevated serum levels of vitamin D17 is minimal. On the other hand, it is known that under light stimulation, retinal neurons release dopamine (activation of dopaminergic pathways)[18]. Dopamine activity (synthesis, turnover, and release) is higher during the day and lower at night (circadian rhythm)[18]. Dopaminergic activation has been implicated in the development and control of the progression of myopia in animals[19] and in children[20]. Outdoor levels of illumination could act as a continuous variable: high levels of illumination would be associated with the stimulation of D1R receptors and low levels of illumination with the stimulation of D2R[21] receptors. The balance between the activation of these retinal receptors would modulate the refractive development of the eyes in such a way that activation of the D1R receptors would cause them to remain hypermetropic, whereas activation of the D2R receptors would produce myopia[21].

3. VIOLET LIGHT

A recent study by Torii et al[22] showed that violet light (VL) with a wavelength of 360-400 nm suppressed the progression of myopia in chicks with myopia induced by visual deprivation and hyperopic defocus caused by 9.00 D lenses, and also activated the myopia suppressor gene (EGR1). In this study, the transmission of VL through ophthalmic lenses (glasses) and contact lenses suppressed the progression of myopia in myopic children. The authors concluded from their study that artificial lighting should be revised to include a UV component, as in sunlight.

Schaeffel and Smith III[23] considered the proposal of Torii et al.[22] provocative, since exposure to short-wavelength light has been the subject of research for decades, and it is known to induce photo-oxidation and retinal degeneration[24].Schaeffel and Smith III[23] pointed out important limitations in the study by Torii et al[22]. The fact that the 9.00 D lenses were glued and did not allow removal for cleaning favored the buildup of dirt, compromising the optics and resulting in blurring effects that interfered in the results of the experiments. It is well established in several species, including chicks, that the magnitude of induced axial myopia is directly related to the degree of degradation of the image produced by diffusing lenses[23]. Schaeffel et al[25]. emphasized that in contrast to humans, the ocular optical media of chicks transmit UV light up to at least 350 nm, and that there are UV receptors in the retina of these animals, so the finding of the VL-regulated gene was not unexpected. To further challenge the findings that myopia progression in schoolchildren was influenced by VL transmission, Schaeffel and Smith III[23] found that students in the control group who used VL-blocking lenses were the youngest and the most myopic. Therefore, it seems very reasonable to argue that the onset of myopia in these students would have occurred earlier, and therefore the rate of myopia progression in these subjects was higher than in the students in the "experimental" groups. Thus, it came as no surprise that the eyes of the students in the control group showed slightly greater increases in their axial lengths.[25] A randomized controlled clinical trial would be the gold standard for these types of analysis.[25] Tsubota[26] responded to all of these queries by stating that he appreciated the interest in and constructive comments about his study, and that he would like to try to obtain further evidence to establish the hypothesis that VL prevents the progression of myopia.

The effects of spectral light distribution on the development of myopia remain an important topic.[23] In monkeys[27] and treeshrews,[28] long wavelength light (> 650 nm, red) acts as a strong inhibitor of eye growth, contrary to the effect observed in chicks.29 The role proposed role for VL in controlling the progression of myopia has not yet been proven entirely convincing, and further studies are needed in humans or monkeys to justify the fact that artificial lighting should be revised to include a UV component, as in sunlight[23].

4. FINAL CONSIDERATIONS

The determinant causes of the onset and progression of myopia are multifactorial[30]. Evidence shows that environmental factors override genetic factors[31]. The relationship between higher levels of education and the development of myopia is not yet well understood[30]. However, Verhoeven et al.[32] showed that individuals with a higher genetic risk (myopic parents) are more susceptible to myopia when exposed to higher education.

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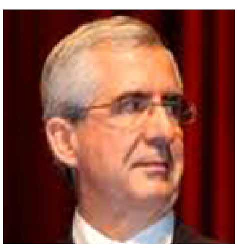

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