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Impact of digital screen use and lifestyle factors on dry eye disease in the paediatric population: Secondary analysis of a cross-sectional study

Michael T.M. Wang, Jennifer P. Craig, Maria Vidal-Rohr, Francesco Menduni, Sandeep Dhallu, Tugce Ipek, Duygu Acar, Alberto Recchioni, Alex France, Alec Kingsnorth, Sophie Speakman, James S. Wolffsohn

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Research correspondence title: Impact of digital screen use and lifestyle factors on dry eye disease in the paediatric population: secondary analysis of a cross-sectional study

Short title: Digital screen use and paediatric dry eye disease

Authors:
Michael T. M. Wang,[1] Jennifer P. Craig[1,2], Maria Vidal-Rohr,[2] Francesco Menduni,[2] Sandeep Dhallu,[2] Tugce Ipek,[2,3] Duygu Acar,[2] Alberto Recchioni,[2,4] Alex France,[5] Alec Kingsnorth,[2] Sophie Speakman,[1] James S. Wolffsohn[2]

Corresponding author:
Associate Professor Jennifer P. Craig
Department of Ophthalmology
New Zealand National Eye Centre
The University of Auckland, New Zealand
Private Bag 92019
Auckland 1142
New Zealand

Phone: +64 9 923 8173
Fax: +64 9 367 7173
Email: jp.craig@auckland.ac.nz

Author institutions:
[1] Department of Ophthalmology, New Zealand National Eye Centre, The University of Auckland, New Zealand
[2] Optometry and Vision Sciences, College of Health and Life Sciences, Aston University, Birmingham, UK
[3] Centre for Craniofacial Biology and Regeneration, King's College London, London, UK
[4] Academic Unit of Ophthalmology, Institute of Inflammation and Ageing, University of Birmingham, Birmingham and Midland Eye Centre, Birmingham, UK
[5] Thea Pharmaceuticals, UK

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Research correspondence

Dry eye disease is a common chronic ophthalmic condition, which is recognised to have significant public health and financial burden globally.[1] Digital screen use has been identified as a modifiable risk factor for dry eye disease in a number of previous adult population epidemiological studies.[1, 2] However, there is growing concern that the increasing trend towards widespread digital screen use among the paediatric population in recent decades, might be associated with adverse impacts to ocular surface health.[3-5] The purpose of this secondary analysis of a large cross-sectional study was therefore to investigate the impact of digital screen use and lifestyle factors on dry eye disease within the paediatric age group.

The study received institutional ethics committee approval and adhered to the tenets of the Declaration of Helsinki. Participants were recruited through open advertisement from visitors at the Royal Society Summer Science Exhibition between July 2 and July 8, 2018 in London, United Kingdom, and paediatric participants aged 16 years and under were included in this secondary analysis. Parents or guardians of participants provided informed consent electronically after reviewing the study information. The sample size was pragmatically determined by the number of participants enrolled during the recruitment period.

Participants were assessed at a single location, and ocular surface parameters were assessed on the left eye of each participant using the Keratograph 5M (Oculus Optikgeräte GmbH, Wetzlar, Germany). The diagnostic criteria for dry eye disease required a Dry Eye Questionnaire (DEQ-5) score ≥6 and a non-invasive tear film breakup time <10s. The criteria were adapted from the rapid non-invasive dry eye assessment algorithm, which has been previously validated and demonstrated high diagnostic consistency with the global consensus TFOS DEWS II criteria,[6] although the DEQ-5 questionnaire from the original TFOS DEWS II battery was retained for the symptomology arm of the diagnostic criteria. A

lifestyle factor questionnaire was administered and answered by participants, with the assistance of parents or guardians as required, with questions investigating risk factors identified in previous epidemiology studies,[1, 2] including contact lens wear, the average hours per day of digital screen exposure, exercise, outdoor activity, and sleep. Participants were asked to rate self-reported diet quality on a 4-point scale (from 1 – poor diet quality to 4 – excellent diet quality); self-reported psychological stress burden on a 4-point scale (from 1 – minimal stress burden to 4 – high stress burden); and self-perceived health status on a 4-point scale (from 1 – poor health status to 4 – excellent health status). Preliminary univariate logistic regression was used to identify potential predictors of dry eye disease. Multivariate logistic regression for predictors of dry eye disease was then conducted, incorporating variables with a univariate association threshold of $p<0.15$. The number of variables used in the multivariate regression analysis was limited to the number of diagnosed participants divided by 10, to avoid overfitting. All tests were two tailed, and $p<0.05$ was considered significant.

The mean ± SD age of the 446 participants (293 females, 152 males, 1 other sex) was 13±2 years (range, 5 to 16 years). Overall, 80 (18%) participants fulfilled the diagnostic criteria for dry eye disease. The median (IQR) digital screen exposure time was 4 (2-5) hours per day, and the median (IQR) amount of sleep was 8 (7-9) hours per day. Unadjusted univariate and multivariate-adjusted odds ratios of dry eye disease are presented in Table 1. Multivariate logistic regression analysis of the cohort of 446 participants demonstrated that greater screen exposure time (per hour each day) was independently associated with increased odds of dry eye disease (OR=1.15; 95% CI, 1.02 to 1.29; p=0.02), while increased sleep (per hour each day) was protective (OR=0.73, 95% CI, 0.58 to 0.91; p=0.006).

Table 1: Logistic regression odds ratio of dry eye disease by demographic and lifestyle factors. Asterisks denote statistically significant values (p<0.05).

Characteristic	Unadjusted univariate logistic regression		Multivariate-adjusted logistic regression	
	OR (95% CI)	p	OR (95% CI)	p
Demographics				
Age (per year)	1.23 (1.06-1.43)	0.006*	1.11 (0.94-1.32)	0.21
Female versus male sex	1.08 (0.64-1.87)	0.78	-	-
East Asian versus White ethnicity	2.07 (0.76-5.61)	0.16	-	-
South Asian versus White ethnicity	1.68 (0.80-3.52)	0.17	-	-
Black versus White ethnicity	1.48 (0.49-4.45)	0.48	-	-
Lifestyle factors				
Contact lens wear	1.20 (0.50-2.89)	0.68	-	-
Outdoor activity (per hour each day)	1.06 (0.95-1.18)	0.29	-	-
Exercise (per hour each day)	1.05 (0.96-1.14)	0.25	-	-
Digital screen exposure time (per hour each day)	1.19 (1.07-1.33)	0.001*	1.15 (1.02-1.29)	0.02*
Sleep (per hour each day)	0.65 (0.53-0.80)	<0.001*	0.73 (0.58-0.91)	0.006*
Self-reported diet quality (per score)	0.79 (0.55-1.14)	0.20	-	-
Self-reported psychological stress burden (per score)	1.22 (0.88-1.69)	0.24	-	-
Self-perceived health status (per score)	0.82 (0.58-116)	0.26	-	-

The findings of this study demonstrated that greater digital screen exposure was associated with higher odds of dry eye disease, while increased sleep was a protective factor. Each hour of increased digital screen exposure per day was associated with a 15% increased odds of dry eye disease. These trends are comparable with those reported in previous adult population epidemiological studies,[1, 2] and future research is required to investigate whether limits placed on digital screen exposure time each day might potentially be effective in preventing the development of dry eye disease. The association between digital screen exposure and dry eye disease is thought to be mediated by the suppression of spontaneous and reflex blinking during tasks requiring significant levels of cognitive loading and visual processing.[1, 2] The consequent reduction in blink rate and completeness can diminish the delivery of meibum to the lid margin, and predispose towards the development of evaporative dry eye disease and meibomian gland dysfunction.[2] Moreover, up-gaze occurring when using desktop monitors can also increase the exposed ocular surface area during the inter-blink interval, further promoting aqueous tear evaporation and ocular surface desiccation.[2] Preliminary adult studies have demonstrated that blink training can improve tear film lipid layer quality, and future studies are required to confirm the clinical efficacy of blink training in the paediatric age group.

In the current study, each hour of increased sleep per day was associated with a 27% decreased odds of dry eye disease. These findings are in agreement with previous adult cohort observational studies,[7] and future studies are required to evaluate whether improved sleep habits might confer a protective effect towards the development of dry eye disease. The precise mechanisms underlying the protective effects of sleep remains yet to be fully understood. Reduced sleep duration is thought to cause increased levels cortisol, adrenaline and noradrenaline, as well as decreased androgen production and parasympathetic tone, and thereby diminish aqueous tear production in the lacrimal glands.[7] Sleep deprivation could also alter circadian patterns of the hypothalamic-pituitary-

adrenal axis and the renin-angiotensin-aldosterone system, leading to increased diuresis, natriuresis and dehydration, which might also downregulate aqueous tear production.[7]

This study is not without limitations. The convenience sample based on visitors to a scientific exhibition might lead to selection bias, and the open advertisement recruitment process can be associated with volunteer bias. In addition, lifestyle factors were self-reported by participants and/or parents and guardians, which may lead to recall bias.

In conclusion, this study showed that greater digital screen exposure was a risk factor for dry eye disease, while increased sleep was a protective factor. The identification of modifiable risk factors of dry eye disease in the current paediatric cohort might inform the design of future interventional studies evaluating the efficacy of associated preventative strategies.

Disclosure statement

The authors have no commercial or proprietary interest in any concept or product described in this article.

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