


DIGITAL EYE STRAIN: CAUSES, CONSEQUENCES AND CLINICAL CARE

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1

Digital eye strain- Definition

▶ Digital eye strain is a condition characterized by **visual disturbance** and/or **ocular discomfort** related to the use of **digital devices** and resulting a range of stresses on ocular system, including **glare, defocus, accommodation dysfunction, fixation disparity, dryness, fatigue and discomfort.**


Hall L, Coles-Brennan C Contact Lens Spectrum 2015
Coles-Brennan C et al., Clinical and Experimental Optometry 2019

2

Excessive Screen time & Digital eye strain

- ▶ 2016 – statistics 5.6 hours per day (average adult American)....
- ▶ Fast track to COVID times... Do you think that is increased?
- ▶ Screen time has increased so much that smart devices and software provide cumulative screentime. Number of time used etc.
- ▶ We pick up smart phones 96 times per day

3



Screen time in 2020

Americans devote 10+ hours a day looking at screens

- ▶ Increased screen time in response to pandemic
 - ▶ Kids' screen time limits = out the window; a shocking 500% increase in screen usage
 - ▶ Twitter poll reported an average increase in adult screen time of 50-100%
- 86% of the average American's free time is spend looking at screens
- National Sleep Foundation reports screen time adversely affects circadian rhythm, suppressing the body's release of melatonin and increasing cortisol

4

End of COVID!!??




5




COVID or not, our workplace....

6

Excessive Screen time & Digital eye strain

- ▶ This is unlikely to decrease unless a conscious choice is made
 - ▶ Or
- ▶ We come up with techniques that will diagnose and manage this burden appropriately

7

“ So, what's the big deal with digital eye strain ? ”

8

We live a life on screens

9

So what's the big deal? Continued...

AGE	SCREEN TIME	Screen time Linked to:
2	42 minutes	Obesity
2-4	160 minutes	Headaches
5-8	3 hours	Eye strain
8-12	6 hours	Myopia
13-18	9 hours	Difficulties with Sleep

10

Prevalence of digital eye strain

- Wide range due to differences in study populations and methodology
- 25 to 93 percent adults
- Likely to increase and affect younger population
- COVID era working style likely to continue for a while

11

Digital eye strain Vs. Computer vision syndrome

- ▶ They both refer to ocular visual and non ocular symptoms related to use of visual display units
- ▶ Computer usage had few constants – distance of use
- ▶ Today we are bombarded with digital displays
 - ▶ Computer- dual or triple monitors, tablets, smart phones, watches, virtual reality headsets, video games, handheld video games... list goes on and on...
- ▶ So, a fair question is are they the same?

12

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Effects of Digital devices on the eye

”

13

General considerations

- ▶ Not all discussed points are confirmed in all studies
- ▶ There could be different issues related to individuals not all symptoms in everyone
- ▶ Symptoms and signs may not correlate
- ▶ Usually, patient has put up with this for a while before contacting you

14

Accommodation Lag

- ▶ Several studies have concluded that smart phone users have a lag of accommodation after use.
- ▶ Reading smartphones versus printed text has shown greater lag at 35-40 cms
- ▶ Both digital tablets and smart phones produced similar response
- ▶ Technique related issues like monocular estimation method versus objective auto-refractors can possibly explain the differences

15

Accommodation facility issues

- ▶ Previous studies have shown reduced accommodative facility can lead to blurred vision
- ▶ Smart phones and iPad etc. are often used in concurrently with other devices- **AKA multitasking**
- ▶ Viewing multiple targets at multiple distances puts lot of demand in **requiring good accommodative facility**
- ▶ Studies have shown mixed results
- ▶ It could be a **cognitive fatigue/demand** issue rather than digital devices

16

Amplitude of accommodation

- ▶ Subjective methods not very accurate and objective methods are needed
 - ▶ Why? Subjective methods are based on stimulus location not accommodative response
- ▶ Subjects using computers or iPad show decreased accommodative response after 20 minutes of use
- ▶ Changes range in magnitude of about 1D
- ▶ Most studies have used subjective methods

17

Summary of accommodative changes



Reduced amplitude



Increased lag in accommodation



Need studies correlating symptoms with these anomalies observed

18

Vergence, NPC and Phoria

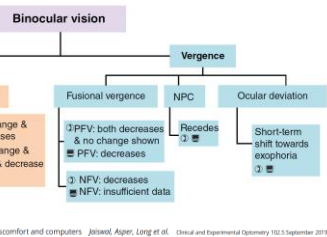
- ▶ Convergence and accommodation work together for near
- ▶ Literature much more in computer use rather than handheld digital devices
- ▶ Both convergence and divergence is reduced when using computer whereas, another study has shown no changes
- ▶ Near point of convergence is also receded with used of handheld digital devices
- ▶ But... working distance get shorter with time...!

19

Vergence, NPC and Phoria cont...

- ▶ Tendency towards exophoria with use of handheld digital devices
- ▶ Overall, conflicting reports

20



21

Digital devices & anterior segment

- ▶ Digital devices can indeed influence blinking patterns
- ▶ Contribute to ocular discomfort, stinging, burning, foreign body sensation and dryness
- ▶ Longer use associated with greater symptoms

22

Blink rate

- ▶ Blink rate is consistently shown to be decreased with computers
- ▶ Blink rate is task dependent and more difficult the task lower the blink rate
- ▶ Complex gaming decreased severely – 400 decisions/min
- ▶ Greater the inter-blink rate, greater the evaporation of tears and thus increased ocular surface discomfort.
- ▶ Not all studies have shown decrease blinking with handheld devices

23

Blink rate and gaze angle

- ▶ More forward the gaze greater the palpebral fissure
- ▶ The more downward gaze smaller the fissure but may also lead to greater inter blink rate
- ▶ Handheld devices are used in various gazes and body positions

24

Blink amplitude

- ▶ Incomplete blinks/ partial blinks with digital devices compared to print copy
- ▶ This field is not well investigated for handheld digital devices.
- ▶ We don't have good/ affordable clinical devices that can assess this...

25

Tear film issues

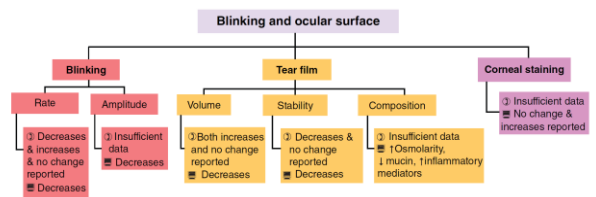
- ▶ Volume of tear film is shown to decreased with using computers
- ▶ Tear film volume increased during gaming!!!!
- ▶ Reduced TBUT after 60 minutes of use of tablets
- ▶ Children that used smart phones less had better TBUT
- ▶ Children that had dry eyes showed improvement in TBUT when smartphone use was stopped

26

Tear film composition

- ▶ Reduced mucin production and increased inflammatory markers with excessive computer use
- ▶ This was seen in individuals that used versus not and also seen in greater use (8 hours) versus lesser (5 hours)
- ▶ Tear osmolarity increased after 7 hours of use

27



Visual discomfort and computers Jäskel, Aap, Long et al. Clinical and Experimental Optometry 102:5 September 2019

28

Non ocular symptoms

- ▶ Asthenopia/Headaches
- ▶ Neck pain
- ▶ Computers upward gaze, tablets phone straight ahead or downward gaze
 - ▶ Adolescents using 14 hours or greater have neck pain, shoulders, hand, wrist and lower back pain

29

Sleep disturbances

- ▶ Sleep disturbances
 - ▶ disruption of the circadian rhythm, particularly in the secretion of melatonin, which controls sleep

Evening use of light-emitting eReaders negatively affects sleep, circadian timing, and next-morning alertness

Anne-Marie Chang^{ab,1,2}, Daniel Aeschbach^{ab,x}, Jeanne F. Duffy^{ab}, and Charles A. Czeisler^{ab}

www.pnas.org/cgi/doi/10.1073/pnas.1418400112

PNAS

30

Current management strategies

31

General rules

- ▶ Comprehensive exams rule out other issues
- ▶ Fix any issues that a patient may have-
 - ▶ subclinical dry eye,
 - ▶ small refractive error,
 - ▶ early presbyopia,
- ▶ uncorrected hypermetropia,
- ▶ Convergence
- ▶ Accomodation and vergence issues

32

Visual acuity considerations



Visual acuity should be much better than demand

Rule of thumb – twice or three times better



Especially digital small handheld devices like phones have much smaller font



Review this with your patient

33

Working distance considerations

- ▶ One in five individuals hold the handheld devices <30 cms
- ▶ Prolong reading on handheld devices leads to even shorter working distance
- ▶ No set working distance for all, play with font size and working distance in combination

34

Lighting levels

- ▶ People read often in **dark or poor lighting** with digital devices as they are **self illuminated**
- ▶ Illuminating engineering society recommends that the ratio of task versus surroundings not to exceed 3
- ▶ Show patients what glare free and good illumination looks like
- ▶ Anti-glare lenses helps a lot

35

Blue blocking lenses

- ▶ Very weak evidence that they help....
- ▶ In fact more evidence that they don't do much more than a placebo effect



36

ORIGINAL INVESTIGATION

Blue-blocking Filters and Digital Eyestrain

Tatsiana Palavets, BA¹ and Mark Rosenfield, MCOptom, PhD, FAAO^{1*}

CONCLUSIONS: A filter that eliminated 99% of the emitted blue light was no more effective at reducing symptoms of DES than an equiluminant ND filter. There is little evidence at this time to support the use of BB filters to minimize near work-induced asthenopia.

Optom Vis Sci. 2021;98(6):68-74. doi:10.1097/OPT.0000000000001318
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Supplemental Digital Content: Direct URL links are provided within the text.

37

Ergonomics

- Holistic approach to visual and ocular hygiene
- Frequent breaks
- Doing a different activity that involves physical movement
- Avoiding multi-tasking

38

“ Can nutrition play a role in amelioration of Digital Eye Strain? ”

39

Can omega -3 help in dry eye issues

- There is plenty evidence about the benefits of omega in general health
- There is plenty evidence of omega helping mild to moderate dry eyes
- Dream study ?
Moderate – severe dry eyes

40

Screen time stress, Carotenoids and Cognitive performance

41

Carotenoids

750 in nature

-50 in diet

-20 in blood

Lutein and zeaxanthin concentrate in the eye

2 carotenoids

42

Carotenoids in retina-Xanthophylls

dietary xanthophylls

Lutein

Zeaxanthin

non-dietary xanthophyll

meso-Zeaxanthin

Ratio of Zeaxanthin to Lutein

Dietary Intake Serum Central Fovea

Photomicrograph courtesy of Dr. Joanne Curran-Coleman.

Nutrients 2028, 12, 1330. doi:10.3390/nu12051330

43

Carotenoids food sources

Foods	Serving Size	Lutein + Zeaxanthin Content (mg)
Spinach, frozen (cooked)	1 cup	29.8
Kale, frozen (cooked)	1 cup	25.6
Swiss chard (cooked)	1 cup	11.0
Collard greens, frozen (cooked)	1 cup	8.9
Summer squash (cooked)	1 cup	4.0
Peas, frozen (cooked)	1 cup	3.5
Brussel sprouts, frozen (cooked)	1 cup	2.4
Broccoli, frozen (cooked)	1 cup	2.0
Edamame, frozen	1 cup	1.6
Sweet yellow corn (boiled)	1 cup	1.5
Asparagus (boiled)	0.5 cup	0.7
Avocado, raw	1 medium-size	0.4
Egg yolk, raw	1 large	0.2

Meso-zeaxanthin is not found in common food: in shrimp shells, turtle fat, and fish skin
 Lem, D.W., Clehant, D.L., Davy, P.G. A Systematic Review of Carotenoids in the Management of Diabetic Retinopathy. *Nutrients* 2021, 13, 2441. <https://doi.org/10.3390/nu13072441>

44

Common misconceptions with carotenoids

- ▶ Carotenoids are only present in macula
- ▶ Present throughout retina
- ▶ Carotenoids are only useful for vision
- ▶ Deposited in lens, brain, skin, adrenal glands

45

Cognition and MPOD Children and Adults

46

Brain carotenoid profile in infants and centenarians

Infant Brain (n=30)

Vishwanathan et al. 2014

Centenarian Brain (n=48)

Johnson EJ et al. 2013

47

Correlation – Human retina and occipital cortex concentrations of lutein and zeaxanthin, have an amazingly strong correlation

	r	P value
Bivariate	0.784	0.004
Age & sex adjusted	0.834	0.010
Age, sex & cognitive status adjusted	0.887	0.008

Macular pigment carotenoids = Lutein (Meso-zeaxanthin) + Zeaxanthin in the retina
 Vishwanathan R, Schaich W, Johnson E J *J Nutr Neurosci*. 2016;19(3):95-101.

48

MPOD is a Biomarker

PG Davey et al. Differences in macular pigment optical density across ethnicities: A comparative study *The Advances in Ophthalmol 2020*

49

Clinical devices

QuantifEye- Zeavision

MapCATSF- Guardian health

50

Measurement of Macular Pigment Optical Density

Heterochromatic flicker Photometry- principle

- Macular pigment absorbs blue light (not green light)
- More macular pigment = longer time you see flicker
- Results are quantified via software

51

QuantifEye® MPS II Instrument

(simple efficient , 2 -3 minute test)

Centre Flickering Target

52

Carotenoids influence visual function

- ▶ **Optical mechanisms**
 - ▶ Glare Disability,
 - ▶ Color Contrast
 - ▶ Visual Range
 - ▶ Contrast Sensitivity
- ▶ * Biological mechanisms
 - ▶ Glare Recovery

53

Carotenoids and digital eye strain?

- ▶ Carotenoids in macula improves vision and decreases ocular fatigue- easy sell
- ▶ But not so straightforward....
- ▶ Cortisol, stress ???

54

frontiers in Nutrition

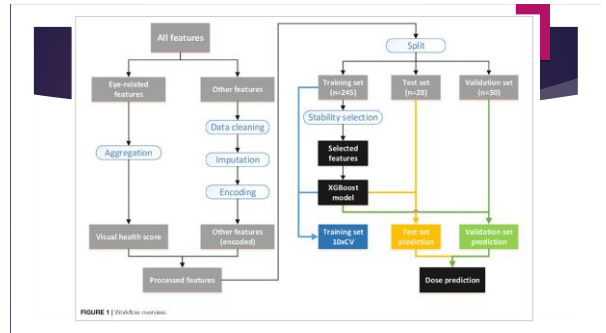
A Machine Learning Based Dose Prediction of Lutein Supplements for Individuals With Eye Fatigue

Juntao Kan¹, Ao Li², Hong Zou¹, Liang Chen¹ and Jun Du^{1*}

¹ Huabai Health Institute, Shanghai, China, ² Department of Bioinformatics, WUJi HealthCOGE Genomics, Shanghai, China

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55



56

► Visual health score (VHS) was a composite score developed from 4 most correlated/predictive parameters

► Total score of eye fatigue, Visuognosis persistence, Macular pigment optical density and Schirmer's test

57

Screen time issues- prediction and precision nutrition

- Most individuals 67.24% need high dose of carotenoids – 14 mg lutein equivalent
- 29.31% may take a lower dose – 10 mg lutein equivalent
- 3.45% cannot be helped

58

A novel botanical formula improves eye fatigue and dry eye: a randomized, double-blind, placebo-controlled study

Juntao Kan,¹ Min Wang,² Ying Liu,¹ Hongyue Liu,¹ Liang Chen,¹ Xue Zhang,¹ Chengrong Huang,¹ Bryan Y Liu,¹ Zhenheng Gu,¹ and Jun Du^{1*}

► Looked at various formula of lutein and zeaxanthin combination

Ingredients	6-mg lutein product ¹		10-mg lutein product ²		14-mg lutein product ³	
	mg	µg	mg	µg	mg	µg
Lutein, mg	1.2	20	2.0	20	2.8	20
Zeaxanthin, mg	1.2	2.0	2.0	2.8	2.8	2.8
Chrysanthemum extract, mg	75	125	125	175	175	175
Ginkgo berry extract, mg	75	125	125	175	175	175
Blackcurrant extract, mg	100	167	167	233	233	233
Placebo	100	167	167	233	233	233
Energy, kJ	71.65	72.25	72.65	73.04	73.04	73.04
Protein, g	0.02	0.02	0.02	0.02	0.02	0.02
Fat, g	0.07	0.09	0.12	0.13	0.13	0.13
Carbohydrate, g	4.03	4.03	4.03	3.96	3.96	3.96

- Baseline, 45 days and 90 days
- All formulations improved eye fatigue score
- Visuognosis persistence improved at 45 and 90 days
- MPD improved at 45 and 90 days
- 10 and 14 mg lutein improved tears secretion at 90 days

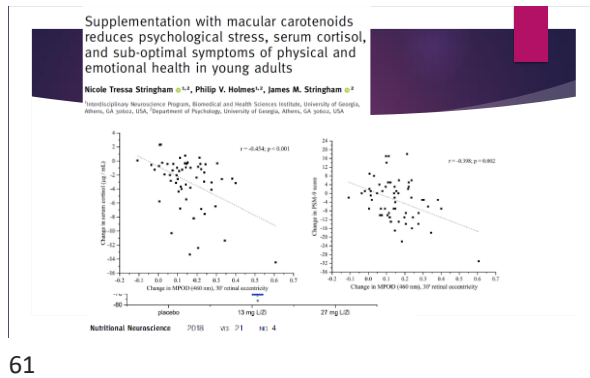
59

Effects of macular xanthophyll supplementation on brain derived neurotrophic factor, pro-inflammatory cytokines, and cognitive performance.

► Six months of daily supplementation with at least 13 mg of Macular carotenoids significantly reduces serum IL-1 β , significantly increases serum Macular carotenoids, BDNF, MPOD, and AOC, and improves several parameters of cognitive performance.

27 mg Mxans

60



61



62

Summary

- ▶ Carotenoids supplementation has a real role in decreasing stress and betterment.
- ▶ Dose matters
- ▶ Duration matters -6-12 months effects visible
- ▶ Don't turn your computers on unless you have taken your Lutein and Zeaxanthin
- ▶ Don't be Lazy; take your LZ (Lutein and Zeaxanthin)

63

Clinical implications

- ▶ Need to reevaluate the definition of digital eye strain
- ▶ Perhaps more complicated and it is an oculo-systemic syndrome
- ▶ Along with management of visual issues certain systemic issues will need to be considered
- ▶ Management of systemic issues may yield a robust relief to the ocular symptoms

64

Thank you

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65