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Impact of blue light filtering glasses on computer vision syndrome in radiology residents: a pilot study

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Abstract. Computer vision syndrome (CVS) is an umbrella term for a pattern of symptoms associated with prolonged digital screen exposure, such as eyestrain, headaches, blurred vision, and dry eyes. Commercially available blue light filtering lenses (BLFL) are advertised as improving CVS. Our pilot study evaluates the effectiveness of BLFL on reducing CVS symptoms and fatigue in a cohort of radiologists. A prospective crossover study was conducted with ten radiology residents randomized into two cohorts: one wearing BLFL first then a sham pair (non-BLFL), and the other wearing a sham pair first then BLFL, over two weeks during normal clinical work. Participants filled out a questionnaire using the validated computer vision syndrome questionnaire (CVS-Q) and the Swedish Occupational Fatigue Inventory (SOFI). The majority of symptoms [11/16 (68.8%) and 13/16 (81.3%) symptoms on the CVS-Q and SOFI, respectively] were reduced (i.e., symptoms less severe) with the BLFL compared to the sham glasses. Females rated symptoms of sleepiness and physical discomfort in the SOFI, and overall CVS-Q, as more severe. Postgraduate year (PGY)-2 residents rated all symptoms as more severe than PGY-3/4s. BLFL may ameliorate CVS symptoms. Future studies with larger sample sizes and participants of different ages are required to verify the potential of BLFL. © *2019 Society of Photo-Optical Instrumentation Engineers (SPIE)* [DOI: 10.1117/1.JMI.7.2.022402]

Keywords: blue light filtration; perception; radiology; image interpretation; education.

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1 Introduction

The visible light spectrum is a range of electromagnetic waves ranging from 400 to 750 nm in wavelength. Within this range, blue light is considered a high-energy short-wavelength (400 to 500 nm) visible light. Typically, exposure to blue light under normal circumstances is of little consequence. Nevertheless, chronic blue light exposure has been a topic of increased scrutiny given the increase in daily electronic device usage (e.g., computers, laptops, televisions, tablets, and cell phones). American screen time has been recorded at an average of just over 10.5 h/day.[1,2] As a result, there has been an increased focus on how to promote healthy screen time usage, predominantly focusing on a pattern of symptoms referred to as computer vision syndrome (CVS).[3]

CVS, also known as digital eye strain, is defined by a range of eye- and vision-related symptoms secondary to prolonged digital screen exposure.[4] Sequelae of CVS can extend beyond the classic eye-related symptoms, affecting both quality of life and work productivity.[5] For nearly three decades, CVS has been recognized as a public health issue, affecting nearly 70% of all computer users.[6,7] To study CVS, objective tools, such as Segui and colleague's 16-item questionnaire,[8] have been developed to measure the extent of CVS symptoms experienced, allowing for the assessment of CVS interventions. Increased exposure to blue light, mainly through fluorescent light and devices with LCD/LED screens, has led to an increased awareness of the risks associated with extended blue light exposure and to the exploration of methods aimed at reducing the potential negative effects to physical health, quality of life, and work productivity.[5,6,9]

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As the incidence and amount of digital screen exposure rises in the workplace and in recreational settings, the importance of risk and benefit awareness of acute and chronic blue light exposure has increased. In 2016, it was estimated that approximately two-thirds of American adults aged 30 to 49 years old spent five or more hours on digital devices.[10] This amount of screen exposure is favored to be higher among the digital-based professions, likely resulting in an even more increased incidence of CVS within this at-risk population. Furthermore, those who experience symptoms of CVS have been shown to demonstrate decreased work accuracy, extended time required to complete tasks, and an increased propensity to take breaks.[11–14] Nevertheless, little is known about the long-term clinical sequelae to chronic digital screen exposure, particularly in adults.[15] In children and adolescents, the literature suggests that extended digital screen time has been associated with decreased activity levels, poorer diets, decreased sleep, attention difficulties, and lower academic performance.[16]

Radiologists are particularly vulnerable to CVS, arguably more than any other type of healthcare provider or most of the nonhealthcare workforce in computer-based working environments. Screen time is significantly related to unhealthy sedentary behaviors that are increasingly of concern with respect not only to their overall health status but also their clinical work performance.[17,18] For example, in a recent survey evaluating the clinical duties of neuroradiologists, Chen and Lexa[19] found that nearly half (49.7%) reported working longer days, 62.7% reported an increased relative value unit production, 71.9% read more cases per hour, and 36.0% even read studies while being sleep deprived (with 13.5% doing so "frequently" and 1.9% doing so "always"). These results, however, are not unique to neuroradiologists. Radiologists are known to spend at least the average American's daily screen time just interpreting cases with typical workdays lasting 8 to 12 h. In the realm of radiology, literature has suggested that the onset of CVS symptoms begins after roughly 8 h of digital screen exposure.[20] Separately, occupational fatigue has extensively been studied and demonstrated to worsen the radiologist's performance, particularly for subtle findings and multiple abnormalities.[20–22] Krupinski et al.[23,24] have been studying fatigue in radiologists for over 10 years, and their work has clearly demonstrated the negative impact it has on diagnostic accuracy in both experienced radiologists and trainees.

As a result of the increasing concern for healthy screen time usage, there has been a recent surge in commercial products designed to find a balance between effectively reducing blue light hazards without compromising its essential visual and health benefits.[25] However, there remains a paucity of research exploring the impact of these devices on radiologists, effectively placing them at high risk for developing CVS. To address this gap in knowledge, this pilot study explores the effectiveness of blue light filtering (BLF) glasses in reducing CVS symptoms and occupational fatigue among radiologists.

2 Materials and Methods

This prospective study, which was approved by our institutional review board, was conducted over the course of 2 weeks from the end of October 2018 to early November 2018. After researching different types of BLF glasses online, a private retailer (Felix Gray, Inc., New York, New York) was selected for the similarity between their clear blue light filtering lenses (BLFL) and customizable nonfiltering lenses (both using the same frames). Ten pairs of glasses that appeared identical were purchased, of which, five had clear BLFL and five had clear non-BLFL. The BLFL filter 50% of 380- to 500-nm blue light, nearly 90% of 400- to 440-nm blue light, and reduced glare by 99% [Figs. 1(a) and 1(b)].

Inclusion criteria for the study were limited to adult radiology trainees, who were subsequently blinded and randomized to a group assigned to wear either BLFL or non-BLFL during their first week then swap for their second week. Participants were asked to wear their respective lens during their normal noncall diagnostic radiology workday, typically lasting from 8:00 AM to 5:00 PM from Monday through Friday. The participants were asked to wear contact lens if they normally wore prescription glasses during the length of this study.

(a)

(b)

Fig. 1 (a) and (b) Examples of glasses with BLFLs purchased for use in this study.

Participants were asked to read studies on standard reading room monitors: Barco Coronis Fusion 6MP DL, model MDCC-6130 (Barco; Kortrijk, Belgium). These monitors are flat panel LCD displays with active screen size of 25.8×16.1 in. (654×409 mm), aspect ratio 16:10, resolution 3280×2048, contrast ratio 1000:1, response time 18 ms, horizontal refresh rate 30 to 150 kHz, and vertical refresh rate 15 to 80 Hz. Reading room luminance differed but was generally between 20 and 40 lux as a result of standardized soft hue dimmed background lights within the room. Viewing distance and angle were varied based on individual preferences since the study was conducted during normal working days not in the laboratory setting. Typically, however, most radiologists sit about 12 to 18 in. from and orthogonally to the display monitor (unless reading with a faculty member, in which case the distance slightly increases and the angle is less orthogonal).

For each of the five evenings in each study arm, the participants were asked to complete a custom 5-min survey, containing questions from the computer vision syndrome questionnaire (CVS-Q, 16 questions, Likert scale 1 to 5)[8] and the Swedish Occupational Fatigue Inventory (SOFI, 25 questions, Likert scale 1 to 10).[26,27] The CVS-Q is a validated assessment of the physical symptoms that may occur during prolonged visual strain.[8] The SOFI is a validated questionnaire assessing mental and physical fatigue by asking multiple similar questions in different categories to assess five latent variables: lack of energy, physical exertion, physical discomfort, lack of motivation, and sleepiness.[26,27] All 25 dimensions contribute to an overall assessment of general fatigue, while 4 dimensions contribute to each of the 5 latent variables. SOFI was designed specifically to assess fatigue in occupational settings. It is purposefully constructed with repetitive/similar questions to have a high sensitivity in evaluating the five latent dimensions since the interpretation of terms (e.g., sleepy and drowsy) varies from person to person. As per SOFI developer protocols, the participants were not given any instructions except to complete the questionnaire to the best of their ability, thus each question was interpreted at personal discretion. SOFI asks respondents to provide a 0 to 10 rating of the extent to which various symptoms are felt at the time of taking the survey (0 = not at all; 10 = to a very high degree). The CVS-Q likewise surveys symptom severity at the time of completion.

The survey was created and administered through Qualtrics® (Provo, Utah). After the participants wore their respective lenses for one week, their lenses were switched (e.g., participants wearing BLFL in week one switched to non-BLFL in the next week and vice versa). Participants were compensated $200 for their time.

Data analysis was conducted by a single author for consistency and performed using StatView v5.0 (SAS Institute, Cary, North Carolina). The data were averaged over all subjects as well as the 5 days in each study arm. The Mann–Whitney test was used to test for differences between each of the symptom questions with and without BLFL. Overall means were also calculated for each of the five SOFI latent variables, the overall SOFI general fatigue variable, and an overall CVS-Q score. Overall means were then tested for differences using the Mann–Whitney test. Two-way analysis of variance (ANOVA) tests were used to evaluate the symptoms (dependent variables) as a function of gender plus session (independent variables), year of residency plus session (independent variables), who wore corrective lenses versus no corrective lenses (independent variables), and the days of each session (first, second, etc.). For analyses, the postgraduate year (PGY) 4 was combined with the PGY-3s since there was only 1 PGY-4.

3 Results

Ten radiology residents, four males and six females with a PGY distribution of seven PGY-2, two PGY-3, and one PGY-4, volunteered and successfully completed the study. As detailed in Table 1, the questionnaire contained both SOFI and CVS-Q questions.

The CVS-Q questionnaire included 16 symptoms that were scored using two rating scales, one for frequency and the other for intensity. The results for CVS-Q are provided in Table 1. The results for SOFI questionnaire are provided in Table 2.

Table 1 CVS-Q results by symptom. The data were averaged over all subjects as well as the 5 days in each study arm.

	BLFL				Non-BLFL				Mann–Whitney	
Symptom	Mean	Standard deviation	Median	Range	Mean	Standard deviation	Median	Range	*z*-value	*P*-value
Burning	1.54	0.92	1.00	1 to 4	1.56	0.94	1.00	1 to 4	−0.059	0.9532
Itching	1.04	0.19	1.00	1 to 2	1.10	0.31	1.00	1 to 2	−0.566	0.5716
Foreign body	1.11	0.32	1.00	1 to 2	1.17	0.43	1.00	1 to 3	−0.283	0.7773
Tearing	1.69	1.02	1.00	1 to 4	1.90	1.06	1.00	1 to 4	−0.873	0.3828
Excessive blinking	3.67	1.11	3.00	2 to 5	3.50	1.09	3.00	1 to 5	0.649	0.5166
Eye redness	2.77	1.11	2.00	2 to 5	3.00	1.24	2.00	1 to 5	−0.780	0.4356
Eye pain	1.31	0.73	1.00	1 to 3	1.56	0.97	1.00	1 to 4	−1.035	0.3007
Heavy eyelids	3.54	0.78	3.00	1 to 5	3.38	0.79	3.50	1 to 5	0.562	0.5739
Dryness	4.06	1.26	4.00	1 to 5	4.23	1.29	5.00	1 to 5	−0.638	0.5234
Blurred vision	2.40	0.66	2.00	1 to 5	2.60	0.82	2.00	2 to 5	−0.859	0.3904
Double vision	1.04	0.19	1.00	1 to 2	1.10	0.37	1.00	1 to 3	−0.393	0.6941
Difficulty focus near	2.52	1.00	2.00	1 to 5	2.46	0.89	2.00	1 to 5	0.000	0.9999
Sensitivity light	2.31	0.54	2.00	2 to 4	2.25	0.57	2.00	1 to 4	0.290	0.7720
Colored halos	1.00	0.00	1.00	1 to 1	1.06	0.25	1.00	1 to 2	−0.538	0.5905
Sight worsening	2.88	1.08	2.00	2 to 5	2.94	1.10	2.00	1 to 5	−0.193	0.8468
Headache	2.77	1.00	2.00	2 to 5	2.75	1.16	2.00	1 to 5	0.214	0.8306
Overall	2.22	0.37	2.18	—	2.29	0.33	2.19	—	−0.735	0.4625

Table 2 SOFI questionnaire results by category and symptom. The data were averaged over all subjects as well as the 5 days in each study arm.

	BLFL				Non-BLFL				Mann–Whitney	
	Mean	Standard deviation	Median	Range	Mean	Standard deviation	Median	Range	*z*-value	*P*-value
Lack of energy	2.58	2.28	2.00	—	2.97	2.30	2.50	—	−0.973	0.3306
Worn out	2.90	2.44	2.00	0 to 8	3.04	2.32	3.00	0 to 9	−0.383	0.7018
Spent	2.61	2.44	2.00	0 to 8	2.98	2.51	2.00	0 to 9	−0.790	0.4295
Drained	2.69	2.52	2.00	0 to 8	3.15	2.60	2.50	0 to 9	−0.942	0.3463
Overworked	2.10	2.16	2.00	0 to 8	2.71	2.77	2.00	0 to 8	−0.821	0.4116
Lack of motivation	2.44	1.59	2.00	—	3.02	1.85	2.00	—	−1.411	0.1583
Lack concern	4.75	2.88	4.00	1 to 8	5.85	2.78	8.00	1 to 8	−1.780	0.0751
Passive	1.79	2.15	1.00	0 to 8	2.42	2.70	1.00	0 to 8	−0.880	0.3790
Indifferent	1.61	2.08	1.00	0 to 8	1.88	2.55	0.50	0 to 8	−0.062	0.9505
Uninterested	1.62	2.26	1.00	0 to 9	1.92	2.69	2.50	0 to 8	−0.138	0.8903
Sleepiness	2.19	2.24	1.50	—	2.81	2.31	2.50	—	−1.37	0.1698
Falling asleep	2.35	2.46	2.00	0 to 8	2.71	2.54	2.00	0 to 8	−0.735	0.4625
Drowsy	1.65	2.50	0.00	0 to 8	2.56	2.63	5.00	0 to 9	−1.901	0.0573
Yawning	2.15	2.41	1.50	0 to 9	2.50	2.50	2.00	0 to 8	−0.697	0.4859
Sleepy	2.64	2.51	2.00	0 to 8	3.46	2.90	3.00	0 to 9	−1.349	0.1774
Physical exertion	0.43	0.74	0.00	—	0.39	0.67	0.00	—	0.290	0.7720
Palpitations	0.42	0.94	0.00	0 to 4	0.38	1.00	0.00	0 to 5	0.366	0.7146
Sweaty	0.75	1.34	0.00	0 to 5	0.63	1.34	0.00	0 to 7	0.048	0.9615
Out of breath	0.27	0.60	0.00	0 to 2	0.29	0.82	0.00	0 to 5	−0.083	0.9340
Breathing heavily	0.27	0.56	0.00	0 to 2	0.27	0.64	0.00	0 to 3	0.176	0.8603
Physical discomfort	0.85	0.89	0.50	—	1.29	1.35	1.00	—	−1.587	0.1125
Tense muscles	1.71	1.96	1.00	0 to 8	2.35	2.51	2.00	0 to 9	−1.125	0.2608
Numbness	0.40	0.75	0.00	0 to 3	0.48	1.09	0.00	0 to 6	−0.100	0.9203
Stiff joints	0.65	0.93	0.00	0 to 4	1.17	1.67	1.00	0 to 7	−1.273	0.2030
Aching	0.65	0.97	0.00	0 to 4	1.15	1.68	1.00	0 to 7	−1.356	0.1752
Overall general fatigue	1.75	1.26	1.42	—	2.10	1.41	1.72	—	−1.34	0.1807

There were significant differences (Table 3) when tested with a two-way ANOVA for the SOFI latent variables of sleepiness ($F = 5.67$, $P = 0.02$) and physical discomfort ($F = 5.38$, $P = 0.02$) and the overall CVS-Q ($F = 3.81$, $P = 0.05$) as a function of gender, with females rating symptoms as more severe than men. For year of residency, all of the SOFI latent variables (Table 4) were rated as significantly more severe by the PGY-2s than the PGY-3/4s, but there were no differences as a function of BLFL versus non-BLFL even though for both groups

Table 3 Symptom variables (mean, SD, and median) as a function of gender.

Variable	Females BLFL	Females non-BLFL	Males BLFL	Males non-BLFL	Gender	BLFL/ non-BLFL
Lack of energy	2.72 (2.23)	3.06 (1.93)	2.34 (2.39)	2.83 (2.83)	$F = 0.43$	$F = 0.76$
	2.25	2.50	1.50	2.2%	$P = 0.51$	$P = 0.39$
Lack of motivation	2.32 (1.84)	2.74 (1.98)	2.64 (1.10)	3.43 (1.58)	$F = 2.06$	$F = 2.99$
	2.00	2.00	2.00	3.50	$P = 0.16$	$P = 0.08$
Sleepiness	2.66 (2.34)	3.12 (2.23)	1.45 (1.89)	2.22 (2.37)	$F = 5.67$	$F = 2.02$
	2.00	3.00	0.75	1.50	$P = 0.02$	$P = 0.16$
Physical exertion	0.51 (0.76)	0.34 (0.51)	0.30 (0.70)	0.47 (0.87)	$F = 0.06$	$F = 0.01$
	0.00	0.00	0.00	0.00	$P = 0.81$	$P = 0.99$
Physical discomfort	1.03 (0.88)	1.53 (1.36)	0.57 (0.84)	0.92 (1.29)	$F = 5.38$	$F = 3.38$
	0.88	1.00	0.13	0.50	$P = 0.02$	$P = 0.06$
Overall general fatigue	1.90 (1.34)	2.18 (1.40)	1.54 (1.1)	1.96 (1.45)	$F = 1.09$	$F = 1.68$
	1.54	1.96	0.98	1.48	$P = 0.29$	$P = 0.19$
Overall CVS-Q	2.31 (0.41)	2.31 (0.39)	2.10 (0.26)	2.24 (0.21)	$F = 3.81$	$F = 1.07$
	2.28	2.25	2.13	2.19	$P = 0.05$	$P = 0.30$

Table 4 Symptom variables (mean, SD, and median) as a function of year of residency.

Variable	PGY-2 BLFL	PGY-2 non-BLFL	PGY-3/4 BLFL	PGY-3/4 non-BLFL	Year	BLFL/ non-BLFL
Lack of energy	3.28 (2.29)	3.67 (2.06)	0.83 (0.90)	1.27 (1.99)	$F = 29.61$	$F = 0.85$
	3.75	3.25	0.25	0.50	$P < 0.0001$	$P = 0.36$
Lack of motivation	2.66 (1.84)	3.54 (1.95)	1.92 (0.26)	1.73 (0.42)	$F = 12.80$	$F = 0.98$
	2.25	3.13	2.00	2.00	$P = 0.0005$	$P = 0.33$
Sleepiness	2.98 (2.38)	3.57 (2.17)	0.72 (0.69)	0.95 (1.42)	$F = 27.92$	$F = 1.28$
	2.50	3.13	0.75	0.25	$P < 0.0001$	$P = 0.26$
Physical exertion	0.60 (0.81)	0.55 (0.74)	0.00 (0.00)	0.00 (0.00)	$F = 15.65$	$F = 0.29$
	0.00	0.25	0.00	0.00	$P = 0.0001$	$P = 0.86$
Physical discomfort	1.07 (0.92)	1.54 (1.45)	0.32 (0.50)	0.66 (0.81)	$F = 11.85$	$F = 2.91$
	0.75	1.13	0.00	0.50	$P = 0.0009$	$P = 0.09$
Overall general fatigue	2.11 (1.33)	2.54 (1.40	0.89 (0.27)	1.02 (0.70)	$F = 27.22$	$F = 1.14$
	1.88	2.06)	0.72	0.84	$P < 0.0001$	$P = 0.29$
Overall CVS-Q	2.28 (0.40)	2.32 (0.36)	2.11 (0.25)	2.21 (0.23)	$F = 3.19$	$F = 0.83$
	2.19	2.31	2.19	2.13	$P = 0.07$	$P = 0.36$

symptoms were consistently rated as less severe with the BLFL glasses. There were no differences as a function of those who wear corrective lenses versus no corrective lenses. There were no differences as a function of day of each session (e.g., first and second).

4 Discussion

This preliminary study is the first of its kind in the radiology space to investigate the impact of BLFL on symptoms of CVS and occupational fatigue in radiologists. The results presented here suggest a trend toward CVS symptom amelioration with the usage of BLFL. These findings are in accordance with published literature, which has suggested that BLFL are able to decrease the incidence and severity of CVS symptoms and sequelae.[15,25,28] In our study, two symptoms were decreased and approached statistically significant values in the BLFL group: "drowsy" and "lack of concern," P-value of 0.057 and 0.075, respectively. However, it is important to note that the other metrics recorded in the same overarching dimension did not trend toward statistical significance which ultimately makes these data points inconclusive. More interestingly, however, was the observation that the majority of CVS and fatigue symptoms [11/16 (68.8%) and 13/16 (81.3%) symptoms on the CVS and SOFI questionnaire, respectively] were reported to feel less severe in the BLFL session versus the non-BLFL session—suggesting that a better powered study may be able to elucidate a statistically significant effect.

To date, there are only a few published studies evaluating the effect of BLFL on CVS symptoms; while many of the study results have been mixed, the majority have suggested that BLFL can reduce CVS symptomatology and sequelae.[5,29] In a 2017 review, Lawrenson et al.[15] identified three (of 118) randomized control studies that analyzed the effect of BLFL, grading their level of certainty in the studies as low or very low and requiring additional high-quality studies to address the purported benefits of BLFL. Notably, the three studies reviewed all had the same significant limitation of having yellow-tinted BLFL, which effectively limited the adequate blinding of the study participants. In a prospective clinical study, Ide et al.[30] found that eye fatigue, as measured by critical flicker-fusion frequency (a visual measurement of executive function and proxy of eye fatigue), was significantly reduced by BLFL. Additionally, similarly endeavored studies found that the level of reduction of CVS symptoms and sequelae is a factor of the BLFL intensity,[28,29] in essence, the more blue light is filtered, the lower the incidence of CVS symptoms and sequelae.

These results have raised the question about the efficacy of luminance reduction, not necessarily BLF, in successfully ameliorating CVS symptoms. Palavets and Rosenfield[31] sought to answer this question in one of their studies, which found that BLFL were no better than non-BLFL at effectively reducing CVS symptoms after 30 min of continuous screen time, instead suggesting that decreased screen luminance was able to achieve the same effects as BLFL. While excessive blue light exposure can be theoretically harmful, an adequate amount of exposure is imperative for the assurance of adequate visual function and overall health.[32] For example, blue light plays an important role in circadian rhythm regulation by indirectly affecting the production of melatonin.[33] Blue light also plays an important role in night vision and color discrimination.[25] Psychological effects, such as in the setting of seasonal affective disorder, have also been attributed to reduced blue light exposure.[34]

Although there is insufficient data to draw definite conclusions about the effectiveness of commercially available BLF glasses, there are many simple recommendations to reduce symptoms of CVS and occupational fatigue for the radiologist. The American Academy of Ophthalmologists recommends "eye ergonomic tips" which include the "20–20–20" rule: for every 20 min, shift your eyes to look at an object at least 20 ft away, for at least 20 s.[35] Furthermore, sit about 25 in. away from your computer screen (which should be tilted slightly down), reduce as much screen glare as possible, and strive to keep the digital screen not much brighter than the surrounding light. Taking more frequent breaks (microbreaks) from the computer terminal has been demonstrated to not only reduce the incidence CVS but also preserve one's productivity.[36,37]

The results regarding gender differences for the SOFI latent variables of sleepiness and physical discomfort and the overall CVS-Q scores are rather interesting, as are the very significant results that PGY-2s rated nearly every symptom on both scales as more severe than the PGY-3/4s.

Seidel and Krupinski[38] also found in a study assessing musculoskeletal discomfort symptoms in radiologists that females experienced discomfort in more body areas (e.g., shoulder, forearm, and buttocks) than males and at higher severity levels. The reasons for these gender disparities require further investigation, but there is evidence that males and females have different sitting postures which could affect musculoskeletal discomfort.[39]

The very significant difference in nearly every symptom as a function of trainee year is also very interesting. Krupinski et al.[20–23] have consistently found in their studies on measuring symptoms of visual and overall fatigue (using SOFI) that radiologists in training report more severe symptoms of visual and overall fatigue than do faculty radiologists. This study is the first to demonstrate that there are significant differences even within trainee years. Prior studies have hypothesized that being a trainee is overall very stressful and fatiguing due to the nature of the new learning environment, new skills and knowledge being acquired, and the pressures of having to perform clinically at a level not experienced before. Our current data support these hypotheses and also suggest that PGY-2 residents are impacted even more than their residency peers. Once past the first year of radiology training, these residents seem to adjust and perhaps develop coping skills not found during their first year; this is clearly an important topic for further investigation.

Limitations of this study included a small sample size, which limited the power of the study. We did not control other factors such as measuring amount of sleep, caffeine intake, interest in the current rotation, or daily noon conference didactic lectures which may have affected energy levels in the participants. Given this is a pilot study assessing for feasibility, future study should consider controlling these factors. While the BLFL and non-BLFL had similar appearances, there was nothing to stop participants from carefully examining the lenses for subtle BLF properties during their 8-h shifts or significant reduction in glare—potentially introducing bias into the study. Additionally, the short period of time (5 days) wearing each pair of glasses by the participants may have limited the observable differences in occupational fatigue and CVS. Since the study participants consisted primarily of new radiology trainees, it would be interesting to determine if the impact might be different with more experienced (i.e., older) radiologists, especially given our results on the impact of training year. It is also important to acknowledge that there are many factors, many of which are impossible to effectively control, that can contribute to symptoms of fatigue external to the daily radiology work the participants were engaged in. Nevertheless, we believe that completing a multiday questionnaire helped balance any potential outlier responses due to external factors on any given day. Future studies could track via a daily diary the impact of such external factors.

In conclusion, the results of this study, although not statistically significant, suggest that BLFL may be able to ameliorate CVS symptoms among radiology trainees. Nearly every symptom measured was rated as lower (less severe) when wearing the BLFL. Therefore, we find the results promising that BLF glasses may be one of many tools available to radiologists to help reduce the impact of CVS. While the effects of BLFL have yet to be demonstrated without a doubt, our study and the literature suggest that BLFL may benefit those who are prone to experiencing CVS symptoms and sequelae, thus at the very least BLF glasses may be of benefit to some and are certainly unlikely to be of any harm. As society's exposure to digital screens increases each year, it is of great importance that methods to reduce CVS incidence and severity are explored and employed in order to ensure better health and performance in the modern digital age.

Disclosures

No conflicts of interest, financial or otherwise, are declared by the authors. This study was approved by our institutional review board.

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