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Ergophthalmology in accounting offices: the computer vision syndrome (CVS)

Ergoftalmologia em escritórios de contabilidade: a síndrome visual do computador (SVC)

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ABSTRACT

***Purpose**: This study aimed to determine the presence of the symptoms of computer vision syndrome (CVS) accounting office employees. **Methods**: The research tools used were a questionnaire based on the set of symptoms of CVS rated by Likert scale (1-5) and workplace observations based on Ergonomic Workplace Analysis (EWA). **Results**: The participants who worked with a viewing angle of less than 10° relative to the screen had more symptoms, particularly of pain in the back of the neck and back (p = 0.0460). The participants who used lighting other than 450 and 699 lux reported significant headache (p = 0.0045) and dry eye (p = 0.0329) symptoms. Younger workers had more headaches (p = 0.0182), and workers with fewer years of employment had more headaches and dry eyes symptoms (p = 0.0164 and p = 0.0479, respectively). A total of 37% of the participants reported a lack of guidance regarding prevention and painful symptoms in the back of the neck and back (p = 0.0936). **Conclusion**: Younger participants with fewer years of employment, who had not received information regarding proper computer use, who did not use lighting between 450 and 699 lux or who worked with viewing angles of less than 10° had more computer vision syndrome symptoms.*

***Keywords:** Ergonomics; Ophthalmology; Attitude to computers; Lighting; Eye health; Working environment; Occupational health*

RESUMO

Objetivo: Este trabalho objetivou averiguar a presença dos sintomas da Síndrome Visual dos Computadores (SVC) trabalhadores de escritórios de contabilidade. **Métodos**: Como instrumentos de pesquisa utilizou-se um questionário baseado no conjunto de sintomas da SVC, avaliado por Escala Likert (1-5), e foram realizadas observações no local de trabalho baseadas na Avaliação Ergonômica de Postos de Trabalho. **Resultados**: Os participantes que trabalhavam com o ângulo de visão menor do que 10° em relação à tela foram os que apresentaram mais sintomas sobretudo de dor na parte posterior do pescoço e nas costas (p=0,0460). Aqueles que usavam iluminação diferente de 450 e 699 lux reportaram sintomas significativos para dor de cabeça (p=0,0045) e ressecamento ocular (p=0,0329). Os mais jovens apresentaram mais dor de cabeça (p=0,0182) e aqueles com menor tempo de trabalho mais sintomas de dor de cabeça e ressecamento ocular (respectivamente p=0,0164 e p=0,0479). A falta de recebimento de orientações sobre prevenção foi confirmada por 37% participantes que referiram mais sintomas de dor na parte posterior do pescoço e nas costas (p=0,0936). **Conclusão:** Os participantes mais jovens, com menor tempo de trabalho, que não haviam recebido informações sobre o uso de computador, não utilizavam iluminação entre 450 e 699 lux ou trabalhavam com o ângulo de visão menor do que 10º apresentaram mais sintomas da síndrome visual do computador.

Descritores: Ergonomia; Oftalmologia; Atitude frente aos computadores; Iluminação; Saúde ocular; Ambiente de trabalho; Saúde do trabalhador

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Introduction

Computing is considered the second revolution in the working world after the industrial revolution, and its appropriate use requires safety and comfort.[1] Many work tasks use the visual organs, and approximately 80% of emotions are perceived through sight.[2] This regular use emphasizes the importance of improving the relationship between the visual capabilities of the human being and the use of video monitors in the execution of work tasks. An adaptation of the work environment to the psychophysiological characteristics of the worker is provided for in Regulatory Standard no. 17 (NR-17) of the Ministry of Labor in Brazil.[3]

Although it is empirical, the truth is that the transformations in the working environment following this second revolution have required high and progressive efficiency of the oculomotor and central nervous systems to process visual information. These requirements may overload a body's homeostatic control mechanisms and harm a worker's health, with possible repercussions to other organs and systems.

There is no convincing scientific evidence that video monitors are harmful to the eyes.[4] However, because of the excessive or inappropriate use of these resources, signs and symptoms, particularly ocular and musculoskeletal, have been reported more frequently by users in recent years.[1] Considering the controversies that have been presented by researchers, it is clear that this subject will lead to new studies to better understand the causes and effects in real work environments.

The most common symptoms that are reported by workers who are exposed to such environmental factors are eyestrain, watery eyes, diplopia, photophobia, blurred vision and dry eye syndrome.[5-8] A group of symptoms has been classified as computer vision syndrome (CVS) and includes eyestrain (ES), headache (HA), blurred vision (BV), pain in the back of the neck or back (BNBP) and dry eyes (DE).[5,7]

In this context, this study aims to identify the prevalence of CVS in accounting office workers and to identify the main CVS-related symptoms that are reported by accounting workers.

Methods

This work is an applied and descriptive study that began with the identification of accounting offices in Joaçaba in the years 2015 and 2016. Telephone contact was made to schedule the presentation of the study, the invitation to participate and the subsequent field data collection.

The inclusion criteria were that participants should work in accounting offices, use computer screens as a working tool and be present in the workplace at the scheduled data collection time. The exclusion criteria were the non-use of computers and the non-agreement to voluntarily participate in the study. The participants who agreed to participate signed a free and informed consent form, and the research protocol was approved by the Research Ethics Committee of the University of West Santa Catarina (Universidade do Oeste de Santa Catarina) under number 40196.

Two data collection instruments were used, namely, a questionnaire and workplace measurements. The questionnaire was developed by the authors based on the set of CVS symptoms that were presented by Yan et al.,[5] which are also the main symptoms that were presented by Anshel.[7] The participants completed the questionnaire by using a Likert scale in which a numerical value of 1 (not important) to 5 (very important) was assigned to each of the following symptoms: eyestrain; headache; blurred vision; pain in the back of the neck or back; and dry eyes. Sociodemographic questions were also included along with other issues that related to the years of employment, guidelines received and the breaks that are used for resting.

The Ergonomic Workplace Analysis (EWA) method served as the basis for the evaluation of the workspace and the work that was performed in it. This method was followed by a composite three-stage model of a demand analysis, task analysis and activity analysis.

For the analysis of the ergophthalmological variables, which were performed individually, several observations were made. These observations included the verification of the presence of reflections on the computer screen by direct observation, the measurement of the distance between the eyes and monitor and between the eyes and keyboard by using a tape measure, the measurement of the viewing angle to the computer screen by photographic analysis and by using the MeazureTM C Thing Software, Mountain View - CA, United States, software and the measurement of ambient lighting by using a Minipa MLM-1332 lux meter.

The data were analyzed with Pearson's chi-square test by employing clusters of the categorical variables as described in the tables in the results section. When it was necessary to compare the multiple independent variables, the Kruskal-Wallis test was used. A descriptive level of $p < 0.05$ was adopted. All analyses were performed with Statistica 7.0® (StatSoft) statistical software.

Results

Of the 23 accounting offices that were identified in the municipality, 18 (78.3%) agreed to participate, and among the 115 existing employees, 113 (98.2%) met the inclusion criteria and agreed to complete the questionnaire. A total of 74 (65.5%) of the participants were female, and 39 (34.5%) were male.

The mean age of the participants was 31.8 years, with a standard deviation of 10.1. The highest age was 63 years, and the lowest age was 18 years. When the participants were divided into age groups, 25 (22.1%) were under 23 years of age, 28 (24.8%) were between ages 23 and 26 years, 28 (24.8%) were between 27 and 36 years, 18 (15.9%) were between 37 and 50 years, and 14 (12.4%) were over 50 years of age.

Regarding years of employment, 77 (68.1%) had worked for less than 10 years, 18 (15.9%) had worked between 10 and 19 years, 9 (8%) had worked between 20 and 30 years, 5 (4.4%) had worked between 30 and 39 years, and 4 (3.5%) had worked for over 40 years.

A total of 61 participants (53.9%) worked as accounting clerks, 21 (18.6%) were accountants, and the other 31 (27.4%) participants had other employment roles.

Regarding the hours worked per day, 7 (6.2%) participants worked less than 4 hours, 54 (47.8%) worked between 4 and 8 hours, and 52 (46%) worked more than 8 hours.

Regarding the eye care that relates to computer use, 71 (62.8%) participants had received information, and 42 (37.2%) had access to such information.

Regarding the break time from using the computer during the working day, 11 (9.7%) participants had a break of 5 to 10

minutes per hour, 19 (16.8%) had a break of 5 to 10 minutes every 2 hours, 9 (8%) had a break of 15 minutes every 2 hours, 9 (8%) did not have a break, 31 (27.4%) looked away occasionally without necessarily having some other type of break, and 34 (30.1%) performed other activities that did not involve the use of a computer.

The finding of reflected light in the monitors was positive in 20 (17.7%) participants and negative in 93 (82.3%) participants.

The viewing angle was calculated between an imaginary horizontal line that passes straight at eye level and an imaginary line that connects the eyes of the participant to the center of the monitor. Regarding the viewing angle, 6 (5.3%) participants showed an angle of less than 5°, 32 (28.3%) showed an angle between 5° and 9.9°, 31 (27.4%) showed an angle between 10° and 14.9°, 27 (23.9%) showed an angle between 15° and 19.9°, and 17 (15%) showed an angle of over 19.9°.

A total of 39 (34.5%) participants worked with their eyes less than 56 cm away from the keyboard, 37 (32.7%) worked with their eyes between 56 and 60 cm away from the keyboard, 30 (26.5%) worked with their eyes between 61 and 66 cm away from the keyboard, and 7 (6.2%) worked with their eyes at distances greater than 66 cm from the keyboard. Concerning the distance of their eyes from the monitor, 26 (23%) participants

Table 1

Symptoms by the participants' gender

Gender	N	%	ES (p = 0.9878)	HA (p = 0.4248)	BV (p = 0.2574)	BNBP (p = 0.7232)	DE (p = 0.3746)	Mean
Male	39	34.5	3.2	2.1	2.9	3.1	2.4	2.74
Female	74	65.5	3.1	2.3	2.7	3.4	2.4	2.78
Total	113	100	3.1	2.2	2.8	3.3	2.4	2.76

ES = Eyestrain; HA = Headache; BV = Blurred vision; BNBP = Pain in the back of the neck or back; DE = Dry eyes.

Table 2

Symptoms according to the participants' age group

Age group	N	%	ES (p=0.2843)	HA (p=0.0182)	BV (p=0.8603)	BNBP (p=0.7646)	DE (p=0.2598)	Mean
Under 23	25	22.1	3.5	2.6	3.0	3.3	2.2	2.93
23 to 26	28	24.8	3.3	2.5	2.9	3.5	2.6	2.97
27 to 36	28	24.8	2.9	2.5	2.6	3.5	2.6	2.82
37 to 50	18	15.9	2.8	1.3	2.4	2.8	2.4	2.36
Over 50	14	12.4	3.1	1.8	2.8	3.2	2.2	2.58

ES = Eyestrain; HA = Headache; BV = Blurred vision; BNBP = Pain in the back of the neck or back; DE = Dry eyes

Table 3

Symptoms and years of employment of the participants

Years of employment	N	%	ES (p=0.2843)	HA (p=0.0164)	BV (p=0.2461)	BNBP (p=0.9422)	DE (p=0.0479)	Mean
Less than 10 years;	77	68.1	3.2	2.5	2.9	3.4	2.3	2.85
10 to 19 years;	18	15.9	2.9	1.7	2.4	3.1	2.7	2.57
20 to 30 years;	9	8.0	3.3	1.9	2.8	3.1	2.7	2.76
30 to 39 years;	5	4.4	3.4	1.4	3.0	2.6	2.2	2.52
40 years or more	4	3.5	2.5	1.8	2.5	3.5	2.0	2.45

ES = Eyestrain; HA = Headache; BV = Blurred vision; BNBP = Pain in the back of the neck or back; DE = Dry eyes.

Table 4

Symptoms according to the participants' daily workload

Workload	N	%	ES (p=0.4710)	HA (p=0.4763)	BV (p=0.1731)	BNBP (p=0.3081)	DE (p=0.8629)	Mean
Less than 4 hours	7	6.2	2.9	1.7	2.1	3.0	1.7	2.29
4 to 8 hours	54	47.8	3.1	2.3	2.7	3.1	2.4	2.70
More than 8 hours	52	46	3.3	2.3	2.9	3.5	2.5	2.90

ES = Eyestrain; HA = Headache; BV = Blurred vision; BNBP = Pain in the back of the neck or back; DE = Dry eyes.

worked at a distance of less than 56 cm, 32 (28.3%) worked at a distance between 56 and 60 cm, 29 (25.7%) worked at a distance between 61 and 66 cm, and 26 (23%) worked at a distance that was greater than 66 cm.

The lighting intensity at keyboard height was less than 270 lux for 36 (31.9%) participants, between 270 and 449 lux for 34 (30.1%) participants, between 450 and 699 lux for 20 (17.7%) participants and greater than 699 lux for 23 (20.3%) participants.

By using a scale from 1 (not important) to 5 (very important), the total symptoms of each CVS component by gender obtained a mean score of 2.74 points among the male participants and 2.78 points among the female participants, with no significant difference between the groups for any symptom (Table 1). The variations of symptoms among the age groups were statistically significant for the HA symptom, and the younger age group had a higher mean (p = 0.0182) (Table 2).

The difference of symptoms in relation to the accounting employment was statistically significant for the HA (p = 0.0164) and DE (p = 0.0479) symptoms, and the participants with more years of employment had fewer symptoms (Table 3). There was no significant difference among the groups for any of the symptoms in relation to the number of working hours (Table 4).

Table 5

Symptoms according to receiving guidelines on eye care in computer use

Guidelines	N	%	ES (p=0.7980)	HA (p=0.4430)	BV (p=0.1148)	BNBP (p=0.0936)	DE (p=0.3220)	Mean
Yes	71	62.8	3.1	2.1	2.7	3.2	2.5	2.69
No	42	37.2	3.2	2.5	3.0	3.5	2.3	2.90

ES = Eyestrain; HA = Headache; BV = Blurred vision; BNBP = Pain in the back of the neck or back; DE = Dry eyes.

Table 6

Symptoms according to the participants' breaks from computer use

Resting break	N	%	ES (p=0.1119)	HA (p=0.1253)	BV (p=0.4482)	BNBP (p=0.2551)	DE (p=0.2812)	Mean
5 to 10 minutes per hour	11	9.7	3.1	1.8	2.2	2.6	1.9	2.33
5 to 10 minutes every 2 hours	19	16.8	3.6	2.4	3.2	3.8	3.0	3.20
15 minutes every 2 hours	9	8	2.6	2.0	2.8	2.9	1.8	2.40
No break	9	8	3.8	2.7	3.8	3.5	3.5	3.46
Looks away occasionally	31	27.4	3.1	2.5	2.7	3.5	2.2	2.80
Other activities away from computer	34	30.1	2.8	2.1	2.5	3.1	2.2	2.56

ES = Eyestrain; HA = Headache; BV = Blurred vision; BNBP = Pain in the back of the neck or back; DE = Dry eyes.

Table 7
Symptoms according to viewing angle measurement

Viewing angle	N	%	ES (p=0.8488)	HA (p=0.9053)	BV (p=0.7865)	BNBP (p=0.0460)	DE (p=0.3050)	Mean
Less than 5	6	5.3	3.3	2.7	3.1	4.4	2.1	3.14
5 to 9.9	32	28.3	3.4	2.4	2.9	3.5	2.7	2.99
10 to 14.9	31	27.4	3.0	2.2	2.7	3.2	2.4	2.69
15 to 19.9	27	23.9	3.1	2.1	2.7	3.0	2.2	2.62
More than 19.9	17	15	3.1	2.0	2.5	3.0	2.3	2.58

ES = Eyestrain; HA = Headache; BV = Blurred vision; BNBP = Pain in the back of the neck or back; DE = Dry eyes.

Table 8

Symptoms according to the measurement of ambient lighting at keyboard height

Illuminance (Lux)	N	%	ES (p=0.0963)	HA (p=0.0045)	BV (p=0.0737)	BNBP (p=0.6714)	DE (p=0.0329)	Mean
Less than 270	36	31.9	3.3	2.1	2.9	3.6	2.5	2.86
270 to 449	34	30.1	2.9	2.5	2.8	3.2	2.2	2.73
450 to 699	20	17.7	3.1	1.7	2.6	2.9	2.3	2.49
More than 699	23	20.3	3.3	2.6	2.8	3.3	2.7	2.92

ES = Eyestrain; HA = Headache; BV = Blurred vision; BNBP = Pain in the back of the neck or back; DE = Dry eyes.

The groups that had or not previously received guidelines on proper computer usage showed no difference in symptoms (Table 5), although the relationship between receiving information and BNBP was very close to significant, because the participants who had received information manifested slightly fewer symptoms ($p = 0.0936$). The difference among these groups was not statistically significant in relation to the minute breaks per working hour (Table 6).

The mean CVS-related symptom score for the 20 (18%) participants with screen reflections was 2.60 points, and for the 93 (82%) participants with no reflections, the mean CVS-related symptom score was 2.80 points. The difference of the symptoms according to viewing angle measurement in the responses among the groups was statistically significant for BNBP, where the decrease in symptoms was inversely proportional to the angle of vision (Table 7).

For the participants with less than a 56 cm-distance between the eyes and keyboard, the calculated overall mean for all symptoms was 2.85 points; for the participants whose measurement was between 56 cm and 60 cm, the mean was 2.68 points; for the participants whose measurement was between 61 cm and 66 cm, the mean was 2.77 points; and for the participants with measurements of more than 66 cm, the mean was 2.80 points. The difference among the groups was not statistically significant ($p > 0.05$).

Among the participants with less than a 56 cm-distance between the eyes and monitor, the calculated overall mean for all symptoms was 2.77 points; for the participants with this measurement between 56 cm and 60 cm, the mean was 2.79 points; for the participants with this measurement between 61 cm and 66 cm, the mean was 2.69 points; and for the participants with a distance of more than 66 cm, the mean was 2.82 points. The difference among the groups was not statistically significant ($p > 0.05$).

There was a significant correlation between illuminance and the symptoms of HA and DE, and the correlation with ES and BV was close to significant (Table 8).

Discussion

The choice of accounting offices was because accounting clerks are directly mentioned in Regulatory Instruction no. 98/2003 of the Brazilian National Institute of Social Security as being among the professionals at risk of developing a disability from computer use.[9] The municipality of Joaçaba in western part of Santa Catarina state is considered an important reference center for more than 27 satellite cities with similar life, production and consumption characteristics. For these reasons, this study concentrates on workers in this municipality (for further details, see IBGE data.[10] Most participants were female, and there was no significant difference in the mean CVS symptoms between males and females, although BNBP was more intense in women (Table 1). Another survey of computer users found similar results, with no difference in the symptoms between genders.[11] However, research that has been conducted with undergraduate students found a prevalence of CVS symptoms in females,[12] and another study[13] that surveyed physicians and engineers identified neck and shoulder pain in 66.7% of women and 56.4% of men. The prevalence of CVS symptoms in Brazilian women has also been observed in call center operators in São Paulo.[14]

Regarding age, the highest mean CVS symptoms were found in the 23- to 26-year-old group. HA was the only statistically significant symptom ($p = 0.0182$) (Table 2). A study that compared younger and older workers found no significant difference in the symptoms between groups.[15] It is possible that increased pupillary diameter and greater lens transparency makes younger people more sensitive to environmental variations and more susceptible to the appearance of symptoms.[5]

Dry eyes was the only significant symptom among the participants with fewer years of employment (Table 3). Another study found that fewer years of employment (up to 10 years) is a predictor of symptoms, but no explanation was offered for this finding.[12]

There was an increase in symptoms that was proportional to the hours that were worked per day, but the change was not significant among the groups for any of the symptoms (Table 4). However, a recent study has found a significant difference that is proportional to the number of hours that are worked,[12] and a review article concluded that symptoms tend to regress moments after ending work with a computer.[16] Similar results were also found in a study on physicians and engineers.[13]

The group that received no guidelines on eye care when using a computer showed more symptoms; the difference was not significant, although BNBP was very close to significant. This result agrees with other studies that have emphasized the need to provide information on proper computer use.[17-19] (Table 5) Simple adjustment measures can minimize CVS-related symptoms. This result indicates the need to emphasize the guidelines to computer users to prevent symptoms.

The group that had a 5- to 10-minute break every hour had the lowest mean CVS symptoms, but there was no significant difference (Table 6). A recent literature review recommended a 15-minute break every hour or a 5-minute break for every 30 minutes of work.[8] A study that examined the pain threshold after 60, 75 and 90 minutes of work concluded that a failure to take a break may contribute to the development of chronic pain in the shoulders and neck.[20] NR-17 suggests a 10-minute break for every 50 minutes that are worked.

Only 20 (18%) participants had light reflections on their computer screen, and the difference in the general mean of symptoms was minimal. In contrast, there were more intense symptoms in the participants who had no reflections. However, Murphy[21] warned that reflections are harmful to a computer user because they produce images on the monitor with a different focus and depth, which causes symptoms because of the repeated attempts to focus the ciliary muscle. In this context, it is worth mentioning that the Brazilian Regulatory Standard NBR 8995[22] recommends avoiding reflections on the screen that produce an uncomfortable or disabling glare that is caused by badly positioned lighting. The contradictory results possibly occurred because the reflections were peripheral and therefore did not affect the participants' activity or because there were other unidentified factors that affected the results.

The decrease in the intensity of symptoms was inversely proportional to the viewing angle in relation to the screen, especially starting at 10°, and the result for BNBP was significant (Table 7). A small tilt of the eyes downward, in relation to the horizontal line, between 10° and 20° promotes visual comfort.[4,8] An eye position without angulation promotes incomplete blinking with an inadequate lubrication of the eyes.[7] Two studies that compared the angulations of 15° with 30° and 15° with 40° found fewer symptoms and less muscle activity in the group of participants who used an angle of 15°.[23,24] An angle greater than 35° may promote the appearance of reflections.[23] A moderate tilting of the viewing angle helps prevent CVS symptoms by reducing exposure and

protecting against dryness of the eyes.[16] The angle in relation to the line of sight and the tilting of the monitor was not studied as a factor that affects CVS.

The lowest mean of all symptoms was identified in the group with a distance between the eyes and keyboard of 56 to 60 centimeters, although this was not significant. In a review article, Helander et al.[25] recommend a distance of 50 centimeters. Garcia-Lallana et al.[26] propose a position where there is minimal extension, flexion and deviation of the wrist, which indicates the need for adaptation to each situation.

The participants with a distance of 61 to 66 cm between the eyes and computer showed the lowest mean symptoms, but the difference among groups was minimal and not significant. Murphy[21] recommends a distance of 45 to 75 cm between the eyes and computer, and Blais[4] recommends 40 cm. NR-17[3] suggests that other objects (i.e., keyboard, document holder) should be proportional in length to the monitor. The variability of factors hinders the recommendation of a fixed distance.

Regarding ambient lighting, the 450 to 699 lux range of ambient lighting at keyboard height led to the fewest symptoms. The participants who had lower lighting intensity had more HA and DE, and this result was significant. NBR 8995[22] recommends a value of 500 lux for offices. Brazilian Regulatory Standard NBR 5413[27], which was in force at the beginning of this study, recommends a range of 300 to 750 lux. The participants that have been using in greater than 700 lux had also more CVS symptoms. The results of this study coincide with both recommendations and emphasize the importance of lighting in reducing CVS symptoms. It should be noted that 500 lux lighting is recommended for text, but for inputting numbers, for example, 300 lux is recommended.[8]

Conclusions

The present study showed that younger participants with fewer years of employment, who had not received information regarding proper computer use, who did not use lighting between 450 and 699 lux or who worked with viewing angles of less than 10° had more computer vision syndrome symptoms.

Further studies are needed to clarify the factors that affect the manifestation of CVS and could include data on the participants' refraction and location and the number of reflections on the screen.

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