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ARTICLE

Ergonomic intervention program for office workers: a case study about its effect in computer vision syndrome and musculoskeletal discomfort

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ABSTRACT

This study aims to develop and implement an ergonomic intervention program at the workplace of knowledge workers, and to evaluate its impact on the reduction of Computer Vision Syndrome (CVS) and musculoskeletal symptoms. 84 workers were part of the study (mean age 43.2 ± 9.7 years). The intervention included training, delivery of a packaging of artificial tears, and adjustments in workstations. It was conducted intensively along 6 weeks. Data was collected onsite, with questionnaires administered pre-intervention, 2 months after, and 4 months after. Participants exhibited behavioural changes, especially in workplace adjustments and visual rest. By the intervention's end, over 90% had correctly adjusted screens and adopted appropriate postures, while 42.7% adhered to the 20x20x20 rule. CVS severity and prevalence decreased, but not significantly across the three time points. Significant improvements were observed in upper back and neck musculoskeletal symptoms at the end of workdays. Findings suggest that an ergonomic intervention program can benefit employees by reducing visual and musculoskeletal symptoms.

Practitioner summary: This study addresses CVS and MSDs, commonly experienced by individuals working with display screen equipment. It was emphasised the significance of ergonomic interventions in reducing musculoskeletal discomfort. The major finding was the positive behavioural changes, such as improved workplace adjustments and visual rest practices.

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1. Introduction

The computer and other display screen equipment (DSE) have become an essential element for administrative and knowledge workers, as it facilitates access to information, promotes work efficiency, and simplifies communication (Munshi, Varghese, and Dhar-Munshi 2017). Therefore, the time spent looking at DSE, i.e. desktop computers, laptop computers, tablets and smartphones, has been increasing in the last years, being such equipment used for both professional and non-professional purposes (Rosenfield 2011). These behaviours have been linked to adverse effects on users' health and well-being (Gautam, Prakash, and Dangol 2020; Poudel and Khanal 2020).

Visual symptoms such as eye strain, visual fatigue, burning sensation, blurred vision, dry eye, headache, and symptoms related to posture, such as pain and discomfort in the shoulders and neck, are often referred to in the literature as a result of prolonged computer work (Portello et al. 2012; Seguí et al. 2015; Blehm et al. 2005). These symptoms have been related to Computer Vision Syndrome (CVS), and according to Blehm et al. (2005), can be categorised into the following groups: (1) asthenopic (e.g. dry eyes, eye strain), (2) ocular surface (e.g. eye irritation, tearing, red eye), (3) visual (e.g. blurred vision, double vision), and (4) extraocular (e.g. headache, neck, back and shoulder pain). In fact, despite the relevance of musculoskeletal symptoms in workers that use DSE, and the emphasis given in the literature to this occupational health problem, they have also been linked to CVS and can be more severe during tasks that involve prolonged computer use (Aarås et al. 2001; Filon et al. 2019; Das et al. 2022). A recent study developed by Das et al. (2022), verified that 84.4% of the participants reported at least one symptom of CVS.

The time spent using visual display screens is one of the main risk factors described in the literature;

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however, there are others that should also be taken into consideration, especially those associated with the workstation and work environment, such as screen position and quality, viewing distance, lighting, thermal environment and workplace glare (Agarwal, Goel, and Sharma 2013; Altalhi et al. 2020; Alex et al. 2013; Woo, White, and Lai 2016; Ranasinghe et al. 2016; Sakellaris et al. 2016).

Despite the increased number of DSE users and the time spent using these devices, it is possible to reduce the occurrence of symptoms related to CVS as well as musculoskeletal discomfort, through an ergonomic intervention (Alves et al. 2018). However, few studies have been developed to assess the effectiveness of an ergonomic intervention that combines preventive behaviours, eye-level intervention and workstation redesign. Amick et al. (2012), through an ergonomic intervention, tried to improve visualisation angle and distance from the eyes to the screen, and understand the effect of it in the reduction of visual symptoms. Even though no significant effect was identified, the trend was positive during follow-up. Menéndez et al. (2012), verified the impact of two office ergonomic interventions on the reduction of visual symptoms. Mahmoud and Sabbour (2021) assessed the effectiveness of an educational intervention on CVS, observing a decrease in visual symptoms reported by computer users, due to the adoption of protective ergonomic practices. Robertson, Huang, and Lee (2017) and Choobineh et al. (2011) verified the effect of an ergonomic intervention in musculoskeletal symptoms. Robertson et al. (2009) analysed the effect of an ergonomic intervention on workers' knowledge, computer behaviours, and in the reduction of musculoskeletal risk. They observed a significant increase in knowledge in ergonomics after training and a lower musculoskeletal risk compared to the control group, by reducing non-neutral postures and muscular effort. Aarås et al. (2001) analysed the effect of workplace and light systems redesign, as well as of an optometric intervention in some visual symptoms and in musculoskeletal pain. However, the focus was not to determine the CVS, but only, to characterise a limited number of visual symptoms. Despite the inclusion of both training and some ergonomic adjustments in previous interventions, none of them included training for both posture and visual health (see, e.g. Menéndez et al. 2012; Mahmoud and Sabbour 2021; Robertson, Huang, and Lee 2017; Choobineh et al. 2011; Robertson et al. 2009), with the exception of Aarås et al. (2001). Additionally, ergonomic interventions were more focused on workstation redesign and visual distances, keeping behind some other risk factors such as the physical environment (e.g. luminaires and windows orientation) (see, e.g. Amick et al. 2012; Menéndez et al. 2012; Mahmoud and Sabbour 2021). Only Aarås et al. (2001) had in consideration the illumination system redesign.

The present study intends to develop and implement an ergonomic intervention program at the workplace of knowledge workers, and to evaluate its impact on the reduction of CVS and musculoskeletal symptoms. As far as we know, this is the first study including both. The ergonomic intervention program was designed to verify the following: (1) CVS and office ergonomics training provide the knowledge to adjust the workstation, (2) there are significant differences in the severity of CVS before and after the intervention, (3) there are significant differences in the frequency and intensity of CVS-related visual symptoms before and after the intervention, (4) there are significant differences in musculoskeletal discomfort before and after the intervention, (5) taking breaks (20x20x20 rule), as a way of reducing the time of prolonged exposure to the display screen, reduces the severity of visual symptoms, (6) workers who reported using artificial tears regularly showed lower CVS severity.

2. Material and methods

2.1. Participants

The study was carried out in the administrative and technical services of a charity and social assistance institution. The sample was selected according to the following assumptions: (1) working four hours or more at the computer in a normal working day, five days a week; (2) developing tasks in administrative and technical services at least three days a week; (3) not missing work for more than 15 days due to vacation or health problems.

From the total employees of the facility under study (101), 84 knowledge workers fitted the criteria and were included in this study (mean age 43.2 ± 9.7 years, where min = 26 and max = 65; 65.5% female). On average, employees performed computer tasks over 6.9 ± 1.0 hours per day, adding more 1.1 ± 1.0 hours of computer use at home. Some participants use optical correction during administrative tasks, 51.2% wearing glasses and 11.9% contact lenses. All participants used a desktop computer, with individual accessories (keyboard and mouse).

Informed consent was obtained from all participants, in strict accordance with the institutional guidelines of our local ethics committee and after a full given explanation.

2.2. Study design

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of the School of Health of Polytechnic Institute of Porto (CE0046; 03/03/2020).

The research was developed in 5 main stages. The tools and strategies applied in the different stages of the study are described in Table 1.

In order not to identify the participants included in the study, all workers were coded with a letter and three digits (e.g. A001). To this end, to each worker was given a card with their code, which they used whenever requested at different times of data collection.

2.3. Intervention impact assessment – instruments

2.3.1. Sociodemographic data, visualisation habits and workstation conditions questionnaire

A questionnaire was applied at the Pre-intervention stage to collect information about participants' sociodemographic data, visualisation habits and workstation conditions. The questionnaire was divided into 3 sections: (1) sociodemographic characterisation, collecting individual information from employees (e.g. gender, age, activity and length of professional activity, and health condition); (2) computer tasks and viewing habits (e.g. hours of computer work, number of screens on the desktop, number and duration of breaks); (3) workstation conditions (e.g. screen position, illuminance level, reflections).

2.3.2. Computer vision Syndrome questionnaire (CVS-Q)

CVS was determined using the translated Computer Vision Syndrome Questionnaire (CVS-Q) developed by

Table 1. Description of the study steps.

Study stages	Activities	Duration
Preparation	Development of tools to support the intervention and data collection, namely: • Preparation of the information leaflet about the symptomatology associated with CVS, its causes, and good practices to apply. • Definition of the content of the training session and preparation of the PowerPoint. • Preparation of record sheets. • Development of the questionnaires for the evaluation of the of the working conditions, viewing habits and the visual and musculoskeletal symptoms.	3 months
Characterisation	• Application of a questionnaire before the intervention to: 1. characterise the frequency and intensity of symptoms associated with CVS (scale translated from Seguí et al. (2015)); (2) characterise preventive behaviours; 2. subjective assessment of the conditions of the environment and workstation; 3. assess musculoskeletal discomfort (musculoskeletal discomfort scale). • Characterisation of workstations regarding its design and match to the user, as well as the arrangement of the workplace in relation to windows and light fixtures.	1 month
Intervention - first stage	• Training session with a duration of 30 minutes for all employees in a 'classroom' context. • Delivery of the informational pamphlet.	3 weeks
Evaluation of the impact of the training session	Determination of the percentage of workstations redesigned by employee initiative.	1 week (1 week after the 'classroom' session)
Intervention - second stage	Individual on-the-job training of 15 minutes, followed by the redesign of the workplaces when necessary.	2 weeks
Intervention - third stage	• Visual examination of participants with the presence of CVS (pre-intervention questionnaire results). Visual examination included visual acuity evaluation, refraction, cover test, binocular vision tests, ocular motility, near point of convergence and fusional vergence amplitude. Refractive correction and convergence insufficiency treatment was done when applicable. When the near point of convergence and fusional vergence amplitude showed abnormal values, convergence insufficiency treatment was performed in the clinic, using prisms and synoptophore. The exams and treatment were carried out by experienced orthoptists in the pedagogical clinic of ESS|P.Porto. • Delivery of lubricating eye drops to each employee who reported dry eye symptoms in the CVS questionnaire to reduce the discomfort.	1 week (2 months after the intervention)
Follow-up – moment 1	Application of the CVS-related symptoms assessment scale and musculoskeletal pain assessment scale.	1 week (2 months after the intervention)
Follow-up – moment 2	Application of the CVS-related symptoms assessment scale and musculoskeletal pain assessment scale.	1 week (4 months after the intervention)

Seguí et al. (2015) and adapted to Portuguese by Rodrigues and Mateus (2020). The following 16 symptoms were evaluated: burning eyes, itchy eye, foreign body sensation, eyelid twitching, excessive blinking, conjunctival hyperaemia ('red eye'), eye pain, heavy eyelids, dry eye, blurred vision, diplopia, blurred near vision, photophobia, glare, visual loss, and headache. Each symptom was evaluated in terms of its frequency (0 = never; 1 = occasionally; 2 = often/always) and intensity (1 = moderate; 2 = severe). The score was obtained by applying the following Equation 1, as proposed by the authors (Seguí et al., 2015). Whenever the score was equal or higher than 6 (cut-off value), the subject was classified as having CVS.

$$Score = \sum_{i=1}^{16} (frequency\ of\ symptom\ occurrence)_i \times (intensity\ of\ symptom)_i \quad (1)$$

CVS-Q was completed in 3 different stages: (1) Pre-intervention stage; (2) Follow-up - moment 1, corresponding to the second month after the program implementation; (3) Follow-up - moment 2, corresponding to the fourth month after the implementation of the program. Participants were asked to complete the questionnaire at the end of the workday, corresponding to the period when visual symptoms are most present.

2.3.3. Musculoskeletal discomfort visual Analog scale (VAS)

A 100 mm Visual Analog Scale (VAS) was adapted to a body chart and used to determine musculoskeletal discomfort (0= 'no discomfort' and 10= 'extreme discomfort'). The level of discomfort was measured in different parts of the body, according to the body chart: neck, left and right shoulder, left and right elbow, left and right wrist and hand, upper back and lower back. The scale was applied at the beginning and end of the workday. This is a scale broadly used in previous study to assess musculoskeletal discomfort (see e.g. Lamanuzzi et al. 2023; Tapanya et al. 2021).

The VAS to assess musculoskeletal discomfort was applied at all 3 moments, as was the scale for the assessment of visual symptoms (pre-intervention and 2 and 4 months after the intervention) in order to check for changes/improvements in musculoskeletal symptoms.

2.4. Description of intervention activities

2.4.1. Training program

Two training sessions were carried out, one in the classroom and the other at the workstations. Both training sessions were delivered by an ergonomist, that was part of the research team.

The training objectives were: (1) to know the symptoms related to CVS; (2) understand the fundamental principles of ergonomics in offices; (3) recognise the main flaws in the setup and adjustment of your workstation; (4) know the key risk control measures that can be implemented. The training session delivered in the classroom was a Power-Point presentation, were expositive and interrogative teaching methods were applied. The contents included: the concept of CVS, study background, results from the pre-intervention, risk factors for CVS and MSD and prevention measures.

At the end of these sessions, flyers created specifically to this project were delivered to all the participants.

To each employee was also given a 15-minute on-the-job training that consisted of explaining and demonstrating the correct postures and adjustments needed to be made in each workstation.

2.4.2. Workplace redesign

After the training session stage, the necessary readjustments to the workstations were performed. It is important to note that some of the workstations were already previously redesigned by the workers after the 'classroom' session. The posture and distances recommended in ISO 9241-5 (1998) and ISO 9241-303 (2008), respectively, were used as references.

For each computer user, the following measures were verified in collaboration with the workers: (1) height of the chair – in order to ensure that both feet were comfortably supported on the floor, and the legs flexed at an angle of approximately 90°; (2) back supported by the backrest of the chair – in order to ensure an upright sitting posture with lumbar support; (3) supported arm – ideally installed on the chair support, in order to ensure that the forearm and upper arm make an angle of approximately 90°; (4) screen height – in the sense of ensuring appropriate eye height, the top of the monitor should be aligned horizontally with eye level[1]; (5) viewing distance – to ensure that the user maintains an eye distance from the monitor of 400 mm to 750 mm; (6) mouse and keyboard position – kept within arm's reach, which previously meets the supported arm criterion, and placed side by side.

2.5. Data Analysis

A descriptive analysis of all the variables in the study was performed, and the results were expressed in percentages and as mean (x) ± standard deviation (sd).

The normality of the results was verified using the Kolmogorov-Smirnov test. To determine the existence of significant differences in the severity index of visual symptoms, musculoskeletal discomfort, and the prevalence of CVS between the three moments (pre-intervention; follow-up 1; follow-up 2), the Friedman nonparametric test for three paired samples was used. To assess whether the proportion of CVS, use of artificial tears or the application of the 20x20x20 rule (after 20 minutes on the computer, a person should look at an object 20 feet away for 20 seconds) was the same between the tree moments, Q Cochran test for paired samples was used. The non-parametric Wilcoxon test for two paired samples was used to check for significant differences in musculoskeletal discomfort between two moments. To investigate the existence of a relation between the severity index of visual symptoms, the application of the 20x20x20 rule, artificial tears and the presence of allergies, the nonparametric Mann-Whitney test for two independent samples was used.

The significance level was considered as $p < 0.05$. Data analysis procedures were performed using the Statistical Package for Social Sciences (IBM SPSS®, version 25, Inc., Chicago, Illinois).

3. Results

The following subsections describe the results related to the intervention in terms of: (1) workstation adjustment; (2) visual symptoms; (3) musculoskeletal symptoms; (4) preventive behaviours, namely application of the 20x20x20 rule and use of artificial tears.

3.1. Analysis of the impact of the intervention on workstation adjustment

In the week after the training session, the employees adjusted their own workstations individually and voluntarily. Additionally, whenever additional adjustments were necessary, the correction of the workstation was made individually, with the support of an experienced ergonomics, along with explanations about ergonomics of the workstation. These workplace actions are particularly important, not only to raise awareness among those who have not made any adjustments themselves but also to correct those who did so improperly. Table 2 shows the data obtained in percentage, of workstations, in the first week after the intervention.

Table 2. Adjustments made by employees to the workstation.

Variable	% Workstations
Workplace adjustment by employee after training (n = 71)	46.5
Workstation adjusted correctly (n = 71)	16.7

46.5% of workers who attended the training adjusted their workstation immediately after the training. However, the evaluation of the workstation and the adjustments made showed that only 16.7% of workstations were adjusted correctly (35.9% of all adjusted workstations), with at least one aspect of the job needing further correction. The main adjustment errors were associated with computer display height (51.0%), viewing distance (40.0%), and chair height adjustment (10.0%).

Two additional evaluation moments were performed, at the end of 2 months and at the end of 4 months. During these assessments, whenever the workstation design did not prove to be appropriate, a new employee awareness session was carried out, and the workstation was readjusted again. In the end of the intervention, it was possible to realise that 92.1% of the workers had the screen at a correct height and all of them at appropriate distance. Posture was also considered appropriate in 90.8% of the workers.

3.2. Analysis of the impact of the intervention on visual symptoms

Regarding visual symptoms, the results obtained are represented in 3 different evaluation moments: pre-intervention; follow-up - moment 1 (2 months after the intervention); and follow-up - moment 2 (4 months after the intervention). The frequency and intensity with which the participants experienced the different visual symptoms described in Seguí et al. (2015) was analysed. The results obtained are summarised in Table 3 for the 3 moments.

According to the data obtained, it can be observed that in pre-intervention, the symptoms reported as experienced most frequently were headache (0.87 ± 0.64) and burning eyes (0.83 ± 0.51). Considerable values of symptom frequency before the intervention were also obtained for photophobia (light sensitivity) (0.68 ± 0.68), blurred vision (0.56 ± 0.63), red eye (0.54 ± 0.63), blurred near vision (0.51 ± 0.63), and dry eye (0.50 ± 0.67). Similarly, the symptoms experienced most intensely were also dry eye (1.24 ± 0.43) and headache (1.20 ± 0.40).

During the follow-up moments, some changes in the symptoms reported were observed. Even though headache and burning eyes remain as the most

Table 3. Frequency and intensity of each visual symptom by time of assessment.

Visual Symptom		Pre-intervention (x ± sd)	Follow-up (x ± sd) Moment 1	Follow-up (x ± sd) Moment 2	p Value
Burning eyes	Freq.	0.83 ± 0.51	0.76 ± 0.52	0.76 ± 0.49	0.495
	Int.	1.06 ± 0.24	1.02 ± 0.14	1.04 ± 0.19	0.607
Itchy eye	Freq.	0.52 ± 0.57	0.72 ± 0.54	0.67 ± 0.50	**0.047**
	Int.	1.10 ± 0.30	1.02 ± 0.14	1.02 ± 0.14	0.169
Foreign body sensation	Freq.	0.31 ± 0.51	0.30 ± 0.49	0.40 ± 0.59	0.438
	Int.	1.17 ± 0.38	1.10 ± 0.31	1.12 ± 0.33	0.582
Eyelid twitching	Freq.	0.45 ± 0.57	0.56 ± 0.58	0.59 ± 0.64	0.119
	Int.	1.17 ± 0.38	1.08 ± 0.28	1.10 ± 0.31	0.074
Excessive blinking	Freq.	0.29 ± 0.53	0.23 ± 0.45	0.37 ± 0.56	0.553
	Int.	1.10 ± 0.30	1.00 ± 0.00	1.00 ± 0.00	0.692
Red eye	Freq.	0.54 ± 0.63	0.55 ± 0.56	0.51 ± 0.60	0.396
	Int.	1.15 ± 0.37	1.00 ± 0.00	1.03 ± 0.17	0.786
Eye pain	Freq.	0.29 ± 0.45	0.20 ± 0.40	0.27 ± 0.45	0.676
	Int.	1.13 ± 0.34	1.00 ± 0.00	1.05 ± 0.22	0.432
Heavy eyelids	Freq.	0.46 ± 0.57	0.48 ± 0.50	0.54 ± 0.58	0.405
	Int.	1.03 ± 0.29	1.00 ± 0.00	1.00 ± 0.00	0.670
Dry eye	Freq.	0.50 ± 0.67	0.61 ± 0.67	0.58 ± 0.66	**0.032**
	Int.	1.24 ± 0.43	1.14 ± 0.36	1.14 ± 0.35	0.331
Blurred vision	Freq.	0.56 ± 0.63	0.49 ± 0.58	0.49 ± 0.58	0.434
	Int.	1.12 ± 0.33	1.00 ± 0.00	1.03 ± 0.17	0.198
Diplopia	Freq.	0.24 ± 0.51	0.25 ± 0.47	0.26 ± 0.53	0.551
	Int.	1.12 ± 0.33	1.00 ± 0.00	1.00 ± 0.00	0.510
Blurred near vision	Freq.	0.51 ± 0.63	0.49 ± 0.58	0.47 ± 0.60	0.562
	Int.	1.14 ± 0.35	1.00 ± 0.00	1.06 ± 0.25	0.692
Photophobia	Freq.	0.68 ± 0.68	0.73 ± 0.65	0.58 ± 0.66	0.102
	Int.	1.19 ± 0.40	1.09 ± 0.29	1.05 ± 0.23	**0.032**
Glare	Freq.	0.30 ± 0.51	0.20 ± 0.44	0.21 ± 0.50	0.375
	Int.	1.17 ± 0.39	1.00 ± 0.00	1.08 ± 0.28	0.174
Visual loss	Freq.	0.17 ± 0.41	0.13 ± 0.34	0.12 ± 0.33	0.662
	Int.	1.07 ± 0.48	1.00 ± 0.00	1.00 ± 0.00	0.584
Headache	Freq.	0.85 ± 0.61	0.85 ± 0.58	0.75 ± 0.52	**0.036**
	Int.	1.20 ± 0.40	1.15 ± 0.36	1.04 ± 0.19	0.053

Friedman nonparametric test for three paired samples; significance level $p < 0.05$.
Moment 1 – 2 months after the intervention; Moment 2 – 4 months after the intervention; Freq. – Frequency; Int. – Intensity; x – mean; sd – standard deviation.

frequently experienced symptoms, there was a tendency towards their reduction. For symptoms intensity, similar results were observed. There was a reduction in both headache and dry eyes intensity. However, only for photophobia (intensity) and headache (frequency), a significant ($p < 0.05$) reduction was observed between the three moments.

Despite the promising results observed for the ergonomic intervention, it was observed that the frequency of some visual symptoms increased after the intervention, where significant differences were found for the ocular symptoms itchy eye and dry eye ($p < 0.05$).

Table 4 presents the results obtained for the severity index (summatory of the frequency x intensity after being recoded as: 0 = 0; 1 or 2 = 1; 4 = 2) of visual symptoms, determined according to the measurement scale validated by Seguí et al. (2015), as well as the prevalence of CVS, identified in percentage. Accordingly, workers who scored 6 or more, were classified as having symptoms associated with CVS.

Through the analysis of the values obtained for severity in the pre-intervention and follow-up

Table 4. Severity and prevalence of CVS at the 3 moments of assessment.

Moment	Severity (x ± sd)	CVS Prevalence (%)
Pre-intervention	7.08 ± 4.23	63.10
Follow-up - moment 1	6.07 ± 4.37	56.00
Follow-up - moment 2	6.32 ± 4.27	54.80
p-value	0.773*	0.332**

*Friedman nonparametric test for three paired samples; significance level $p < 0.05$.
**Q Cochran test for paired samples; significance level $p < 0.05$.

moments, it is possible to verify that there is a tendency to decrease the severity of visual symptoms reported by the workers (pre-intervention = 7.08 ± 4.23; follow-up first moment = 6.07 ± 4.37; follow-up second moment = 6.32 ± 4.27). However, this reduction was not significant ($p > 0.05$). It is noteworthy that the decrease in symptom severity is more pronounced during the first follow-up compared to the second one, where the value is slightly higher than in the follow-up-moment 1.

Regarding the prevalence of CVS, the results reveal that a gradual reduction throughout the evaluation period of the impact of the intervention. However, the differences between the three moments were not significant ($p > 0.05$).

3.3. Analysis of the impact of the intervention on musculoskeletal symptoms

Fig. 1 shows the results obtained for upper body musculoskeletal symptoms at the pre-intervention, follow-up - moment 1, and follow-up - moment 2, at two different times of the day (beginning and end of the workday).

Before the intervention, it was possible to verify that the most reported musculoskeletal symptoms, at the beginning and end of the day, were discomfort in the lower back (beginning of the day: 1.28 ± 1.69; end of the day: 3.22 ± 2.79), upper back (beginning of the day: 1.23 ± 1.65; end of day: 3.17 ± 2.80), right shoulder (beginning of the day: 1.19 ± 1.86; end of day: 2.65 ± 2.94), and neck (beginning of the day: 1.04 ± 1.60; end of day: 3.29 ± 2.81).

Comparing the pre-intervention with follow-up - moment 1, at the end of the day, there was a tendency towards a decrease in the level of discomfort in all the regions analysed, except for the right elbow, which increased slightly, but this increase was not significant ($p > 0.05$). By observing Fig.1 it is possible to see that the neck, upper back, right shoulder, and lower back were the areas that obtained the most pronounced reductions, with significant differences between the two moments ($p < 0.05$).

Between follow-up - moment 1 and moment 2, a stationary discomfort level was verified in the neck, left wrist, right shoulder, and right wrist areas. However, there was a tendency for an increase in musculoskeletal discomfort felt at the end of the workday, particularly in the lower back, left shoulder, left elbow, upper back, and right elbow, although this was not significant ($p > 0.05$).

Comparing the pre-intervention with follow-up - moment 2, it is possible to verify that the major reductions in discomfort occurred in the upper back and neck, which proved to be significant ($p < 0.05$).

Results from Figure 1 also denote that the symptoms are more pronounced in the right region of the body, specifically the right shoulder, right elbow, and right hand/wrist. These differences were statistically significant at the end of the day for the shoulder and right hand/wrist before the intervention and in follow-up moment 1 ($p < 0.05$). For all these regions, the differences were statistically significant in follow-up moment 2 ($p < 0.05$). At the beginning of the day, these differences were only statistically significant in follow-up moment 1 for the shoulder and right hand/wrist and in follow-up moment 2 for the right elbow and right hand/wrist ($p < 0.05$).

3.4. Analysis of the impact of the intervention on the application of the 20x20x20 rule and the artificial tears

In the training session, the 20x20x20 rule was included in the control measures of symptoms associated with CVS. Also, as part of the control measures, the application of artificial tears was suggested to prevent/reduce the occurrence of dry eye symptoms.

The application of the 20x20x20 rule and artificial tears while using the computer was questioned throughout the evaluation period, corresponding to 1 month before the intervention and 2 and 4 months after the intervention. The results are shown in Table 5.

Table 5 shows that at follow-up - moment 1, 69.0% of the employees said they applied the 20x20x20 rule during continuous work on the computer, a considerable increase in comparison with the data obtained before the intervention (14.9%). However, in the four months following the intervention, there was a decrease in the number of employees who applied this rule to take breaks during computer tasks.

Regarding the application of the 20x20x20 rule and the decrease in the severity of visual symptoms, significant differences were observed at follow-up - moment 2 ($p < 0.05$).

During the intervention period, each employee with dry eye symptoms received a pack of artificial tears, and it was suggested they apply them whenever they

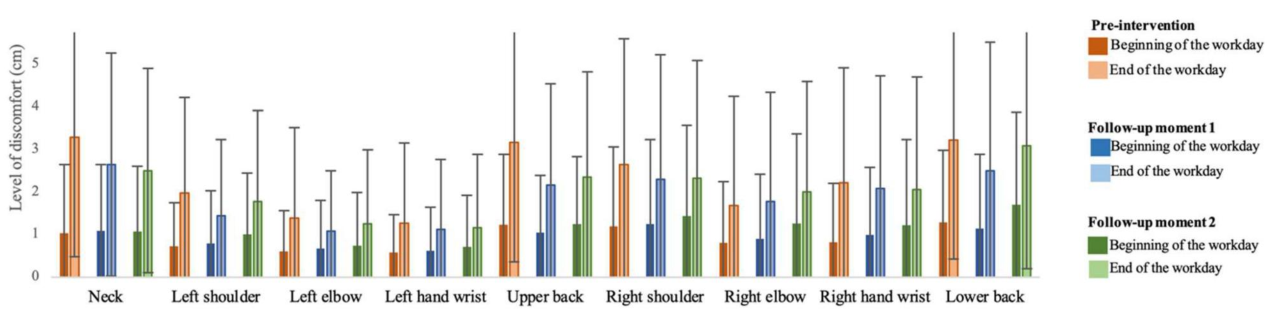

Figure 1. Musculoskeletal discomfort of each region at the three evaluation moments at the beginning and end of the workday.

Table 5. Applying the 20x20x20 rule and artificial tears during computer viewing.

Variable	Pre-intervention (%)	Follow-up Moment 1 (%)	Follow-up Moment 2 (%)	*p*-value
20x20x20 Rule				
Apply	14.9	69.0	42.7	0.03
Not apply	85.1	31.0	57.3	
Artificial tears				
Apply daily to a few times a week	7.4	23.9	21.1	0.001
Rarely/Not used	92.6	76.1	78.9	

Q Cochran test for paired samples; significance level $p < 0.05$.

felt ocular discomfort. According to the results presented in Table 5, it was observed that two months after the intervention 23.9% of the employees said they applied the artificial tears daily/sometimes a week, an increase of 16.5% compared to the pre-intervention. In the four months following the intervention, there was a small decrease in employees who maintained this practice. However, there were no significant differences in the severity of visual symptoms in relation to the use or non-use of artificial tears ($p > 0.05$).

4. Discussion

With this study, an ergonomic intervention program was developed and implemented at the workplace of knowledge workers, combining preventive behaviours, eye-level intervention and workstation redesign. Intervention impact was evaluated by the reduction of CVS and musculoskeletal symptoms.

After the first intervention, related to the training session, a change in the employee's behaviours was verified. This shows the added value of training, since almost half of the workers took the initiative to evaluate and change their own workstation. Several readjustments were done in what regards to workplace design, particular for computer screen. It is known that inadequate viewing angles or distances can lead to increased muscular effort and visual discomfort (Ranasinghe et al. 2016; Woo, White, and Lai 2016). Viewing distances should be determined based on the work context, varying according to task demands, computer screen characteristics, and the visual capacity of each individual (Woo, White, and Lai 2016). Aditionally, in this adjustmnet, individual physical characteristics and preferences of the particpants were considered, such as their antropometric dimentions.

In the present study, the visual symptoms reported as the most frequent and with the highest intensity at the three assessment moments (pre-intervention; follow-up - moment 1 and follow-up - moment 2) were headache and burning eyes. Even so, there is a tendency for its reduction. Photophobia (intensity) and headache (frequency) are the only symptoms that showed a significant reduction between the three moments. Also, Shantakumari et al. (2014) found that the visual symptoms most reported by computer users were headache and burning/eye itching. In turn, Portello et al. (2012) found that the visual symptoms described as most frequent (half the work period to the whole period) were, in decreasing order, eye fatigue, eye dryness, eye strain and excessive sensitivity to light. Aarås et al. (2001) conducted a multidisciplinary intervention, where lighting systems and workplaces were redesigned, and optometric interventions were applied. After improving visual conditions and giving optometric corrections, a significant reduction of visual discomfort was verified, in particularly in what regards to the symptoms of light sensitivity, eye burning and eye irritation. Also, Amick et al. (2012) found that light sensitivity was one of the most responsive symptoms to the change in lighting conditions, and they also found a reduction in dryness and eye pain symptoms. The changes made to the workstation layout in relation to windows and light fixtures, the angle and height of the monitor, as well as the position of the keyboard, and control of external lighting may have influenced the reduction of reflections caused by the lighting conditions of the workstations. Pina (2018) found a considerable percentage of workstations with excessive lighting (>1000 lux) at the level of the desk task area, levels that may cause reflections on the screen and keyboard. In the present study, a reduction in the workstation reflections reported by employees, from 32.5% to 30.7% was also found.

In our study, the offices varied in their layouts. Some were set up as open-plan 'islands', while others were designed for just one or two individuals. Consequently, it was necessary to tailor the redesign to accommodate each specific situation. This contributed also to change the illuminance levels. Nevertheless, an evaluation of the difference in illuminance levels pre- and post-interventions was not conducted. Lighting, both in terms of quantity and quality, is an aspect to consider when working on a computer (Schneider 2002). Insufficient or excessively high illuminance levels (Rosenfield 2011; Gowrisankaran and Sheedy 2015), the presence of reflections (Yan et al. 2008), the direction of lighting, the colour of lighting and surfaces (Reinhold and Tint 2009), the possibility of glare (Anshel 2005), and natural lighting (Hwang and Kim 2011) are factors that can influence the comfort and performance of workers and also contribute to visual changes.

Regarding the severity of visual symptoms reported between the three moments, a tendency to decrease was verified, although not significant. However, an unexpectedly significant increase in the frequency of some ocular symptoms, such as itchy eyes and dry eyes, was observed. This result could be explained by the fact that the intervention follow-up period was coincident with allergy season and increased outdoor temperature. According to the available data by the Portuguese Allergy Network, on that period, the levels of pollens were classified as extremely high in the region where the study was conducted (RPA n.d.). Symptoms usually related to these kinds of allergies include itching and dry eyes (Bielory, 2004; La Rosa et al. 2013). Artificial tears provide a first-line defense at this level. However, when non-pharmacological strategies do not provide adequate symptoms relief, pharmacological treatments should be applied to diminish the allergic response (La Rosa et al. 2013).

Low relative humidity (<40%), high air temperature and air currents promote increased evaporation of the precorneal tear film, resulting in symptoms of ocular discomfort. Also, factors such as dust, pollens, aerosols or combustion products can influence and aggravate ocular symptoms (Parihar et al. 2016). Medication for the treatment of allergies (antihistamines) is also a contributing factor to the symptom of dry eye (Rosenfield 2011). However, in the present study, there were no significant differences in the severity of visual symptoms obtained for the three moments in the individuals who reported having allergies (medical treatment) compared to the others ($p > 0.05$).

In this study, the prevalence of CVS decreased during the study, as expected, despite the non-significant differences between the three time points. This decrease was most prominent between the pre-intervention and follow-up 1. It then tended to decrease more gradually. With the continued program, we believe that significant improvements may be observed. The effect of long term programs was previouly observed by Menéndez et al. (2012). The authors found a nonsignificant reduction in visual symptoms at 6 months follow-up, and only found a significant effect of symptom reduction at 12 months follow-up. Additionally, it is important to note the possible influence of individual factors in these results, such as allergies, which are common at the time of the second assessment (Parihar et al. 2016).

The parts of the body described with higher musculoskeletal discomfort in the three moments of evaluation were the neck, lower and upper back, and right shoulder. Our results also denoted that lower values were obtained for the left upper limb compared to the right. On other hand, Baydur et al. (2016) found that, after the intervention, the possibility of developing symptoms on the right side of the neck and in the right wrist and hand was significantly less comparing to the control group.

Comparing the pre-intervention and follow-up - moment 1, a tendency to decrease musculoskeletal discomfort was observed, at the end of the workday, for all analysed regions. The neck, upper back, right shoulder, and lower back showed a significant reduction in discomfort. The significant reduction verified in the neck area may be justified by the adjustments made to the height of the computer screens, which was the main error verified in the adjustment. In the upper and lower back, the significant reduction observed may be due to the training in office ergonomics, which allowed the acquisition of ergonomic knowledge for the adoption of an adequate sitting posture while working at the computer, as previously observed by Robertson et al. (2009); the adjustment made to the computer screen height and mouse position, may also have contributed to the reduction of discomfort in the upper and lower back, respectively. Regarding the right shoulder, the significant reduction observed may be due to the adjustment made to the keyboard and mouse, as well as the chair height. Similar results were found by Celik et al. (2018). Indeed, subjects tend to report higher levels of pain in the right upper limbs. This observation may be attributed to the fact that the majority of subjects primarily use their right hand for mouse-related tasks (Shannon et al. 2023) and to the relationship between the mouse use and the risk factor of MSDs (Jovanovic and Simunic 2021).

Our results showed a stationary level of discomfort in some areas between the two follow-up moments. Lee et al. (2020) also found that the musculoskeletal symptoms did not show significant differences between follow up moments in any body region.

In our study, a tendency for an increase in musculoskeletal discomfort at the end of the day was found. Also, Lee et al. (2020) verified a small increase in pain intensity occurred in the neck, shoulder, upper back, and wrist/hand after 24 week. The increase observed in the left shoulder may be justified by the adjustment of approach to the desk, which complicates task area management, since most employees type on the keyboard and view papers at the same time. This discomfort could be prevented by the use of a paper holder.

The slight increase in discomfort observed in the right and left elbow may be justified by the fact that the armrest of the chair is not adjustable, neither in height nor in depth, and more than half of the employees choose to rest their arms on the table. The increase in discomfort in the lower back may be due to unknown external factors, since it follows the increase in discomfort at the beginning of the workday.

In general, the results obtained reveal the importance of an intervention that included training and workstation corrections in reducing musculoskeletal symptoms. Robertson et al. (2009) found that the intervention group with ergonomic training and a fully adjustable workstation observed significant reductions in work-related musculoskeletal injuries compared to the control group and the group with only training. This result suggests a synergy between training and workstation corrections, since they provide the knowledge needed for employees to make appropriate adjustments. This can also contribute significantly to reduce CVS, as previously observed by Ranasinghe et al. (2016).

There were also improvements in behaviours regarding the application of the 20x20x20 rule and artificial tears, which contribute to a reduction in the severity of visual symptoms. Alghamdi and Alrasheed (2020) concluded that the application of the 20x20x20 rule induces significant changes in dry eye symptoms with some impact on CVS signs and symptoms. However, there was a decrease in the number of employees who applied this rule, compared the follow-up – moment 1 and follow-up – moment 2 results. These results can be explained by the decrease in the degree of novelty, i.e. 'the honeymoon effect'. Despite this decrease, a significant reduction in the severity of visual symptoms was observed. In fact, it has been postulated that taking appropriate breaks during computer use and looking at distant objects between periods of computer using has significantly effect in controlling the symptoms of CVS (Munshi, Varghese, and Dhar-Munshi 2017). In the future, it will be important to enhance control over the application of this technique, as is the case with using an application that reminds the subject to take breaks every 20 minutes. In this study, it was not possible to implement such a measure due to limitations related to the installation of software on the institution's computers under study.

This study has some limitations that should be acknowledged. The sample under study was small, as was the follow-up period, facts that may have limited some conclusions. The posture assessment was based on the adjustment of the work to the workstation, and no specific method was applied (e.g. a postural risk assessment method such as Rapid Upper Limb Assessment - RULA). Results regarding the application of the 20x20x20 rule and the use of artificial tears were based on workers' reports and may not fully reflect day-to-day reality. However, the main concern in this study is the lack of a control group. Therefore, non- specific effects such as the Hawthorne effect cannot be ruled out as possible explanation for the changes observed in both follow-up momments. This was not considered, since it was a case study in a single institution, where it was not possible to ensure the non-influence of the intervention group on the other participants (imitation effect). The group was also not controled for further medical treatment, such as physioterapy or similar.

Additionally, the version of the questionnaire applied in this study was adapted for the Portuguese population in terms of language and comprehensibility, following the existent procedures available to this end (see Rodrigues and Mateus 2020). According, the cut-off of 6 proposed by the original authors was also used in this study. However, in a previous study conducted with this translated version, a direct relationship between CVS score and the blinking rate was observed, suggesting its appropriateness (Lapa et al. 2023).

5. Conclusions

The results of this study prove the importance of an ergonomic intervention program in reducing CVS and musculoskeletal symptoms. Workers proved to be available for behavioural chances, since it was observed in the end of this project that the number of workstations that match the individuals' anthropometric characteristics was higher and that preventive behaviours such as eye lubrification and visual rest also increased. However, positive health effects were only partly observed. We believe that it happens mostly because of the period for this intervention evaluation. If the company adopt these practices as a routine, higher improvements in workers' health are expected. It is important that this program be maintained over time at this institution and not limited to the time of this study. Only this way significant results in reducing symptoms are expected to be achieve. It is also important to involve the organization's top management to allow the adoption of structural measures that would contribute to the improvement of working conditions.

Note

1. When subjects were wearing progressive lenses, we adjusted the monitor height to be slightly lower.

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