

Project title

Computer Visual Syndrome – Prevalence, Causes and Prevention

Students:

Bárbara Cardoso – Student of the MSc in Hygiene and Safety in Organizations, ESS – P.Porto

Ana Pina – Student of the MSc in Hygiene and Safety in Organizations, ESS – P.Porto

Teachers:

Matilde A. Rodrigues – Department of Environmental Health, Health and Environment Research Center, ESS – P.Porto

Catarina Mateus – Department of Orthoptics, Health and Environment Research Center, ESS – P.Porto

Institution:

Health and Environment Research Center, School of Health of the Polytechnic Institute of Porto, Porto, Portugal

Porto, 28 de june de 2018

1. Project title: Computer Visual Syndrome – Prevalence, Causes and Prevention

2. Team

Students:

Bárbara Cardoso – Student of the MSc in Hygiene and Safety in Organizations, School of Health of the Polytechnic Institute of Porto, Porto, Portugal

Ana Pina – Student of the MSc in Hygiene and Safety in Organizations, School of Health of the Polytechnic Institute of Porto, Porto, Portugal

Teachers:

Matilde A. Rodrigues – Department of Environmental Health, Health and Environment Research Center, School of Health of the Polytechnic Institute of Porto, Porto, Portugal

Catarina Mateus – Department of Orthoptics, Health and Environment Research Center, School of Health of the Polytechnic Institute of Porto, Porto, Portugal

3. Institution:

Health and Environment Research Center, School of Health of the Polytechnic Institute of Porto, Porto, Portugal

4. Partners:

Alcon Portugal – Produtos e Equipamentos Oftalmológicos, Lda. – Ophthalmic products and equipment company

Santa Casa da Misericórdia do Porto – Holy House of Mercy – Institution of social assistance

5. Study problem

People have become increasingly dependent on the use of display screen equipment (DSE), i.e. desktop computers, laptop computers, tablets and smartphones, being such equipment used for both professional and non-professional purposes (Yan et al., 2008). In workplaces, computers play an important role, improving work effectiveness and quality. However, because such equipment is broadly used for a set of tasks that include typing, reading, writing and visualization, in some cases for long hours, in inappropriate environments and workplaces, and under sustained non-neutral postures, health disorders can arise. The literature has emphasized eye-related discomfort and/or visual problems (see e.g. Seguí et al., 2015), as well as musculoskeletal disorders (MSDs) (see e.g. Thorud et al., 2012; Wimalasundera, 2006).

Despite the importance of MSDs, visual problems should not be dismissed when we are studying visual display terminal (VDT) workstations. The literature has highlighted some symptoms such as eye-related symptoms (eyelid tremor, heavy eyelids, dry eyes, watery eyes, burning eyes, eye pain), vision-related

symptoms (eyestrain, eye fatigue, blurred vision, double vision, excessive sensitivity to light, colour distortion and headache), and posture-related symptoms (neck, shoulder and back pain/discomfort) (see e.g. Blehm et al., 2005; Wimalasundera et al., 2006; Uchino et al., 2008; Rosenfield, 2011; Thorud et al., 2012; Seguí et al., 2015). The set of these symptoms is referred as Computer Visual Syndrome (CVS). The prevalence of CVS among workers who use VST workstations is high. Chu et al. (2011) identified CVS-related symptoms in more than 70% of computer users. Similar results were obtained by Agarwal et al. (2013).

The consequences of CVS are not limited to workers' health and wellbeing. Workers visual status is related to productivity in the workplaces where these workers are inserted, as evidenced by Rosenfield (2011). Visual disturbances may lead to an increase in the number of errors or to more frequent pauses, decreasing productivity (Yang et al., 2010).

Visual disorders are multifactorial and may be related to individual factors (e.g. visual condition, gender, age, etc), work habits and ergonomic aspects of the workplaces (Anshel, 2005; Blehm et al., 2005; Hayes et al., 2007; Portello et al., 2012). Gender and workers' age are frequently pointed as individual risk factors for CVS. Additionally, aspects associated with habits and lifestyles, the use of optical correction (glasses or contact lenses), the time spent using display screens, the maximum continuous working time to look at the screen and the number of breaks are factors associated with visual changes and increased CVS prevalence (Blehm et al., 2005; Tauste et al., 2014). The visual performance can also be affected by the image quality of the display screen, size, structure and style of the characters, which can lead to decreased performance (Menozzi et al., 2001) and higher visual fatigue (Anshel 2005a; Fostervold et al., 2006). It should be noted that the distance and position of the screen also affect the visual performance, and may be associated with a higher prevalence of CVS symptoms (Charpe & Kaushik, 2009, Reddy et al., 2013, Robertson 2007, Rosenfield 2011; Yan et al., 2008). Environmental factors, such as air temperature, relative humidity levels and the presence of chemical agents, have also been associated with SVC prevalence (Blehm et al., 2005 and Mashalla, 2014). However, lighting, in terms of its quantity and quality, is a critical aspect to be considered when assigning workplaces with computer (Schneider, 2002).

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, through an ergonomic intervention (Yan et al., 2008). However, few studies have been developed to assess the effectiveness of an ergonomic intervention that combines preventive behaviours, eyes treatment and workplaces redesign. Additionally, despite the existence of some software that helps workers to improve working habits, this kind of instrument should be adjusted to the target work group needs and particularities.

6. Project objectives

The objectives of the project are: (1) to characterize the CVS among the employees of a social care institution, who work four hours or more on the computer, through the identification of affected workers and the determination of its prevalence; (2) identify risk factors related to the CVS; (3) define an ergonomic intervention, creating the necessary tools such as a software; and (4) assess the effect of the ergonomic intervention.

The ergonomic intervention program was designed in order to test the following hypotheses:

H1: The regular use of artificial tears promotes the reduction of visual symptoms;

H2: Breaks, as a way to reduce the time of continuous look to VDT, reduces the prevalence of CVS-associated symptoms (20x20x20 rule);

H3: A higher percentage of employees adopted preventive behaviours after appropriate training.

H4: After training sessions, the percentage of workers that adopted preventive behaviours and the percentage of workplaces rearranged increased.

H5: Workplace rearrangements reduced visual symptoms.

7. Target population

The target population of this project are workers who performs tasks during four or more hours a day in VDT workstations.

8. Intervention design

8.1. Background

In this project, it was designed an ergonomic intervention to improve workplace, work environment, preventive behaviours and employees' visual performance, through an integrated approach. The intervention design was supported on the current knowledge about preventive strategies and control measures to reduce CVS symptoms.

Physical work environment is of particular relevance, mainly in what regards to illumination requirements. It should be created a visual environment that enable workers to perform visual tasks efficiently, comfortably and safely, throughout the whole work period, without visual fatigue and discomfort (ISO 8995:2005). Lighting requirements are specified in different guidelines (see ISO 8995:2005...). Illuminance levels should be appropriate for the tasks performed in VDT workstations. A minimum of 500 lux is frequently recommended in offices were tasks of writing, typing, reading and data processing are being carried out. However, excessive illuminance levels should also be avoided. According to Miguel (2012), illuminance levels

should not be higher than 1000 lux in office rooms. Reflections causing disability and discomfort glare should also be avoided (Anshel, 2005; ISO 8995:2005). In view of this, workers should check the room lighting, including illuminance levels, controlling natural and artificial light, glare, contrast, brightness, reflection. Additionally, they should control the screen lighting. Thermal environment and indoor air quality is also possible to be controlled by workers in some office rooms. Because thermal and air quality parameters have influence on CVS-related symptoms (e.g. dry eye, headache, etc), workers should be instructed how to improve/control it in their workplaces.

Ergonomics of the workstation (work chair, work desk, screen, keyboard, mouse, and document holder) is also a relevant matter, once it has influence on the adopted postures, viewing distances, viewing angles and glare on the screen. In several offices, it is difficult for workers to control the screen quality excepting the bright. However, they can have an active role on the orientation of the workplace in relation to luminaires and windows, as well as on the adjustments of the work chair, work desk, keyboard and mouse. Ergonomic requirements for office work with VDT are described in ISO 9241-5:1998.

Viewing distance, i.e., the distance between the eyes and the middle point of the screen, is pointed as an important risk factor for CVS (Yan et al., 2008; Rosenfield, 2011). Recommendations are different according to the guideline. ISO 9241-303:2008 indicates a viewing distance between 400 and 750 mm and NTP 139 a viewing distance between 450 and 550 mm, with a maximum of 700 mm in exceptional situations. Additionally, the workplace and the visual display should allow a gaze angle between 0° and 40° and a head-tilt angle between 0° and 25° (ISO 9241-303:2008).

The development of good habits while using computers is of paramount importance. Workers should follow the 20x20x20 rule, as recommended by professionals in ophthalmology and orthoptics (Anshel, 2005), i.e., every 20 minutes spend 20 seconds looking at an object 20 feet away. Computer programs can help workers to apply this rule (see e.g. Fenety & Walker, 2002; Mclean et al., 2001). Additionally, the use of artificial tears when workers are experiencing eye discomfort can contribute to reduce dry eye symptoms.

Workers need to have a regular ocular examination to assess eye structure and visual function. They should also perform a refractive evaluation regularly, verifying the need for optical correction and ensuring a good visual acuity (Anshel, 2005).

8.2. Intervention description

8.2.1. Sample:

The project is being carried out in an institution of social assistance for philanthropic purposes and public utility. At this stage of the project, where the intervention design is being tested, only the corporative services unit was included.

The sample was selected according the following inclusion criteria: (1) work four hours or more on the computer in a typical working day, five days per week; (2) develop tasks on the corporative services unit at least three days per week; (3) not to be absent from the work for more than 15 days for vacations or because of health problems. According to these criteria, a total of 103 workers from 14 departments were involved in this study. All workers operated in a VDT workstation, individual or shared with partitions between them (islands). The majority of the workers considered for this study were females (65%) with mean age 41.46 years (± 8.83 years). It was verified that they spent from 4 to 10 hours working on the computer during the working time (6.92 ± 1.13 hours), and that, on average, they performed work that involved tasks to the computer for 16.56 years (± 8.47 years).

8.2.2. Project phases:

Project phases	Activities	Time
Preparation	Development and pre-test of the Questionnaire A: characterization of the frequency and intensity of CVS-related symptoms (scale translated from Seguí et al., 2015); daily tasks; characterization of preventive behaviours; subjective assessment of the workplace and the work environment. Development of an information leaflet: CVS-related symptoms; causes of CVS-related symptoms; control measures. Definition of the classroom training session contents and development of the powerpoint. Design of software for the implementation of rule 20x20x20.	3 months
Problem characterization	Application of the Questionnaire A to all workers before the intervention. Ergonomic analysis of workstation. Screening for dry eye and visual changes.	1 month
Intervention	30-min training sessions to all workers in a "classroom". 15-min training sessions in the workplaces were rearrangements to the workstation were performed. Delivery of the information leaflet. Artificial tear delivery. Installation of software for the implementation of rule 20x20x20 in all computers. Orthoptic treatment of convergence insufficiency.	2 months
Intervention effect assessment – 1st moment	Determination of the percentage of workstations adjusted by initiative of workers.	1 week (1 week after the "classroom" training session)
Intervention effect assessment – 2nd moment	Determination of the percentage of workstations that remains adjusted. Application of the scale to assess CVS-related symptoms (part of Questionnaire A)	1 week (2 months after the intervention)
Intervention effect assessment – 3rd moment	Application of the scale to assess CVS-related symptoms (part of Questionnaire A)	1 week (4 months after the intervention)

8.2.2. Description of activities:

Activities	Description	Estimated costs
Questionnaire for initial diagnosis and intervention assessment	<p>A questionnaire was developed and applied to characterize frequency and intensity of CVS-related symptoms, workers' daily tasks, preventive behaviours, and to perform a subjective assessment of the workplace and the work environment. The first version of the questionnaire was tested regarding the intelligibility of the questions with a sample of 10 workers that were not a part of the study.</p> <p>This questionnaire is divided into 5 sections: (1) sociodemographic characterization, with the objective of collecting individual information (e.g. gender, age, tasks and career longevity); (2) computer tasks and visualization habits (e.g. hours working on computer, breaks, use of glasses, use of artificial tears); (3) workplace conditions (e.g. screen position, lighting level, glare); (4) CVS-related visual symptoms, through a scale translated from Seguí et al. (2015). This scale was applied before and again after the ergonomic intervention in order to assess its effect on CVS-related visual symptoms.</p>	€ 54 (≈0.05 each)
Ergonomic analysis of workstation	<p>Ergonomic requirements were verified in each workstation, including direction in relation to windows and luminaires, chairs (adjustability, lumbar support, backrest, armrests, seat material, swivel), tables (adjustability and space), computer screens (direction, height, viewing distance and screen quality), mouse, keyboard and the existence of document holders, footrests and adopted postures.</p>	
Visual screenings and treatment	<p>Illuminance requirements in all workstations, thermal environment conditions and indoor air quality were assessed using suitable equipment and according the current guidelines (see e.g. ISO 8995:2005; ISO 7730:2005)</p> <p>Before the ergonomic intervention, visual screening tests were performed to all subjects. Visual acuity, convergence, 3D vision and deviations of the visual axes were evaluated. As an activity of the ergonomic intervention program, all the subjects with insufficient convergence and/or large symptomatic exophoria were treated in the orthoptics lab at ESS P.Porto by orthoptists. The subjects were also advised to use optical correction while working on the computer.</p>	
Training sessions and information leaflets	<p>30-min traditional training sessions, with groups of 10 subjects were delivery to all subjects. The training sessions addresses general aspects about CVS and preventive visualization behaviours. Expositive and interrogative teaching methods were used. As a summary of the contents addressed in the session, a information leaflet with general information about CVS was given to each participant.</p>	
Correction of the workstation	<p>15-min training sessions were also delivered in the workplaces individually to each worker. Adjustments in the workplace, postures to adopt and preventive behaviours were explained and exemplified.</p>	
Correction of the workstation	<p>After the training sessions, it was asked whether the worker has made adjustments in the workstation. Whenever it was identified the need for adjustments/readjustments of workstations (e.g. distance from the top of the monitor to the eyes, and the distance to the keyboard and mouse, chair height, etc) and sitting position, corrections were made involving the workers.</p>	
Design and implementation of software	<p>To enable the implementation of the 20x20x20 rule, which provides micro pauses of 20 seconds, every 20 minutes of continuous work to the computer, a software with alerts every 20 minutes was designed and installed in each computer.</p>	
Delivery of artificial tear	<p>Artificial tears were given to each worker. They were instructed to apply the tears when they felt eye discomfort.</p>	€ 1230 (≈10.25 each)

8.2.3. Outcomes assessment:

Approach	Action	Evaluation instrument
Subjective	Application a scale to measure CVS-related symptoms	<p>CVS-Q scale proposed by Seguí et al. (2015) was used in this study as the scale to characterize CVS-related symptoms and determine the severity level of CVS.</p> <p>The evaluation is performed through the frequency and intensity level that the subjects feel each symptom (eye burning, itching/ocular pruritus, foreign body sensation, eyelid tremor, excessive blinking, red eye, eye pain, heavy eyelids, dry eyes, double vision, near blurred vision, excessive sensitivity to light, luminous halo around objects, visual loss sensation, headache). For the variable frequency, the classification system assigns a score from 0 to 2 points, where 0="never", 1="occasionally", and 2="frequently/always". For the intensity variable, 1 was assigned to "moderate" and 2 to "intense".</p> <p>The final score was obtained by applying the following equation:</p> $Score = \sum_{i=1}^{16} (frequency\ of\ symptoms) \times (intensity\ of\ symptoms)$
	Visual screenings	<p>To verify the ocular conditions of the workers, specific tests are carried out by orthoptists who performed the tests described below using compact and portable visual screening equipment. Visual acuity is closely monitored, uncorrected and with correction of the participant (when applicable), using the Jaeger visual acuity scale (Gierek-Ciaciura et al., 2010). In addition, the existence of latent or manifest strabismus is identified, quantifying them through the use of the prism Cover Test or Maddox's Wing (Galloway et al., 2016). The convergence is measured by the RAF Ruler (Westman & Liinamaa, 2012). It is also verified the existence of stereoscopic vision using the Randot Test (Hess et al., 2010).</p>
Objective	Adjustments in workstation	<p>The number of correct adjustments made by workers to his/her workplaces were used as an indicator of the intervention positive effect. These adjustments were determined after the training session and later to determine if the changes performed still remained.</p>

9. Expected results / Project importance

In accordance with the objectives defined for the project in section 2 of this document, it is the intention of the ergonomic intervention to change users' visualization to the computer during working time. This change should be reflected in the reduction of the visual symptoms reported by workers.

Additionally, the project should contribute as an input to national legislation, regarding the regulation of mandatory requirements to be implemented in computer workstations.

10. Expected limitations

Difficulties are expected in controlling the maintenance of adjustments performed in the workstations, as well as the sitting postures during the implementation of the project. Additionally, it is not possible to guarantee the rigorous application of preventive behaviours by the workers (e.g. 20x20x20 rule). Because the research team will not remain at the project site, it is only possible warning and supervise workers when

the team is collecting data in the field. There may also be some employer/ top management reluctance to adopt some measures proposed in the project. In this case, alternative measures should be discussed and considered.

Bibliography

Agarwal, S., Goel, D., & Sharma, A. (2013). Evaluation of the factors which contribute to the ocular complaints in computer users. *Journal of clinical and diagnostic research: JCDR*, 7(2), 331.

Almog, Y., & Nemet, A. (2010). The correlation between visual acuity and color vision as an indicator of the cause of visual loss. *American journal of ophthalmology*, 149(6), 1000-1004.

Anshel, J. (2005). The Eyes and Visual System. In J. Anshel (Ed.), *Visual Ergonomics Handbook* (pp. 5- 16). Boca Raton: CRC Press.

Beberide, R.S., Cuixart, N. (2002). El trabajo com pantallas de visualización. *Notas Técnicas de Prevención. NTP 139*. Instituto Nacional de Seguridade e Higiene en el Trabajo. Madrid.

Blehm, C., Vishnu, S., Khattak, A., Mitra, S., & Yee, R. W. (2005). Computer vision syndrome: a review. *Survey of ophthalmology*, 50(3), 253-262.

Charpe, N. A., & Kaushik, V. (2009). Computer vision syndrome (CVS): Recognition and control in software professionals. *Journal of Human Ecology*, 28(1), 67-69.

Chu, C., Rosenfield, M., Portello, J. K., Benzoni, J. A., & Collier, J. D. (2011). A comparison of symptoms after viewing text on a computer screen and hardcopy. *Ophthalmic and Physiological Optics*, 31(1), 29-32.

Fenety, A., & Walker, J. M. (2002). Short-term effects of workstation exercises on musculoskeletal discomfort and postural changes in seated video display unit workers. *Physical Therapy*, 82(6), 578-589.

Fostervold, K. I., Aarås, A., & Lie, I. (2006). Work with visual display units: long-term health effects of high and downward line-of-sight in ordinary office environments. *International Journal of Industrial Ergonomics*, 36(4), 331-343.

Galloway, N. R., Amoaku, W. M. K., Galloway, P. H., Browning, A. C., & Galloway, N. R. (2016). *Common eye diseases and their management*. 4th ed. Switzerland: Springer. ISBN: 978-3-319- 32867-6

Gierek-Ciaciura, S., Cwalina, L., Bednarski, L., & Mrukwa-Kominek, E. (2010). A comparative clinical study of the visual results between three types of multifocal lenses. *Graefe's Archive for Clinical and Experimental Ophthalmology*, 248(1), 133.

Hess, R. F., Mansouri, B., & Thompson, B. (2010). A new binocular approach to the treatment of amblyopia in adults well beyond the critical period of visual development. *Restorative Neurology and Neuroscience*, 28(6), 793-802.

ISO 9241-303:2008. Ergonomics of human-system interaction – Part 303. Requirements for electronic visual displays. International Standard Organization.

ISO 9241-5:1998 Ergonomic requirements for office work with visual display terminals (VDTs) Part 5: Workstation layout and postural requirements). International Standard Organization.

ISO 8995:2005. Lighting of indoor workplaces. International Standard Organization.

ISO 7730:2005. Ergonomics of the thermal environment -- Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria. International Standard Organization.

Mashalla, Y. J. (2014). Impact of computer technology on health: Computer Vision Syndrome (CVS). *Medical Practice and Reviews*, 5(3), 20-30.

McLean L, Tingley M, Scott RN, Rickards J. Computer terminal work and the benefit of microbreaks. *ApplErgon* 2001;32(3):225–37.

Menozi, M., Lang, F., Naepflin, U., Zeller, C., & Krueger, H. (2001). CRT versus LCD: Effects of refresh rate, display technology and background luminance in visual performance. *Displays*, 22(3), 79-85.

Portello, J. K., Rosenfield, M., Bababekova, Y., Estrada, J. M., & Leon, A. (2012). Computer-related visual symptoms in office workers. *Ophthalmic and Physiological Optics*, 32(5), 375-382.

Reddy, S. C., Low, C. K., Lim, Y. P., Low, L. L., Mardina, F., & Nursaleha, M. P. (2013). Computer vision syndrome: a study of knowledge and practices in university students. *Nepalese journal of Ophthalmology*, 5(2), 161-168.

Robertson, M.M. (2007) Health and Performance Consequences of Office Ergonomic Interventions Among Computer Workers. In: Dainoff M.J. (Eds). *Ergonomics and Health Aspects of Work with Computers*. EHAWC 2007. Lecture Notes in Computer Science, vol 4566. Springer, Berlin, Heidelberg

Rosenfield, M. (2011). Computer vision syndrome: a review of ocular causes and potential treatments. *Ophthalmic and Physiological Optics*, 31(5), 502-515.

Schneider, M. (2002). *Do School Facilities Affect Academic Outcomes?* National Clearinghouse for Educational Facilities, Washington, DC: ERIC Publications

Seguí, M-M., Cabrero-Gracia, J., Crespo, A., Verdú, J., Ronda, E., 2015. A reliable and valid questionnaire was developed to measure computer vision syndrome at the workplace. *Journal of Clinical Epidemiology* 68 (6), 662-673.

Tauste Francés, A., Ronda-Pérez, E., & Seguí Crespo, M. D. M. (2014). Ocular and visual alterations in computer workers contact lens wearers: scoping review. *Revista Espanola de Salud Publica*, 88(2), 203-215.

Thorud, H. M. S., Helland, M., Aarås, A., Kvikstad, T. M., Lindberg, L. G., & Horgen, G. (2012). Eye-related pain induced

Uchino, M., Schaumberg, D. A., Dogru, M., Uchino, Y., Fukagawa, K., Shimmura, S., Satoh, T., Takebayashi T. & Tsubota, K. (2008). Prevalence of dry eye disease among Japanese visual display terminal users. *Ophthalmology*, 115(11), 1982-1988.

Wimalasundera, S. (2006). Computer vision syndrome. *Galle Medical Journal*, 11(1).

Yan, Z., Hu, L., Chen, H., & Lu, F. (2008). Computer Vision Syndrome: A widely spreading but largely unknown epidemic among computer users. *Computers in Human Behavior*, 24(5), 2026-2042.

Yang, S.N., Tai, Y.C., Hayes, J.R., Doherty, R., Corriveau, P., Sheedy, J.E., 2010. Effects of font size and display quality on reading performance