

Prevalence of Computer Vision Syndrome and Its Risk Factors in a Spanish University Population

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Objectives: To determine the prevalence of digital eye strain or computer vision syndrome (CVS) and its risk factors in a university population (University of Valladolid, Spain).

Methods: An anonymous cross-sectional online survey was conducted in a university population [staff (lecturers and administrative employees) and students (undergraduate, master's, and PhD)], including two validated questionnaires (Ocular Surface Disease Index [OSDI] and the 17-item Computer-Vision Symptom Scale questionnaire [CVSS17]) and questions about sociodemographic data and visual display terminal use. The prevalence and risk factors for CVS (CVSS17 $\geq$ 29) (multivariate logistic regression model) were calculated.

Results: One thousand nine participants responded to the survey (35.2 $\pm$ 15.2 years; 64.1% women). The mean OSDI and CVSS17 questionnaire scores were 18.9 $\pm$ 15.6 and 31.5 $\pm$ 6.4, respectively, and 35.4% of the respondents had dry eye symptoms (OSDI $>$ 22). The total prevalence of CVS was 65.4% (95% CI 62.1–68.3). Undergraduate students showed the highest CVS prevalence (72.6%; $P<0.01$), which was significant. In addition, women, participants younger than 36 years old, contact lens wearers, and subjects with dry eye symptoms reported a statistically higher CVSS17 score ($P\leq 0.01$). In the multivariate model, significant factors associated with the presence of CVS ($P\leq 0.03$) were female sex (OR=2.10; 95% CI 1.54–2.88), dry eye symptoms (OSDI $>$ 22) (OR=16.98; 95% CI 10.36–27.84), VTD use ≥ 6 hr daily (OR=1.96; 95% CI 1.09–3.52), and being an undergraduate student (OR=2.23; 95% CI 1.54–3.24).

Conclusion: A high prevalence (65.4%) of CVS was found among the Spanish university population, with the undergraduate student group having the highest prevalence (72.6%). Female sex, more than 6 hr/day of visual display terminal use, being an undergraduate student, and dry eye symptoms significantly increased the risk of CVS in the university population.

Key Words: Computer vision syndrome—University population—Dry eye—Prevalence.

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In recent decades, new forms of digital displays have been developed and become widespread throughout the world, making them indispensable in every personal, professional, or academic activity. The use of visual display terminals (VDTs), such as computers, laptops, smartphones, tablets, or e-readers, increases the visual demands on the user and can lead to several ocular symptoms related to digital displays that can adversely affect both quality of life¹ and productivity.²

This group of eye- and vision-related problems associated with prolonged use of VDTs is described as digital eye strain or computer vision syndrome (CVS) by the American Optometric Association.³ Computer vision syndrome involves asthenopic symptoms (eye strain, tired eyes, or headache), ocular surface symptoms (eye dryness, ocular redness, and itching or tearing, among others), visual disturbances (double vision or blurred vision), and extraocular discomfort (head, neck, or back pain).^{3–5} It is estimated that CVS could affect 80% of adults who use digital devices for at least 2 hr daily.³ This condition could have a global prevalence of 60 million people worldwide with an incidence of one million new cases each year.⁴ In eye care practice, a diagnosis of CVS mainly depends on subjective subject answers to different validated questionnaires, one of which is the 17-item Computer-Vision Symptom Scale questionnaire (CVSS17).^{6,7}

It is well known that VDT users exhibit decreased blinking frequency and amplitude, leading to an increase in ocular surface exposure, tear evaporation, and alteration of meibomian gland secretion,^{8,9} which contribute to the development of dry eye symptomatology,⁹ and close to 50% of VDT users suffer from dry eye disease (DED).¹⁰ It has also been reported that contact lens (CL) wear may increase or exacerbate the presence of CVS symptoms.¹¹ In addition, a greater effort is required from the accommodative system because of the greater number of working hours with the VDT placed at a close distance and a higher angle of visualization, which can cause fatigue symptoms, especially in cases of uncorrected refractive error or previous accommodation anomalies.⁸

It is estimated that from 2000 to the present, the number of internet users has increased by 1,392%, which means that 67.9% of the world's population is a user of some digital device.¹² Given the worldwide rise in the use of technology, VDT use has created an unprecedented revolution in learning or teaching strategies in higher educational institutions, especially after the COVID-19 pandemic.¹³ For this reason, the detection and prevention of CVS in this population to guarantee the visual health of the academic population is crucial and challenging. Eye care practitioners should be aware of the potential impact of VDT use on CVS and its related factors to respond with the most effective preventive strategies.^{6,7}

Therefore, the aim of this study was to determine the prevalence of CVS and its risk factors among students and staff at the University of Valladolid (Spain) to provide evidence-based epidemiology data to help eye care providers improve visual health in the university population.

METHODS

Population and Design of the Study

An anonymous cross-sectional online survey was emailed to the total population (approximately 25,700 people) of the University of Valladolid (Spain), including students (undergraduate, master’s, and PhD degrees) and staff (lecturers and administrative employees), during the 2022/2023 academic year. The online questionnaire was designed using Microsoft Forms and hosted on a secure network server of the University of Valladolid to determine the symptomatology related to CVS. Before answering the questionnaire, all participants gave their consent to be enrolled in this study. This study was approved by the Human Sciences Ethics Committee of Valladolid Area-Este Clinic Hospital (Castilla y Leon Public Health System-SACYL) and followed the tenets of the Declaration of Helsinki and the standards of Good Clinical Practice. The online questionnaire was sent in mid-November 2022 and was left open for five weeks for completion. Participants cannot modify their answers after sending the questionnaire.

Questionnaire Design

The online questionnaire was organized into three sections with all compulsory questions. The first section collected sociodemographic data (sex, age, and connection with the university), systemic and ocular health (systemic and/or ocular disorders, pharmacological treatment, and ocular surgery), current optical correction and their preference when using VDTs (spectacles and/or CL wear), VDT exposure (daily hours of use of digital devices both inside and outside the classroom or work office), use of artificial tears, and information on breaks taken when working with VDTs.

The second section included the validated CVSS17 questionnaire^{6,7} that was designed to provide a subject-reported measure of CVS over the preceding month among VDT users.^{6,7} This questionnaire is composed of 17 questions, which provide a total score ranging from 17 to 53 points (the higher the score, the greater the subject’s CVS symptomatology). The CVSS17 provides information on approximately 15 different symptoms, including a symptom’s severity and frequency and the subject’s opinion. Computer vision syndrome can be classified into five levels according to the total score, with level 1 corresponding to an absence of symptoms and level 5 to very severe discomfort related to the use of digital screens.⁶ Participants with CVSS17 total scores ≥ 29 points (levels 3, 4, and 5) were considered to have CVS symptoms.

The third section of the questionnaire included the OSDI questionnaire to determine the symptomatology related to DED.¹⁴ It includes 12 items that evaluate the frequency of symptoms over the preceding week. The OSDI questionnaire is structured into three main domains: ocular symptoms (5 questions), vision-related daily function (4 questions), and environmental triggers (3 questions). The OSDI score ranges between 0 and 100, where higher scores represent a greater severity of symptoms, and is classified as follows: no symptoms (score ≤ 12), mild (score 13–22), moderate (score 23–32), and severe symptoms (score

33–100).¹⁵ In addition, participants were grouped into two categories, non-DED symptomatology (OSDI ≤ 22) and DED symptomatology (OSDI > 22), following recommendations to provide comparable results with previous epidemiological DED reports.¹⁶

Statistical Analysis

Statistical analyses were performed using SPSS for Windows software (version 27.0; SPSS, Inc., Chicago, IL) and Microsoft Office Excel (Microsoft Corp., Washington, DC). The normal distribution of the variables was assessed with the Kolmogorov–Smirnov test. Mean, SD, and percentages were used to describe the data when appropriate. Continuous variables were assessed with the Kruskal–Wallis and Mann–Whitney *U* tests, and categorical variables were assessed with the chi-square test. Descriptive analysis of CVS prevalence (according to CVSS17 levels 1–5 and CVSS17 score < 29 and ≥ 29) was performed on the total sample and on groups based on the main study variables of university group [students (undergraduate, master’s, and PhD students) and

TABLE 1. Distribution of the Sociodemographic Questionnaire Answers in the Total Sample (n=1,009) of the University Population According to VDT Use, Systemic and Ocular Health, Optical Correction Characteristics, Artificial Tears, or Break Times When Respondents Used VDTs

Parameter	Frequency (%)	95% CI
VDT use		
Smartphone	97.93	97.0–98.7
Computer	97.6	96.6–98.6
TV	53.4	50.2–56.7
Tablet	28.2	25.5–31.2
Systemic disease		
Yes	18.5	16.1–20.7
No	81.5	79.0–83.8
Systemic medication		
Yes	32.1	29.1–35.1
No	67.9	64.9–70.7
Medication that affects the ocular surface		
Yes	10.4	8.5–12.4
No	89.6	87.6–91.5
Ocular disease		
Yes	21.8	19.2–24.4
No	78.2	75.5–80.6
Ocular surgery		
Yes	6.4	5.0–8.0
No	93.6	92.1–95.0
Spectacles wear		
Never	29.0	26.1–31.8
Not now	3.8	2.6–5.0
Distance	30.7	27.8–33.5
Near	12.1	9.9–14.1
All distances	24.4	21.6–27.0
CL wear		
Never	61.4	58.3–64.2
Not now	18.2	15.9–20.8
Yes	20.3	17.9–22.7
Prefer correction when using VDT		
None	33.9	31.0–37.2
Spectacles	55.6	52.2–59.1
CL	4.4	3.1–5.8
Spectacles/CL	6.1	4.5–7.6
Installation of artificial tears		
Yes	10.2	8.3–12.2
No	89.8	87.9–91.8
Take breaks when using VDT		
No	28.4	25.7–31.2
Look up from the screen	22.5	19.9–25.3
Get up from seats	48.2	45.0–51.4
Other	0.9	0.3–1.5

CI, confidence interval; CL, contact lens; VDT, visual display terminal.

university staff (lectures and administrative employees)], sex (women and men), age (analyzed in both two [≤ 35 and > 35 years old] age groups and five [18–25, 26–35, 36–45, 46–55, and > 55 years] age groups), CL wear, and dryness symptomatology (participants with [OSDI >22] and without [OSDI ≤ 22] dryness symptomatology). The 17-item Computer-Vision Symptom Scale questionnaire levels and CVS prevalence were reported as percentages with 95% confidence intervals (95% CIs) calculated using bootstrapping through random repetition of 1,000 samples.

The odds ratios (ORs) along with Wald χ^2 tests and 95% CIs were calculated with multivariate logistic regression analysis to assess the relationships of university group (undergraduate, master's, or PhD students; lecturers; and administrative employees), sex, age (≤ 35 and > 35 years old), CL wear, VDT use, and dryness symptomatology as independent variables with CVS (CVSS17 ≥ 29 points). All statistical analyses were considered significant at $P < 0.05$.

RESULTS

Descriptive Data of the Overall Sample

One thousand nine participants responded to the survey (response rate of 3.9%) and were included in this study. Table 1 summarizes the sociodemographic characteristics of the overall sample. The mean age was 35.2 ± 15.2 years (range 18–69 years). Of the total participants, 64.1% ($n = 647$) were women ($P < 0.001$). The average hours of daily VDT use to study or work in an office were 5.8 ± 2.2 (ranging from 0 to 14). On the other hand, the average number of hours of personal VDT use was 3.5 ± 2.0 (ranging from 0 to 12). The mean OSDI score was 18.9 ± 15.6 (0–90.9), and the percentage of respondents with dry eye symptoms (OSDI >22) was 35.4% (95% CI 32.5–38.2). Participants were classified according to their role at the university as lecturers ($n = 271$, 26.9%), administrative employees ($n = 208$, 20.6%), undergraduate students ($n = 405$, 40.1%), master's degree students ($n = 53$, 5.3%), and PhD students ($n = 72$, 7.1%).

CVSS17 Scores

The mean CVSS17 score in the overall sample was 31.5 ± 6.4 (95% CI 31.1–31.9). Lecturers had the lowest CVSS17 score, with

statistically significant differences from administrative staff and undergraduate students ($P < 0.01$; Fig. 1). In addition, women, participants younger than 36 years old, CL wearers, and subjects with dry eye symptoms had statistically higher CVSS17 scores ($P < 0.03$; Fig. 1).

Overall Computer Vision Syndrome Prevalence

According to the CVSS17 score, 7.8% (95% CI 6.1–9.5) of the participants were classified at level 1, 26.8% (95% CI 23.9–29.5) at level 2, 38.1% (95% CI 34.9–41.1) at level 3, 22.5% (95% CI 19.9–25.0) at level 4%, and 4.9% (95% CI 3.5–6.3) at level 5 ($P < 0.001$). The total prevalence of CVS (CVSS17 score ≥ 29) was 65.4% (95% CI 62.1–68.3), and 34.6% (95% CI 31.7–37.9) of the sample did not have CVS (CVSS17 score < 29) ($P < 0.001$).

Computer Vision Syndrome Prevalence in University Groups

Statistically significant differences in the percentages of CVS level and symptomatic CVS in each university group were found (Fig. 2). A higher percentage of students were classified as levels 3, 4, and 5 ($P = 0.01$) and had CVS (70.2%, 95% CI 66.0–74.0; $P < 0.01$) compared with university staff. A detailed analysis among the different university groups found a similar trend, with a significantly different proportion of CVS levels ($P < 0.01$) and symptomatic CVS ($P < 0.01$) (Fig. 3). Undergraduate students showed the highest CVS prevalence (72.6%), followed by master's students (67.9%), with lecturers having the lowest prevalence of CVS (54.6%). Table 2 summarizes the results of the university groups.

Computer Vision Syndrome Prevalence by Sex

Women showed a higher proportion of CVS levels 3, 4, and 5 ($P < 0.01$; Fig. 2) and a higher CVS prevalence ($P < 0.01$; 73.7%, 95% CI 70.2–77.0) compared with men (50.6%, 95% CI 45.3–55.5).

Computer Vision Syndrome Prevalence by Age

A similar trend was found according to age groups, where participants younger than 35 years old showed a higher proportion

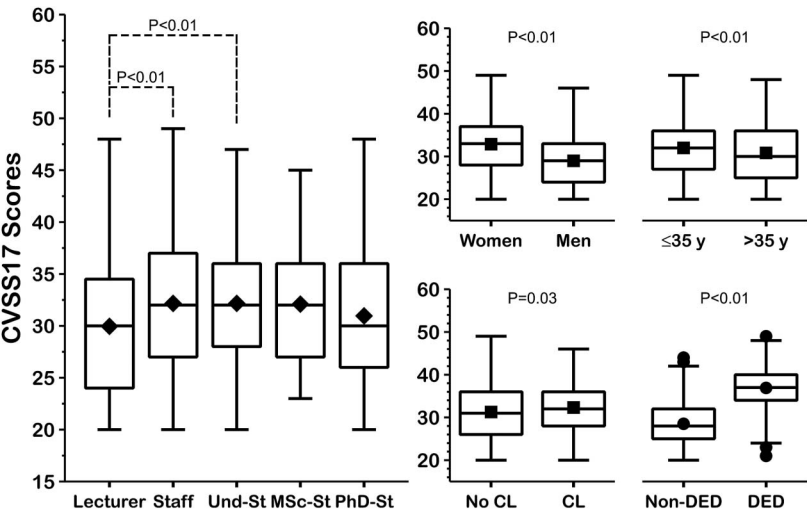


FIG. 1. Summary of differences in CVSS17 scores between university role, sex, age, CL wear, and DED symptoms groups. Mean, maximum, minimum, and Mann-Whitney U test P values are presented for each variable. CL, contact lens; CVSS17, The 17-item Computer-Vision Symptom Scale questionnaire; DED, dry eye disease; MSc-St, master students; PhD-St, doctorate students; Und-St, undergraduate students; y, years.

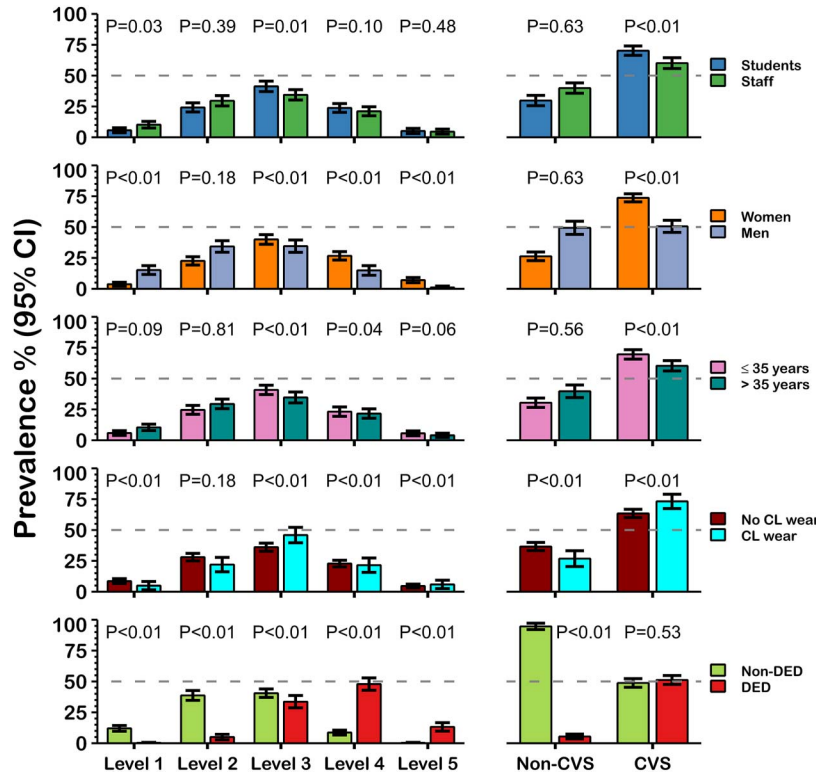


FIG. 2. Summary of CVSS17 levels and CVS prevalence by each group analyzed. The 95% CI bars are represented. The χ^2 P values for each CVS level (1–5) and for groups with or without CVS are shown. CI, confidence interval; CVS, computer vision syndrome; CVSS17, The 17-item Computer-Vision Symptom Scale questionnaire.

of CVS levels 3, 4, and 5 ($P<0.01$; Fig. 2) and a higher percentage of CVS (69.7%, 95% CI 65.8–73.4; $P<0.01$). A detailed analysis of the age groups found that all groups showed a greater than 50% prevalence of symptomatic CVS ($P<0.01$, Table 3). The percentage of CVS decreased with increasing age ($P<0.01$), from a prevalence of 72.2% in the youngest group (18–25 years) to 59.9% in the group older than 55 years (Table 3).

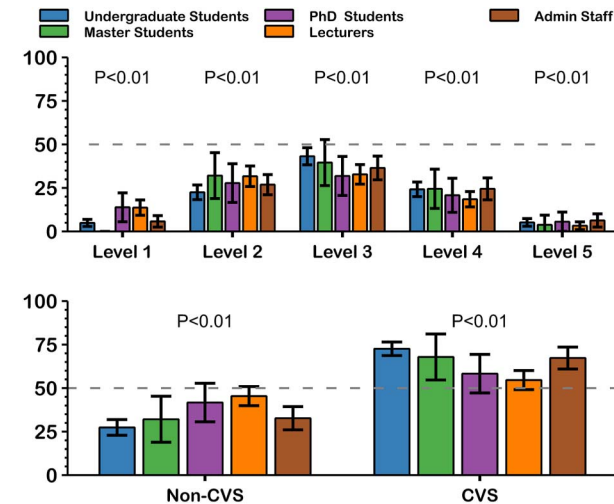


FIG. 3. Summary of CVSS17 levels and CVS prevalence by university population groups. The 95% CI bars are represented. The χ^2 P values for each CVS level (1–5) and for groups with or without CVS are shown. CI, confidence interval; CVS, computer vision syndrome; CVSS17, The 17-item Computer-Vision Symptom Scale questionnaire.

Computer Vision Syndrome Prevalence by Contact Lens Wear

Contact lens wearers showed a higher percentage of CVS levels 3 and 5 ($P=0.04$; Fig. 2) and a significantly higher CVS prevalence (73.2%, 95% CI 66.8–79.0; $P=0.01$) than non-CL wearers (63.4%, 95% CI 60.1–66.8).

Computer Vision Syndrome Prevalence by Dry Eye Symptomatology

Participants with dryness symptomatology (OSDI score >22) showed a statistically higher percentage of CVS levels 3, 4, and 5 ($P<0.01$; Fig. 2). In addition, participants with dryness symptomatology showed a statistically significant difference in CVS prevalence ($P<0.01$). In this analysis, a substantial percentage of participants without CVS symptoms did not have dryness symptomatology (94.5%, 95% CI 92.0–96.6), but a slightly higher percentage of participants with CVS (51.2%, 95% CI 47.2–55.3) showed dryness symptomatology (Fig. 2).

Computer Vision Syndrome Prevalence by Other Study Variables

Finally, no statistically significant differences ($P\geq 0.35$; Table 4) between the CVS and non-CVS groups were found for systemic diseases, systemic medication, medication affecting the ocular surface, ocular surgeries, or the time breaks taken by participants when using VDTs. In turn, the proportion of respondents using VDTs for ≥ 6 hr daily and the use of artificial tears were

TABLE 2. Distribution of the University Population Sample and Differences According to the Variables Studied

Parameter	Lecturer Staff (n=271) (Min–Max)	Administrative Employees (n=208) (Min–Max)	Undergraduate Students (n=405) (Min–Max)	Master Students (n=53) (Min–Max)	PhD Students (n=72) (Min–Max)	P	All Staff (n=479) (Min–Max)	All Students (n=530) (Min–Max)	P
Age	47.7±10.7 (23–69)	49.2±9.7 (23–65)	21.7±6.1 (18–68)	27.2±7.0 (22–55)	32.8±8.8 (22–61)	<0.01	48.3±10.3 (23–69)	48.3±10.3 (23–69)	<0.01
Sex (women) (%)	57.6 (51.7–63.1)	64.9 (58.7–71.2)	66.9 (62.5–71.4)	67.9 (54.7–79.2)	68.1 (55.6–79.1)	0.12	60.8 (56.4–65.1)	67.2 (63.2–71.1)	0.03
CVSS17 score	29.9±6.6 (20–48)	32.2±6.5 (20–49)	32.2±6.0 (20–47)	32.1±5.5 (23–45)	30.9±6.8 (20–48)	<0.01	30.9±6.6 (20–49)	32.0±6.1 (20–48)	<0.01
OSDI score	16.6±15.2 (0–90.9)	21.4±18.2 (0–89.6)	19.7±14.7 (0–72.9)	17.4±12.6 (0–43.8)	17.5±14.6 (0–60.4)	<0.01	18.6±16.7 (0–90.9)	19.2±14.5 (0–72.9)	0.07
Study-work office hours use VDT	6.7±2.0 (1–14)	6.3±1.6 (1–11)	5.0±2.4 (0–12)	5.7±2.3 (0–10)	6.6±2.2 (2–12)	<0.01	6.5±1.8 (1–14)	5.3±2.4 (0–12)	<0.01
Personal hours use VDT	2.8±1.5 (0–8)	2.9±1.5 (0–10)	4.3±2.2 (0–12)	3.6±2.1 (0–12)	3.5±1.7 (0–9)	<0.01	2.8±1.5 (0–8)	4.1±2.2 (0–12)	<0.01

Parameter	Lecturer Staff (95% CI)	Administrative Employees (95% CI)	Undergraduate Students (95% CI)	Master Students (95% CI)	PhD Students (95% CI)	P	All Staff (95% CI)	All Students (95% CI)	P
CVSS17≥29 points	54.6 (49.1–60.1)	67.3 (60.6–73.6)	72.6 (60.6–73.6)	67.9 (68.1–76.5) 0 (0–0)	58.3 (47.2–69.4) 13.9	<0.01	60.1 (55.9–64.5) 10.2	70.2 (66–74) 5.7 (4–7.7)	<0.01
Level 1	13.7 (10.0–18.1)	5.8 (2.9–9.1)	4.9 (3.0–6.9)	32.1 (18.9–18.1)	27.8 (18.1–38.9)	<0.01	29.6 (25.9–33.8)	24.2 (20.4–27.9)	0.39
Level 2	31.7 (26.2–37.6)	26.9 (21.2–32.7)	22.5 (18.5–26.7)	39.6 (26.5–52.8)	31.9 (20.8–43.1)	<0.01	34.4 (29.9–38.6)	41.3 (37.4–45.5)	<0.01
Level 3	32.8 (27.7–38.4)	36.5 (30.3–43.3)	43.2 (38.5–48.1)	24.5 (13.2–35.8)	20.8 (12.5–30.6)	<0.01	21.1 (17.3–24.8)	23.8 (20.2–27.4)	0.10
Level 4	18.5 (14.0–22.9)	24.5 (18.8–30.8)	24.2 (20.2–28.4)	3.8 (0–9.4)	5.6 (1.4–11.1)	<0.01	4.6 (2.9–6.7)	5.1 (3.4–7.2)	0.48
Level 5	3.3 (1.1–5.5)	6.3 (3.4–10.1)	5.2 (3.2–7.4)	32.1 (20.8–45.3)	33.3 (23.6–44.4)	<0.01	34.7 (30.7–39.5)	36.0 (32.1–40.2)	0.60
Dryness symptomatology (OSDI>22)	29.9 (24.7–35.8)	40.9 (34.6–47.6)	37.0 (32.6–41.7)						
VDT use									
Smartphone	97.0 (94.8–98.9)	96.2 (93.3–98.6)	99.5 (98.8–100)	96.2 (90.6–100)	98.6 (95.8–100)	0.04	96.7 (95.0–98.1)	99.1 (98.3–99.8)	<0.01
PC	99.6 (98.9–100)	99 (97.6–100)	95.1 (92.6–97.0)	98.1 (94.3–100)	100 (100–100)	<0.01	99.4 (98.5–100)	96.0 (94.2–97.5)	<0.01
Television	63.5 (57.9–69.4)	76.9 (71.2–82.2)	35.8 (31.1–40.5)	43.4 (30.2–56.6)	54.2 (43.1–65.3)	<0.01	69.3 (64.9–73.3)	39.1 (35.3–43.2)	<0.01
Tablet	28.4 (22.9–33.6)	29.8 (23.6–36.1)	26.9 (23.0–31.1)	35.8 (22.6–49.0)	25 (15.3–34.7)	0.65	29.0 (25.3–32.8)	27.5 (23.7–31.3)	0.61

CI, confidence interval; CVSS17, The 17-item Computer-Vision Symptom Scale questionnaire; VDT, visual display terminal.

significantly higher in the group with significant CVS symptoms ($P\leq0.03$).

Risk Factors for Computer Vision Syndrome

According to the multivariate-adjusted model, significant factors associated with the presence of CVS ($P\leq0.03$) were female sex (OR=2.10), dry eye symptoms (OSDI>22) (OR=16.98), VTD use ≥6 hr daily (OR=1.96), and being an undergraduate student (OR=2.23) (Fig. 4). Although there was a trend of a higher prevalence of CVS in CL users and subjects ≤35 years old, there was a nonsignificant association between CL wear (OR=1.18, 95% CI 0.80–1.77; $P=0.42$) and age group (OR=0.93, 95% CI 0.56–1.54; $P=0.78$) and the risk of CVS in the multivariate model.

DISCUSSION

This is the first study conducted considering different university population groups (lecturers, administrative employees, and under-

graduate, master’s, and PhD students) to determine the prevalence and associated factors of CVS in a large sample of 1,009 subjects of a highly educated population.

A high prevalence of CVS of 65.4% was found in the university population assessed, with undergraduate students having the highest prevalence (72.6%) and lecturers having the lowest prevalence (54.6%; $P<0.01$). These results are consistent with other reports that found a similar CVS prevalence in Spanish university students [between 73.8%¹⁷ (undergraduate and postgraduate students) and 76.6%¹⁸ (undergraduate and master’s degrees) with the CVS-Q questionnaire] and in other countries and degrees. For example, a CVS prevalence between 69.1%¹⁹ (in medical students; CVS-Q questionnaire) and 77.1%¹⁹ (in undergraduate students; CVS-Q questionnaire) was described in the United States, 80%²⁰ (in medicine and engineering students; nonvalidated questionnaire) in India, and 82.5%²¹ (in medical students who wear spectacles; CVS-Q questionnaire) in Paraguay, and the highest prevalence reported was 90%²² (undergraduate students from five universities; nonvalidated questionnaire) in Malaysian students.

TABLE 3. Distribution of the Sample and Differences According to the Variables Studied by Age Groups

Parameter	18–25 years (n=417) (Min–Max)	26–35 years (n=139) (Min–Max)	36–45 years (n=131) (Min–Max)	46–55 years (n=160) (Min–Max)	>55 years (n=162) (Min–Max)	P	≤35 years (n=556) (Min–Max)	>35 years (n=453) (Min–Max)	P
Age	20.7±2.0 (18–25)	29.8±2.7 (26–35)	40.6±2.9 (36–45)	50.5±2.4 (46–54)	59.3±3.5 (55–69)	<0.01	23.0±4.5 (18–35)	50.8±8.0 (36–69)	<0.01
Sex (women) (%)	67.9 (63.5–72.4)	62.6 (54.7–70.5)	67.9 (60.3–75.6)	60.0 (51.9–66.9)	56.8 (48.8–64.8)	0.08	66.5 (62.4–70.7)	61.1 (56.5–65.1)	0.08
CVSS17 score	32.1±5.9 (20–46)	31.6±7.0 (20–49)	30.9±6.0 (20–45)	31.0±6.7 (20–47)	30.7±6.8 (20–48)	0.06	32.0±6.2 (20–49)	30.8±6.5 (20–48)	<0.01
OSDI score	19.2±14.3 (0–72.9)	19.6±17.1 (0–75)	17.9±15.0 (0–62.5)	17.7±15.2 (0–81.8)	19.7±18.1 (0–90.9)	0.44	19.3±15.0 (0–75.0)	18.5±16.2 (0–90.9)	0.08
Study-work office hours use VDT	5.0±2.2 (0–12)	6.7±2.1 (0–12)	6.5±2.0 (1–12)	6.7±2.0 (1–14)	6.2±1.8 (1–10)	<0.01	5.4±2.3 (0–12)	6.5±1.9 (1–14)	<0.01
Personal hours use VDT	4.3±2.2 (0–12)	3.7±1.9 (5–12)	2.8±1.5 (0–8)	2.7±1.6 (0–10)	2.7±1.4 (0–8)	<0.01	4.2±2.1 (0–12)	2.7±1.5 (0–10)	<0.01
Parameter	18–25 years (95% CI)	26–35 years (95% CI)	36–45 years (95% CI)	46–55 years (95% CI)	>55 years (n=162)	P	≤35 years (n=556) (Min–Max)	>35 years (n=453) (Min–Max)	P
CVSS17≥29 points	72.2 (67.6–76.5)	61.9 (54.0–69.8)	61.8 (53.4–70.2)	59.4 (52.5–66.9)	59.9 (51.9–66.7)	<0.01	69.6 (65.8–73.4)	60.3 (55.2–64.5)	<0.01
Level 1	4.6 (2.6–6.7)	9.4 (4.3–14.4)	6.9 (3.1–11.5)	11.3 (6.3–16.3)	12.3 (8.0–17.9)	0.24	5.8 (3.8–7.7)	10.4 (7.5–13)	0.09
Level 2	23.3 (19.4–27.1)	28.8 (21.6–36.7)	31.3 (27.3–39.7)	29.4 (21.9–36.3)	27.8 (21.0–34.0)	<0.01	24.6 (21.2–28.2)	29.4 (25.2–33.3)	0.81
Level 3	43.6 (39.1–48.7)	32.4 (24.5–41)	37.4 (29.0–45.8)	30 (23.1–36.9)	37 (29.6–43.8)	<0.01	40.8 (36.7–44.6)	34.7 (30.2–39.1)	<0.01
Level 4	24 (20.1–28.1)	20.9 (13.7–27.3)	22.1 (15.3–29.8)	24.4 (18.1–31.3)	18.5 (13.0–24.7)	<0.01	23.2 (19.6–27)	21.6 (18.1–25.4)	0.04
Level 5	4.6 (2.6–6.7)	8.6 (4.3–13.7)	2.3 (0–5.3)	5 (1.9–8.8)	4.3 (1.2–8.0)	<0.01	5.6 (3.8–7.6)	4.0 (2.4–5.7)	0.06
Dryness symptomatology (OSDI>22)	35.5 (30.9–40.0)	37.4 (29.5–45.3)	33.6 (26.0–42.0)	32.5 (25.6–39.4)	37.7 (30.2–45.1)	0.85	36.0 (32.0–40.3)	34.7 (30.2–39.3)	0.62
VDT use									
Smartphone	99.5 (98.8–100)	99.3 (87.8–100)	99.2 (97.7–100)	97.5 (95.0–99.4)	92.0 (87.7–95.7)	<0.01	99.5 (98.7–100)	96.0 (94.0–98.0)	<0.01
PC	95.7 (93.5–97.8)	97.8 (95.0–100)	98.5 (96.2–100)	99.4 (98.1–100)	100 (100–100)	0.01	96.2 (94.6–97.8)	99.3 (98.5–100)	<0.01
Television	34.5 (30.5–38.8)	54.0 (46.0–62.6)	67.2 (58.8–75.6)	71.9 (64.4–78.8)	72.2 (65.4–79.0)	<0.01	39.4 (35.4–43.5)	70.6 (66.5–74.8)	<0.01
Tablet	26.1 (21.8–30.4)	25.2 (18.0–32.4)	19.1 (12.2–25.9)	33.8 (26.3–41.3)	38.3 (30.9–45.7)	<0.01	25.9 (22.3–29.9)	31.1 (26.9–35.5)	0.07

CI, confidence interval; CVSS17, The 17-item Computer-Vision Symptom Scale questionnaire; VDT, visual display terminal.

The prevalence of CVS in the university student population was significantly higher than the prevalence in lecturers (54.6%) and administrative employees (67.3%). However, the CVS prevalence in lecturers and administrative staff is similar to the previously reported prevalence in other professional populations, such as Italian office workers (67.2%; CVS-Q questionnaire)²³ and

TABLE 4. Comparison Between the CVS and Non-CVS Groups for Each Factor Evaluated

Parameter	CVS (CVSS17≥29) (n=660) (95% CI; Range)	Not CVS (CVSS17<29) (n=349) (95% CI; Range)	P
Age	34.3±15.2 (33.2–35.5; 18–68)	37.6±15.2 (36.0–39.2; 18–69)	<0.01
Sex (women) (%)	72.3 (68.8–75.5)	48.7 (43.3–53.6)	<0.01
CVSS17 score	35.2±4.5 (34.8–35.5; 29–49)	24.5±2.4 (24.3–24.8; 20–28)	<0.01
OSDI score	24.9±15.4 (23.7–26.0; 0–90.9)	7.8±7.8 (6.9–8.6; 0–50)	<0.01
Study-work office hours use VDT	6.0±2.2 (5.8–6.2; 0–12)	5.7±2.3 (5.4–5.9; 0–14)	0.04
Personal hours use VDT	3.6±2.0 (3.5–3.8; 0–12)	3.3±2.0 (3.1–3.6; 0–12)	<0.01
VDT use ≥6 hr daily (%)	94.5 (92.7–96.2)	90.8 (87.7–93.7)	0.03
CL wear (%)	22.9 (19.6–26.1)	15.8 (12.0–19.8)	<0.01
OSDI (>22 points) (%)	51.1 (47.2–54.9)	5.4 (3.2–8.0)	<0.01
Systemic diseases (%)	19.4 (16.5–22.3)	16.9 (12.9–20.6)	0.35
Systemic medication (%)	32.5 (28.7–36.0)	31.5 (26.9–36.4)	0.77
Medication affecting the ocular surface (%)	11.1 (8.8–13.4)	9.2 (6.6–12.3)	0.35
Ocular surgery (%)	7.0 (5.0–9.0)	5.4 (3.2–7.7)	0.36
Artificial tears (%)	13.5 (10.9–16.1)	3.7 (1.7–5.7)	<0.01
Time breaks when using VDT (%)	71.8 (68.3–75.2)	71.3 (66.2–75.2)	0.87

CI, confidence interval; CVS, computer vision syndrome; CVSS17, The 17-item Computer-Vision Symptom Scale questionnaire; VDT, visual display terminal.

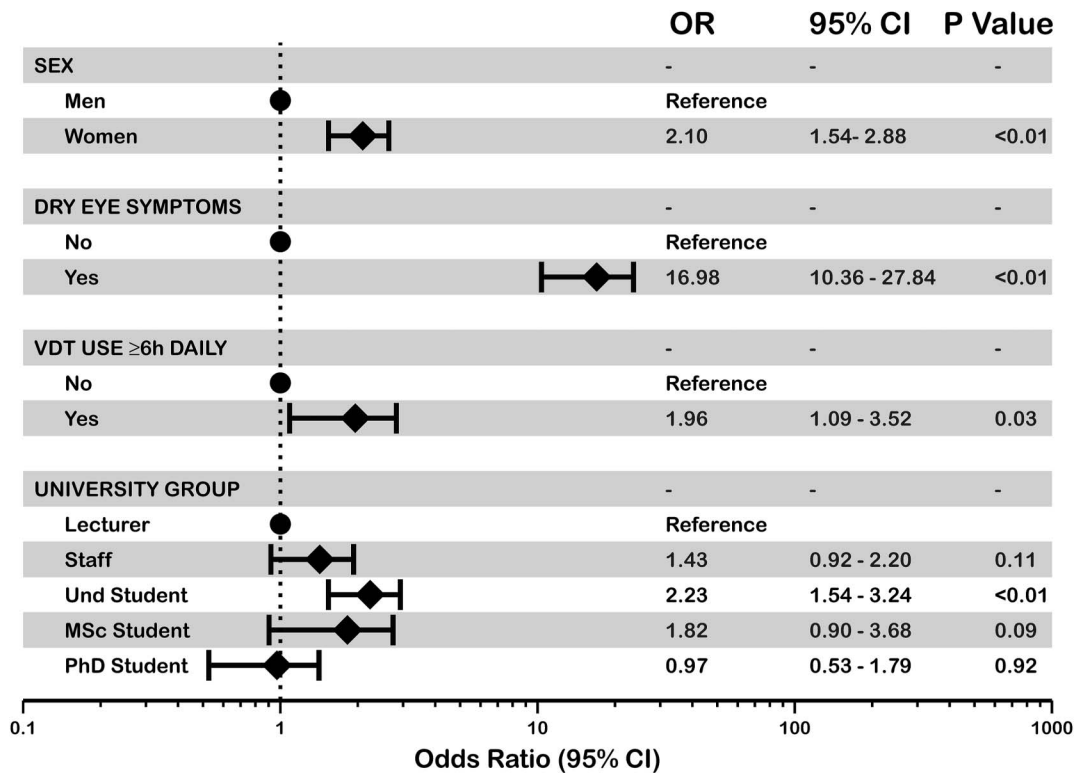


FIG. 4. Association of CVS with main risk factors. The results of the multivariate logistic regression model for CVS versus non-CVS are shown for the independent variables of sex, dry eye symptoms, VDT use ≥ 6 hr daily, and university groups. CI, confidence interval; CVS, computer vision syndrome; OR, odds ratio; VDT, visual display terminal.

Spanish healthcare workers (56.8%; CVS-Q questionnaire).²⁴ Therefore, these results suggest that undergraduate students have a greater risk of developing CVS, as the multivariate logistic model confirmed that students have more than double the probability of suffering from CVS (OR=2.19; 95% CI 1.51–3.17; $P<0.01$) than the rest of the university population assessed (Fig. 4). However, although the prevalence of CVS varies depending on the population assessed and the questionnaire used, all previous reports described an elevated prevalence of CVS in undergraduate university students, which could develop into a major public health problem in developing countries, contributing to reduced academic performance and work productivity with a negative impact on the quality of life of VDT users.^{1,25}

According to the multivariate logistic model, being an undergraduate student is not the only risk factor for developing CVS in the assessed Spanish university population. Women (OR=2.10; 95% CI 1.54–2.88; $P<0.01$) also had more than double the probability of suffering from CVS than men (Fig. 4). This higher risk for women has been previously described,^{17,23,26–28} and other authors have found similar (OR=1.78; 95% CI 1.35–2.34 in female professionally active computer users²⁸) or higher (OR=2.95; 95% CI 2.14–4.08¹⁷ in female university students and OR=3.42; 95% CI 1.94–6.04²³ in female office workers) female-associated risks of CVS. Some authors suggest that this higher risk is related to the higher prevalence of DED in women,¹⁶ and the relationship between female sex and DED is well known.¹⁶ Therefore, special attention should be given to female VDT users by eye care practi-

tioners. Nevertheless, because most of the participants (64.1%) in this survey were women [with a higher percentage in all studied groups (Table 2) and age groups (Table 3)], further research to assess the reasons for the higher risk of CVS in females should be conducted.

Moderate or severe dry eye symptoms (OSDI>22) represent the highest risk of CVS (OR=16.98; 95% CI 10.36–27.84; $P<0.01$; Fig. 4). The percentage of participants with dryness symptomatology (OSDI score>22) was significantly higher ($P<0.01$) in the CVS group (51.2%) than in the non-CVS group (5.4%). These results are consistent with recent literature reports that have found a significant relationship between dry eye symptoms and VDT use.^{10,29} In addition, undergraduate students with CVS had higher OSDI scores, and the higher the OSDI value is, the greater the risk of CVS (OR=1.20; 95% CI 1.17–1.24; $P<0.01$).¹⁷ According to the OSDI score, 35.4% of the university population assessed presented moderate or severe dry eye symptoms. It is also well known that the prevalence of DED increases in people over 50 years old,¹⁶ and therefore, older participants could be expected to exhibit CVS. However, the results showed a slightly higher CVS prevalence in younger VDT users (Table 3), with no statistically significant risk factor (OR=0.93, 95% CI 0.56–1.54; $P=0.78$), consistent with a previous report¹⁸ that found lower CVS among older undergraduate students (22–29 years) than among younger undergraduate students (18–19 years).

A higher prevalence of DED symptomatology was found compared with that of a recent epidemiology report in a large

population (n=1,077) in Spain that found dryness symptoms (OSDI>22) in 15.5% (95% CI 13.2–17.6) of the population, suggesting a higher risk of DED symptomatology in the university population.³⁰ Other reports (in office workers in New York) also found a higher prevalence (29.9%) of dryness symptomatology.¹² However, in a 2016 meta-analysis, the global prevalence of DED in office workers was estimated to be 49.5% (ranging from 9.5% to 87.5%), although the authors highlighted the necessity of implementing common DED diagnostic criteria in research to allow for a more relevant estimation of DED prevalence.¹⁰

This high prevalence of dry eye symptoms may be largely because the use of VDTs increases the vicious cycle of dry eyes.^{16,31} The use of VDTs decreases blink rates and increases incomplete blinks, resulting in tear film instability, increased tear evaporation, and hyperosmolarity.³¹ Given that VDT use is a consistent risk factor for DED,^{10,29} eye care practitioners should pay special attention to VDT users with preexisting symptoms of dryness, as they are at an increased risk of suffering from CVS. According to the current literature, management strategies for digital display-induced dry eye to improve tear film stability and decrease tear evaporation, such as blink animation programs, oral intake of omega-3 fatty acids, the 20–20–20 rule, instillation of high-viscosity artificial tears, or adjustable chairs with ergonomic training, are usually recommended.^{31,32}

Moreover, study findings that spending more than 6 hr/day with digital devices doubles the probability of suffering from CVS are common.^{5,23} The results of this study are consistent with those of other studies; a CVS OR of 1.96 (95% CI 1.09–3.52; $P=0.03$) was found in participants who used VDTs more than 6 hr daily. In addition, the CVS group spent significantly more time in front of digital screens for study/work-related tasks and personal use than the non-CVS group ($P<0.01$; Table 4), and although in both groups most of the participants (over 90%) spent more than 6 hr/day in front of VDTs, this percentage was significantly higher in the CVS group ($P=0.03$; Table 4).

In addition, it is extensively recognized that CL wear is one of the leading risk factors for DED,¹⁶ with reports suggesting a DED prevalence of up to four times higher in CL wearers.¹⁷ Considering that dryness symptomatology is one of the main causes of CVS, CL wear may also be related to CVS. However, although a significantly higher number of CL wearers (22.7%) was found in the CVS group than in the non-CVS group (15.8%), CL wear was not a significant risk factor for CVS (OR=1.18; 95% CI 0.80–1.77; $P=0.42$). Our results are in line with those published by Meyer et al.³³ who found that CL wearers do not experience symptoms of digital eye strain at higher frequency or severity than non-CL wearers. These authors emphasize that the digital strain symptoms may not be directly linked to the surface sensation of the CL itself but may result from several simultaneous factors, such as blink pattern, nonergonomic environment, taking breaks, or binocular vision factors.³³ By contrast, other studies have reported that CL wear is a risk factor for CVS (OR=1.97; 95% CI 1.16–2.20; $P=0.01$)¹⁷ in a sample of 851 university students and that regular CL wear (OR=4.85; 95% CI 1.25–18.8; $P=0.02$) could also increase CVS after 6 hr of computer work.¹¹

The main limitation of this study is the cross-sectional study design, which limits the inference of causality of the results but allows to demonstrate the association between CVS and the identified risk factors due to the large number of participants. Moreover, in

this study, no eye care clinical examinations were conducted, and all the variables analyzed were self-reported, so future studies including an eye examination could be necessary to improve the description of the relationship between CVS and refractive or ocular surface characteristics in subjects. In addition, the survey did not include questions about stress, hours of sleep, neck, and shoulder pain, or ergonomic or environmental conditions (indoor air quality, lighting conditions, etc.) during VDT use, which could lead to measurement bias. In future studies, it would be interesting to compare the prevalence of CVS in university students and staff between different countries using the same methodological procedure and validated questionnaires to improve knowledge about CVS. These findings could inform preventive strategies and provide information on the implications of CVS in university populations, especially among younger subjects. Finally, eye care practitioners should be aware of the relevance of triaging questionnaires and CVS risk factors when exploring university populations and/or subjects who use VDTs for long periods for study, work, or personal tasks.

CONCLUSIONS

This study investigated the prevalence of CVS and its associated factors in a large Spanish university population. Computer vision syndrome was found to have a prevalence of 65.4%, with undergraduate students having the highest prevalence (7 of 10 students). Female sex, more than 6 hr/day of VDT use, being an undergraduate student, and presenting dry eye symptoms significantly increased the risk of CVS. These results highlight the importance of preventing CVS in university populations and the paramount role of eye care practitioners in reducing eye complications related to CVS in subjects who use VDTs for long periods and present CVS risk factors.

REFERENCES

- Hayes JR, Sheedy JE, Stelmack JA, et al. Computer use, symptoms, and quality of life. *Optom Vis Sci* 2007;84:738–744.
- Daum KM, Clore KA, Simms SS, et al. Productivity associated with visual status of computer users. *Optometry* 2004;75:33–47.
- American Optometric Association. *Computer Vision Syndrome*. Available at: <https://www.aoa.org/patients-and-public/caring-for-your-vision/protecting-your-vision/computer-vision-syndrome>. Accessed June 29, 2023.
- Singh S, McGuinness MB, Anderson AJ, et al. Interventions for the management of computer vision syndrome: A systematic review and meta-analysis. *Ophthalmology* 2022;129:1192–1215.
- Talens-Estrelles C, García-Marqués JV, Cervino A, et al. Use of digital displays and ocular surface alterations: A review. *Ocul Surf* 2021;19:252–265.
- González-Pérez M, Susi R, Barrio A, et al. Five levels of performance and two subscales identified in the computer-vision symptom scale (CVSS17) by Rasch, factor, and discriminant analysis. *PLoS One* 2018;13:e0202173.
- González-Pérez M, Susi R, Antona B, et al. The computer-vision symptom scale (CVSS17): Development and initial validation. *Invest Ophthalmol Vis Sci* 2014;55:4504–4511.
- Rosenfield M. Computer vision syndrome: A review of ocular causes and potential treatments. *Ophthalmic Physiol Opt* 2011;31:502–515.
- Uchino M, Yokoi N, Uchino Y, et al. Prevalence of dry eye disease and its risk factors in visual display terminal users: The Osaka study. *Am J Ophthalmol* 2013;156:759–766.
- Courtin R, Pereira B, Naughton G, et al. Prevalence of dry eye disease in visual display terminal workers: A systematic review and meta-analysis. *BMJ Open* 2016;6:e009675.
- Tauste A, Ronda E, Molina MJ, et al. Effect of contact lens use on computer vision syndrome. *Ophthalmic Physiol Opt* 2016;36:112–119.

12. World Internet Users Statistics and 2019 World Population Stats. Available at: <https://www.internetworldstats.com/stats.htm>. Accessed February 20, 2024.
13. Talens-Estarellles C, García-Marqués JV, Cervino A, et al. Online vs in-person education: Evaluating the potential influence of teaching modality on dry eye symptoms and risk factors during the COVID-19 pandemic. *Eye Contact Lens* 2021;47:565–572.
14. Schiffman RM, Christianson MD, Jacobsen G, et al. Reliability and validity of the ocular surface disease index. *Arch Ophthalmol* 2000;118:615–621.
15. Miller KL, Walt JG, Mink DR, et al. Minimal clinically important difference for the ocular surface disease index. *Arch Ophthalmol* 2010;128:94–101.
16. Stapleton F, Alves M, Bunya VY, et al. TFOS DEWS II epidemiology report. *Ocul Surf* 2017;15:334–365.
17. Talens-Estarellles C, García-Marqués JV, Cerviño A, et al. Dry eye-related risk factors for digital eye strain. *Eye Contact Lens* 2022;48:410–415.
18. Cantó-Sancho N, Sánchez-Brau M, Ivorra-Soler B, et al. Computer vision syndrome prevalence according to individual and video display terminal exposure characteristics in Spanish university students. *Int J Clin Pract* 2021;75:e13681.
19. Wang C, Joltikov KA, Kravets S, et al. Computer vision syndrome in undergraduate and medical students during the COVID-19 pandemic. *Clin Ophthalmol* 2023;17:1087–1096.
20. Logaraj M, Madhupriya V, Hegde S. Computer vision syndrome and associated factors among medical and engineering students in Chennai. *Ann Med Health Sci Res* 2014;4:179–185.
21. Coronel-Ocampos J, Gómez J, Gómez A, et al. Computer visual syndrome in medical students from a private university in Paraguay: A survey study. *Front Public Health* 2022;10:935405.
22. Reddy SC, Low CK, Lim YP, et al. Computer vision syndrome: A study of knowledge and practices in university students. *Nepal J Ophthalmol* 2013;5: 161–168.
23. Cantó-Sancho N, Porru S, Casati S, et al. Prevalence and risk factors of computer vision syndrome—assessed in office workers by a validated questionnaire. *PeerJ* 2023;11:e14937.
24. Arttime-Ríos E, Suárez-Sánchez A, Sánchez-Lasheras F, et al. Computer vision syndrome in healthcare workers using video display terminals: An exploration of the risk factors. *J Adv Nurs* 2022;78:2095–2110.
25. Anbesu EW, Lema AK. Prevalence of computer vision syndrome: A systematic review and meta-analysis. *Sci Rep* 2023;13:1801.
26. Portello JK, Rosenfield M, Bababekova Y, et al. Computer-related visual symptoms in office workers. *Ophthalmic Physiol Opt* 2012;32:375–382.
27. Ranasinghe P, Wathurapatha WS, Perera YS, et al. Computer vision syndrome among computer office workers in a developing country: An evaluation of prevalence and risk factors. *BMC Res Notes* 2016;9:150.
28. Toomingas A, Hagberg M, Heiden M, et al. Risk factors, incidence and persistence of symptoms from the eyes among professional computer users. *Work* 2014;47:291–301.
29. Sánchez-Valerio MDR, Mohamed-Noriega K, Zamora-Ginez I, et al. Dry eye disease association with computer exposure time among subjects with computer vision syndrome. *Clin Ophthalmol* 2020;14:4311–4317.
30. Martin R, EMO Research Group. Symptoms of dry eye related to the relative humidity of living places. *Cont Lens Anterior Eye* 2023;46:101865.
31. Kamøy B, Magno M, Nøland ST, et al. Video display terminal use and dry eye: Preventive measures and future perspectives. *Acta Ophthalmol* 2022; 100:723–739.
32. Talens-Estarellles C, García-Marqués JV, Cerviño A, et al. Ocular surface predisposing factors for digital display-induced dry eye. *Clin Exp Optom* 2023;106:373–379.
33. Meyer D, Rickert M, Kollbaum P. Ocular symptoms associated with digital device use in contact lens and non-contact lens groups. *Cont Lens Anterior Eye* 2021;44:42–50.