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Computer vision symptoms in people with and without neck pain

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ABSTRACT

Background: Sixty-four to 90% of computer users experience symptoms of computer vision syndrome (CVS). People with CVS symptoms experience neck pain (NP), and people with NP can have visual symptoms.
Objectives: (1) To examine differences in CVS symptoms in computer users with and without persistent NP. (2) To determine relationships between visual ergonomics, demographics, and CVS in those with and without persistent NP
Design: Comparative cross-sectional observational study
Method: An online survey consisting of multiple questionnaires including the Computer Vision Syndrome Questionnaire (CVS-Q), Visual Symptoms Survey (VSS), and Convergence Insufficiency Symptoms Survey (CISS) was completed by 167 participants.
Results: The persistent NP group had significantly higher CVS-Q, VSS, and CISS scores ($p < 0.01$) compared to controls. No relationships were found between visual ergonomics, demographics, and visual symptoms in both groups.
Conclusions: People with persitent NP are more likely to present with CVS than controls. Clinicians should consider assessing visual symptoms in people presenting with persisting NP.

1. Introduction

The invention of the computer has changed and shaped the lives of many generations, and it has transformed the workplace. Office work has always involved a range of activities, such as typing, filing, reading, and writing. With the evolution of the computer, all these tasks can now be completed using the one device. (Blehm et al., 2005). The computer has even become an integral part of daily life at home. Eighty-six percent of Australian households have access to the internet, with 94% owning a computer (ABS, 2016). It has been reported that 64–90% of computer users experience symptoms of computer vision syndrome (CVS), defined as the collection of symptoms that result from prolonged computer use (AOA, 2017; Blehm et al., 2005). These include ocular symptoms, such as eye strain and irritation of the eyes, visual symptoms such as blurred vision, and musculoskeletal symptoms such as neck and shoulder pain (Anshel, 2005; Blehm et al., 2005; Gowrisankaran and Sheedy, 2015; Yan et al., 2008). As the number of computer users and time spent using a computer are likely to increase, it is necessary to further understand the links between computer use, musculoskeletal, and visual symptoms.

The combined visual and neck symptoms in CVS is intriguing as the neck is an important and sensitive sensory organ. It has a high percentage of proprioceptors that trigger reflexes in the eyes and the inner ear. This allows for precise control of head and eye movements, as well as posture (Armstrong et al., 2008; Della Casa, Helbling, Meichtry, Luomajoki and Kool, 2014). Apart from pain and dizziness, people with persistent neck pain have reported numerous visual symptoms, such as tired eyes or blurred vision, which are consistent with the presentation of CVS (Thorud et al., 2012; Treleaven and Takasaki, 2014). Oculomotor deficits in those with neck pain are thought to be the cause of these visual symptoms. The deficits include: poor eye-head coordination, gaze stability, and smooth pursuit eye movement control; resultant of altered cervical afferent input (Treleaven et al., 2011; Treleaven et al., 2005; Treleaven and Takasaki, 2014).

The visual ergonomics of the computer environment influence both the visual system and musculoskeletal structures around the neck (Blehm et al., 2005; Gowrisankaran and Sheedy, 2015; Hood and Hood, 2016). Visual ergonomics is defined as interactions between humans and other elements of a system such as the visual environment (lighting and workstation setup), visually demanding work, visual function and performance, visual comfort and safety, optical corrections, and other safety tools (Toomingas, 2014). Consequently, inadequate lighting,

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incorrect computer viewing height and distance, as well as continuous periods of computer use, are associated with an increase in visual discomfort, and neck strain, ache and pain in healthy individuals (Blehm et al., 2005; Hemphälä and Eklund, 2012; Yan et al., 2008). It is possible that the number of computer screens used may have an impact on CVS, but limited research has been conducted to identify any association.

While intermittent neck pain is a small component of CVS, it is also plausible that ocular symptoms occur in relation to neck pain or are independent of computer use in those with persistent neck pain. To date, it is unknown if people with persistent neck pain experience an exacerbation of CVS compared to those without persistent neck pain, due to the potential ability of computer use to exacerbate both neck pain and visual complaints. As such, the primary aim of this research study was to examine the differences in the presentation of CVS symptoms in computer users with and without persistent neck pain. The secondary aim was to identify relationships between selected visual ergonomics features (e.g. number of screens, duration, and type of computer use) and CVS in those with and without persistent neck pain. It is hypothesised that subjects with persistent neck pain will experience greater CVS than those without. In addition, certain individual characteristics and visual ergonomic features will be associated with greater CVS in those with persistent neck pain.

2. Methods

2.1. Design

A cross-sectional study was conducted using an online survey methodology.

2.2. Participants

Over a period of 20 weeks, volunteers over the age of 17 years who reported using a computer for more than 3 h per day were recruited from The University of Queensland and the general public, via online advertising. Both controls without persistent neck pain (healthy controls) and those with persistent neck pain (neck pain) participated. Inclusion and exclusion was determined via screening questions embedded in the online survey. They are as follows:

Healthy control group: Control participants without persistent neck pain were eligible if they presented with a neck disability index (NDI) score of < 10% (Macdermid et al., 2009), and had neither experienced neck pain in the preceding three months, nor had a history of chronic head/neck pain.

Persistent neck pain group: Participants were included if they presented with neck pain of varying intensities over the previous 3 months, and had a NDI of ≥10%. This level of pain and disability was selected as it reportedly reflects a person who has at least a mild disability associated with their neck pain disorder (Vernon and Mior, 1991). To be classified as having persistent neck pain, symptoms that lasted for 3 months or more were required.

All participants whose survey responses indicated a history of a prior head injury or cervical fracture/dislocation, a diagnosed vestibular or inner ear pathology, a neurological disorder, or were receiving treatment for a malignant condition, were excluded from the study (Vernon and Mior, 1991).

The Human Medical Research Ethics Committee of The University of Queensland granted ethical clearance for this study, and all participants gave informed consent by checking a tick box prior to proceeding with the questionnaire.

2.3. Measurements

An online survey (hosted by Google Forms, and required 15 min to complete) collected demographic data; information regarding neck pain, such as the location of pain; frequency of dizziness; and current medications (Lee et al., 2005). The survey consisted of questions on aspects of visual ergonomics for both home and work computers: the visual environment which includes the number of computer screens in the workstation; the height of the computer screen in the workstation (top of computer is level with eyes/not level with eyes) which is a contributory factor to neck pain (Korhonen et al., 2003); and the usage of optical correction when working on the computer (e.g. single focal, bifocal, lens, graduated lens). There were also questions on the duration of computer use per day outside of work including: the number of hours a computer was used per day, the length of time on the computer before taking a break, and total daily length of time and proportion of the day spent in front of a screen (including laptops, desktops, and smart devices) for work or leisure (Long and Helland, 2012).

Computer Vision Syndrome was determined with the *Computer Vision Syndrome Questionnaire (CVS-Q)*. This scale was developed bydel Mar Seguí, Cabrero-García, Crespo, Verdú, and Ronda (2015) to measure visual symptoms related to exposure to computers in the workplace. There are 16 items enquiring about symptoms such as blurred vision, tearing, and excessive blinking when using the computer. A 3-point Likert scale is used to rate symptom frequency (0 = Never, 1 = Occasionally, 2 = Often or Always) and intensity (0 = Never, 1 = Moderate, 2 = Intense). The scores for intensity and frequency were multiplied and then recoded (0 → 0, 1 or 2 → 1, 4 → 2) as per del Mar Seguí et al. (2015). The scores were then summed to provide a total score out of 32. According to del Mar Seguí et al. (2015), a score of ≥6 points indicates the likely presence of CVS with good sensitivity (75%), specificity (70%) and is reported to have a high test-retest repeatability.

Vision symptoms were assessed using the *Vision Symptom Survey (VSS)*, consisting of 14 items pertaining to visual symptoms based on a proforma used in previous research in those with neck pain (Treleaven and Takasaki, 2014). Symptoms assessed include words moving on the page, inability to judge distances, and spots in their vision (Hawker et al., 2011). Participants were to indicate the average frequency that they experience each symptom on a 5-point scale (0 = Never, 1 = Not often, 2 = Occasional, 3 = Fairly Often, 4 = Always), and the average intensity of symptoms on a 4-point scale (0 = never, 1 = mild, 2 = moderate, 3 = severe). For each item, the score for frequency and intensity were multiplied, and then summed to give a final score with the maximum total of 168 (Treleaven and Takasaki, 2014). A secondary VSS score was calculated by removing scores for questions that had also featured in the CVS-Q. This helped to confirm that the relationships found were not a result of repeated questions. The secondary version included 11 items, with a total score of 132.

Symptoms relating to convergence insufficiency were assessed with the revised 15-item *Convergence Insufficiency Symptom Survey (CISS)*. Convergence insufficiency is a condition in which there is an inability to converge the eyes at near point and relatively little or no deviation of the eyes with distance fixation (Daum, 1984). This causes one eye to turn outward instead of inward in tandem with the contralateral eye, creating double or blurred vision. Symptoms of CISS include discomfort and headaches whilst doing close work. The frequency of each symptom was rated on a 5-point scale (0 = Never, 1 = Not often, 2 = Occasional, 3 = Fairly Often, 4 = Always), with the sum of the items' scores used to give a total score out of 60. Values ≥ 21 are considered to have good discrimination for convergence insufficiency, and the internal consistency of the CISS has been shown to be excellent (Rouse et al., 2004). This questionnaire was included in the survey as a high prevalence of convergence insufficiency has been seen among computer workers (Gur et al., 1994), and any form of vergence anomalies are likely to result in CVS symptoms during prolonged near vision viewing of an electronic screen (Rosenfield, 2011).

The intensity of neck pain and dizziness was evaluated with a modified *11-point Visual Analogue Scale (VAS)*. Due to restrictions of the survey platform used, a 100 mm visual analogue scale with only 11 points as a guide was used to assist the participants to rate their current

Table 1
Demographics and questionnaire data (median and inter quartile range unless stated) of the control group and persistent neck pain group.

		Control (n = 93)	Persistent Neck Pain (n = 74)	P-Value
CVS	Presence of Computer Vision Syndrome (n, %)	31.0 (33.3)	54.0 (73.0)	< **0.01**
Demographics	Age [years]	23.0 (24.0)	26.5 (24.0)	0.155
	Gender [Female] (n, %)	62.0 (66.7)	57.0 (77.3)	0.170
Neck pain and Disability	VAS pain [/100]	0.0 (0.0)	29.5 (31.0)	< **0.01**
	NDI [%]	2.0 (4.0)	17.9 (12.0)	< **0.01**
Dizziness	DHIsf [/13]	13.0 (0.0)	10.5 (4.0)	< **0.01**
Vision Questionnaire Scores	Computer Vision Syndrome Questionnaire Score [/64]	5 (6)	10 (6)	< **0.01**
	Visual Symptom Survey Score [/168]	7 (9)	19 (20)	< **0.01**
	Edited Visual Symptom Survey Score [/132]	6 (7)	15 (17)	< **0.01**
	Convergence Insufficiency Symptom Survey Score [/60]	9 (10)	18 (15)	< **0.01**
	Presence of Convergence Insufficiency (n, %)	6.00 (6.40)	31.0 (41.9)	< **0.01**
Visual Ergonomics	Use of optical correction devices [Yes] (n, %)	56.0 (60.2)	46.0 (62.2)	0.873
	Number of computer screens (Mean, SD)	1 (0.5)	1 (1.0)	0.987
	Monitor Positioning [at eye level] (n, %)	48.0 (51.6)	32.0 (43.2)	0.354
	Time using computer before a break in hours (Mean, SD)	1.88 (1.20)	1.85 (1.30)	0.867
	Total computer use per workday (n, %)	32.0 (34.0)	19.0 (26.0)	0.241
	≤6 h	61.0 (66.0)	55.0 (74.0)	
	> 6 h			

NDI: Neck Disability Index.
DHIsf: Dizziness Handicap Index Short Form (The scoring is reversed with a score of 13 showing nil disability while a score of 0 shows maximum disability).
Good Computer positioning: Top of visual display terminal level with eyes.
CVSQ: Computer Vision Syndrome Questionnaire (> 6 = CVS Present).
VSS: Visual Symptom Survey [Maximum Score = 168].
Edited VSS: 11 item VSS with repeated questions from CVSQ removed [Maximum score = 132].
CISS: Convergence Insufficiency Symptom Survey (> 21 = Convergence Insufficiency present).
*All variables were not normal with the exception of the number of computer screens and the time using the computer before a break.
VAS pain: Visual Analogue Scale for Pain (Maximum Score = 100).

intensity of neck pain and dizziness as well as average neck pain and dizziness during the last week. The scores were then scaled back up to 100 mm. Higher scores indicate greater intensity of pain or dizziness (0 = no pain/no dizziness, 100 = worst pain imaginable/worst dizziness) (Hawker et al., 2011; Litcher-Kelly et al., 2007; Williamson and Hoggart, 2005).

The *Neck Pain Disability Index (NDI)* was used to assess self-reported disability in activities of daily living due to neck pain, such as personal care, reading, headaches, and driving. The scores of the survey's ten questions were summed up to give a maximum of 50. The percentage of the total possible score of 50 was used in analysis. A score of 10% is considered to demonstrate the presence of at least a mild disability due to neck pain (Vernon, 2008). The NDI has been shown to be a very reliable indicator of neck pain and disability, with a higher percentage indicating greater disability (Vernon, 2008).

The *Dizziness Handicap Index short form (DHIsf)* was used to evaluate the level of disability due to dizziness, with scores from 0 (maximum disability) to 13 (no disability). The DHIsf was used instead of the 25 item DHI as it was shorter and simpler in its scoring format, yet reliable and consistent with the original DHI (Ardıç et al., 2016; Tesio et al., 1999), which had good internal consistency and high test-retest reliability (Jacobson and Newman, 1990). The DHIsf was included since dizziness is a common symptom in people with neck pain and could contribute to visual symptoms and oculomotor deficits (Treleaven, 2011; Treleaven and Takasaki, 2014).

2.4. Data management

Data were analysed using STATA version 14.0. Group data were analysed for descriptive and comparative purposes. Group comparisons were undertaken by exploring central tendency of the recorded scores. A Shapiro-Wilk test investigated the distribution of data by group. The non-parametric Fishers Exact Test was for all variables to determine whether their proportions were different between the 2 groups (healthy controls and persistent neck pain). The contingency table used for this test compared the dependent variable versus persistent neck pain or healthy controls.

All the data were non-normally distributed with the exception of the number of computer screens and the time using the computer before a break. Hence the non-normally distributed data were analysed using the Kruskal-Wallis test with Bonferroni correction for Type-1 error (*a priori* sig. value $p < 0.0017$).

Spearman's Rho Correlation identified any relationships between the questionnaire scores (CVSQ, VSS and CISS scores) and remaining ordinal or scaled variables (demographics and visual ergonomics).

Data for the following was collapsed as follows: The height of the computer screen in the workstation (top of the computer screen level with eyes/not level with eyes), hours of computer use (≤6/ > 6 h per day), optical correction use (yes/no), presence of CVS (yes/no), and presence of CISS (yes/no). The Mann-Whitney *U* test was conducted to evaluate all the questionnaire data, as well as age, number of computer screens, and time between breaks, to compare between the healthy controls and persistent neck pain groups as they were not normally distributed (McKnight and Najab, 2010). It was also used to assess the between group differences for each of the 14 individual questions in the VSS. A Bonferroni correction was done which found an alpha score of 0.00357 which was applied.

The Spearman's Rank-Order Correlation Test was used to examine the relationships between age, NDI scores, DHI scores, computer usage hours, number of computer screens, breaks between computer usage, and the questionnaire data (CVS-Q, VSS and CISS) for both participants with neck pain and the control group. It is a test to measure the strength and direction of association between two ranked variables (Zar, 1972). The Spearman's test was also undertaken to examine the relationships between all the ordinal or scaled variables and each of the scales (CVS-Q, VSS and CISS), as well as to compare the relationship between CVS-Q and VSS when repeated questions used in the CVS-Q were removed (VSS-CVS-Q).

3. Results

Two hundred and fifteen participants completed the survey, of which 48 participants were excluded, leaving 167 eligible participants (74 with neck pain and 93 controls). Reasons for exclusion were known inner ear pathology (n = 11); controls who reported being pain free yet unrealistically scored a NDI > 10% (n = 11); those who reported neck pain but did not reach the required level of neck pain and disability i.e. NDI < 10% (n = 23); and unrealistic answers, for example, reported total hours in a day using the computer, laptop, and mobile devices exceeding 24 h (n = 3). There were no significant differences between the participants in terms of age, gender, optical correction use, total computer usage per day, number of computer screens, number of hours before breaks, and height of computers. (Table 1). The mean rank score of each questionnaire (CVS-Q, VSS, CISS, NDI) except the DHIsf (which was scored in reverse, proportion of participants with above threshold scores for CVS and CISS, as well as the VAS for neck pain was significantly greater ($p < 0.01$) in the persistent neck pain group as compared to controls (Table 1). The results for the DHIsf was similarly significantly ($p < 0.01$) greater in the control group as compared to the neck pain group.

Participants with persistent neck pain reported significantly higher scores ($p < 0.00375$) in 13 of the 14 individual VSS items. The only exception was having spots in their eyes (p = 0.00987). The symptoms that showed the largest difference between the control and persistent neck pain groups were, in descending order, visual fatigue, difficulties with concentration, sensitivity to light, itchy eyes, and eye strain (Fig. 1).

There was a positive low to moderate correlation between the mean score on the NDI ($r > 0.40$) and the VSS, CVS-Q, CISS scores in both groups. There was a significant moderate negative correlation between the DHIsf and VSS, CVS-Q, CISS in the persistent neck pain group. The number of computer screens used showed a small but significant correlation to the CVS-Q (r = 0.35) and VSS (r = 0.32) questionnaire scores in the persistent neck pain group. (Table 2). There were moderately strong and significant positive correlations ($r > 0.60$) between the VSS, CVS-Q, CISS and the edited VSS questionnaire (VSS scores minus repeated questions from the CVS-Q).

4. Discussion

The results suggest that participants in this study with persistent neck pain experience greater CVS than controls, thus supporting our hypothesis that there is a significant association between neck pain and CVS in individuals with persistent neck pain. In addition, there were no significant individual or visual ergonomic features that were associated with greater CVS in those with persistent neck pain. The results confirm the presence and significance of visual symptoms that are associated with persistent neck pain in computer users, and this does not seem to be related to specific features of computer use and more about the presence of persistent neck pain. Thus, CVS should be considered in the assessment and management of people with persistent neck pain.

Table 2
Correlation (r) between questionnaires and various factors.

	Control			Persistent Neck Pain		
	CVS-Q	VSS	CISS	CVS-Q	VSS	CISS
Age	0.12	0.05	0.07	0.21	0.22	0.12
VAS pain	0.24*	0.23*	0.21*	0.12	0.08	0.07
NDI	0.43**	0.42**	0.36**	0.34**	0.50**	0.48**
DHIsf	−0.09	−0.12	−0.11	−0.45**	−0.55**	−0.52**
Computer usage hours	−0.14	−0.10	−0.09	−0.01	−0.03	−0.03
No. of computer screens	0.05	0.11	0.04	0.35**	0.31**	0.19
No. of computer screens without the outlier	0.05	0.11	0.04	0.32**	0.27*	0.16
Computer hours before break	0.16	0.18	0.12	0.05	0.12	0.09
CVSQ Score	1.00	0.73**	0.62**	1.00	0.77**	0.63**
VSS Score	0.73**	1.00	0.88**	0.77**	1.00	0.81**
CISS Score	0.62**	0.88**	1.00	0.63**	0.81**	1.00
Edited VSS	0.65**	0.97**	0.90**	0.75**	0.97**	0.77**

*$p < 0.05$ **$p < 0.01$.
VAS pain: Visual Analogue Scale for Pain.
NDI: Neck Disability Index.
DHIsf: Dizziness Handicap Index Short Form.
CVSQ: Computer Vision Syndrome Questionnaire.
VSS: Visual Symptom Survey.
CISS: Convergence Insufficiency Symptom Survey.
Edited VSS: VSS with repeated questions from CVSQ removed.
Outlier referred to the one dataset which had 8 computer screens.

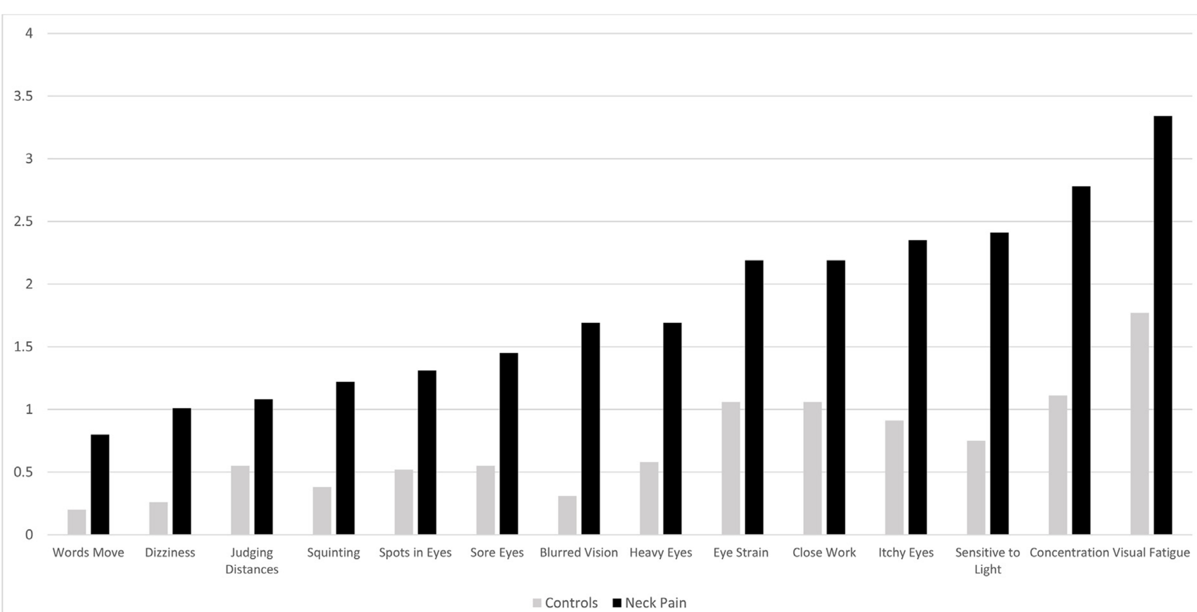

Fig. 1. Magnitude (Frequency X Severity) of symptoms in the Visual symptom survey (VSS) for each of the 14 items in ascending order. All items were significantly ($p < 0.00357$) higher in those with persistent neck pain compared to controls with the exception of having spots in eyes (0.00987).
*The maximum score for an item is 12.

4.1. Group differences

Seventy-three percent of participants with persistent neck pain had CVS-Q scores greater than the threshold (> 6), as compared to 33% of controls, indicating the presence of CVS (del Mar Seguí et al., 2015). Overall, the combined group prevalence was similar to that which was reported by Tauste et al. (2016) among a general population of computer users (53%), which likely included those with and without persistent neck pain.

The differences in CVS between the groups did not appear to be related to the visual ergonomic features assessed in this study. The visual ergonomic setup was similar in both the control and persistent neck pain groups, with the mean values as follows: (1) optical correction use (60.2% and 62.2% respectively), (2) number of computer screens (1.26 computers screens and 1.36 computer screens respectively), and (3) hours of computer use before taking a break (1.88 and 1.85 h respectively). These results suggest that visual ergonomics may not influence the occurrence of CVS as significantly as it was previously thought to (Blehm et al., 2005). It could also be possible that the questions used in the survey were not sensitive enough to pick up differences in visual ergonomics. The results may also be attributed to an insufficient sample size that may be too small to detect differences; or to the inability of participants to give accurate estimates about the amount of time they spend viewing screens.

With regards to convergence insufficiency, 42% of the participants in the persistent neck pain group were shown to have convergence insufficiency, as compared to 6.4% in the control group. The prevalence of convergence insufficiency in the persistent neck pain population is much larger than the range of 7.7–17.6% reported by previous studies in adults and children (Martinez-Palomera, 1997; Rouse et al., 1999; Rouse et al., 1998). This could mean that the presence of persistent neck pain can have an impact on the convergence of the eyes. Alternatively, it could reflect overlap in items between the questionnaires. Interestingly, a recent study did not find any correlation between the CISS and objective measurements of convergence insufficiency in those with neck pain (Giffard et al., 2017). This could mean that the CISS may not be specific enough in picking up traits of convergence insufficiency, or that the subjective symptoms felt by an individual may not necessarily correspond with objective measures of insufficient convergence in the eyes and may be more related to visual disturbances in general. Thus, more research is required to examine the effects of persistent neck pain on convergence insufficiency.

4.2. Relationships between measures

Previous studies have shown a relationship between age and CVS (Ranasinghe et al., 2016; Rosenfield, 2011), and have also demonstrated that females are at a greater risk of CVS (Portello et al., 2012; Ranasinghe et al., 2016; Ríos et al., 2017; Rosenfield, 2011). In contrast, our study found no differences in the prevalence of CVS with respect to age and gender, despite having similar demographics to previous studies (Gerr et al., 2002; Giffard et al., 2017; Treleaven and Takasaki, 2014). At the same time, it is intriguing to note that neck pain is also more common in females (57%) as compared to males, which is consistent with previous reports (Bovim et al., 1994; Côté et al., 2004).

Surprisingly, few relationships were found between visual ergonomics and visual symptoms. While the range between the maximum and minimum of the number of computer screens is very small – out of the 167 participants, only 5 participants had more than 2 computer screens (3 screens (n = 4), 8 screens (n = 1)) – there was a mild to moderate correlation (r = 0.35, 0.31) between the number of computer screens, and the CVS-Q and VSS, evident only in the persistent neck pain group. As there was one person with a very high number of screens, there was a possibility that it was strongly influencing the regression line. However, when the outlying dataset of the 1 person with 8 screens was removed, there remained a mild to moderate correlation (r = 0.32, 0.27) between the number of computer screens, the CVS-Q and VSS questionnaires. No other study has investigated the number of computer screens used in relation to persistent neck pain or CVS. This could mean that people with persistent neck pain are more likely to experience CVS if they use multiple computer screens at their workstation, and this may need to be considered by employers and clinicians in the management of these workers. This could be due to the need to constantly shift gaze and turn the neck to view multiple screens, resulting in the worsening of neck pain and in turn, CVS. It may also be possible that the people reporting total hours of computer use were concurrently using multiple devices such as the computer, laptop and phone which could have a potential impact on neck pain. However, more research is required to confirm this.

Previously people using optical corrections like contact lenses were shown to be more likely to experience CVS (Tauste et al., 2016). In the current study, the use of optical correction devices, such as glasses and contact lenses, showed no differences between the neck pain and non-neck pain groups. More research is needed to investigate the relationship between the use of optical correction devices and CVS in those with neck pain. While Blehm et al. (2005) suggests that the visual environment, optical correction devices, and visually demanding work are the main sources of visual symptoms, the results of this study suggest that this may not be the case for those with persistent neck pain. In addition, the presence of persistent neck pain should be factored in for those with visual complaints.

4.3. Visual symptoms

Our previous study reported visual symptoms in people with and without persistent neck pain, using the VSS that was designed to capture visual disturbances resulting from several different causes, including computer use. However, this has not been validated to date (Treleaven and Takasaki, 2014). The advantage of using the CVS-Q is that it has been validated, and can be used to screen for CVS. As such it is not surprising that the presence of CVS is correlated to the CVS-Q scores in both groups (r = 0.32, 0.67). Moderate correlations were also found between NDI questionnaire scores and the CVS – Q scores in both groups (r = 0.43, 0.34). This further strengthens the knowledge that neck pain does indeed have an association with the presence of CVS as previously established (Blehm et al., 2005). The results of this study also show high correlations in both groups between the CVS-Q, and both the VSS (r = 0.73, 0.77) and the CISS (r = 0.62,0.63). It is possible that this was due to some overlap of items in the questionnaires. Nevertheless, even in the edited version of the VSS, which was created by removing the scores for questions repeated in the CVS-Q, a similar correlation between the CVS-Q and the edited VSS (0.65, 0.75) was seen. This is expected as they measure the same construct of visual symptoms. More research is required to determine the most suitable measure to assess visual disturbances in those with persistent neck pain.

Interestingly, the main specific visual complaints in those with persistent neck pain included the ability to concentrate, visual fatigue, and sensitivity to light which supports our previous research findings (Treleaven and Takasaki, 2014) (Fig. 1). This may suggest that the presence of persistent neck pain, rather than computer use is related to visual symptoms.

There is also a possibility that people who already experience persistent neck pain may experience CVS to a greater degree than those without neck pain. This could be due to visual disturbances related to oculomotor control disturbances that have been identified in some individuals with neck pain (Treleaven et al., 2005, 2011; Treleaven and Takasaki, 2014), especially those complaining of dizziness or unsteadiness. In the current study, a mild to moderate relationship was found between both the symptom of dizziness and the level of neck pain, and the three visual questionnaire scores in those with neck pain. No other variable measured seemed to be related to visual symptoms. Thus, further research to determine relationships between self-reported visual disturbances and oculomotor deficits in those with neck pain is required.

4.4. Limitations

As the sample was not random, it is difficult to generalise this survey to the larger population of computer users. However, it still provides us with a glimpse of the younger population of workers, as the median age and distribution of the participants were younger than the general population of workers. In addition, the cross-sectional design of this study does not permit determination of causation. Hence, it is not possible to determine if the visual symptoms cause neck pain or vice versa. A second limitation is that only a few aspects of visual ergonomics were assessed in this study, as other aspects of the visual environment such as lighting, computer glare, as well as vision function and comfort, are difficult to evaluate in a survey and thus, were not included. As such, we cannot conclusively say that visual ergonomics has no relationship with visual symptoms in people with persistent neck pain. We also did not exclude people with a known visual condition, which may have affected the results. However, as all participants were using a computer, suitable functional vision was assumed. Another limitation is that we did not ask about the severity of short or long sightedness in those who used visual aids. It could have been possible for participants to have a higher propensity to have CVS due to higher powered glasses. It is also possible that the optical correction devices used were inappropriate or outdated. A question could have been included to determine if the participants have had their eyes professionally examined in the past year to give insight into the appropriateness and accuracy of the optical correction devices used. Lastly, due to the format of Google forms, we were unable to determine the number of participants who commenced the survey but did not complete it which could have affected the response rate of people with CVS if they were unable to tolerate the entire length of the survey.

4.5. Future directions and implications

The results of this study have some implications for the management of CVS in people with persistent neck pain. The current treatment of CVS is focused on manipulating the visual ergonomic environment (Blehm et al., 2005). This involves optimising lighting, computer position, taking regular work breaks, the use of lubricating eye drops, and computer glasses (Blehm et al., 2005; Yan et al., 2008). As the prevalence of CVS was greater in those with persistent neck pain, it is possible that treating neck symptoms may alleviate some of the visual symptoms. As such, future studies should consider whether treating persistent neck pain or the visual symptoms first would be more beneficial for the patient if they have both CVS and persistent neck pain. A threshold score for the VSS could also be investigated to provide an alternative to the CVS-Q. Further research can also be done to see if the CVS-Q or VSS is able to be used as a substitute for objective measures of CVS. In addition, with a significant number of persistent neck pain participants showing visual symptoms, future studies can consider adding visual screening to the standard assessment for people with persistent neck pain. In addition, an investigation could be conducted to assess if tools currently used to examine disability associated with neck pain, such as the NDI, can be modified to include questions regarding vision.

5. Conclusion

This study demonstrated that participants with persistent neck pain are significantly more likely to meet the threshold for CVS than those who do not have persistent neck pain. This finding did not seem to be strongly related to visual ergonomics or individual factors, but may be related to the level of neck pain and dizziness experienced. Clinicians should consider assessing visual symptoms in people presenting with persistent neck pain and vice versa. Future research should investigate the relationships between visual complaints and objective visual deficits in those with persistent neck pain, as well as their relationships with other features of visual ergonomics such as lighting and glare. We acknowledge that scope of practice may preclude some practitioners from assessing visual symptoms. Awareness of the potential contribution of visual problems may prompt those clinicians to recommend a visit to the relevant clinician. Several avenues for future research are available to further explore persistent neck pain and visual complaints in computer users.

Ethical statement

Ethical clearance was obtained from The University of Queensland's Medical Research Ethics Committee and was adhered to throughout the study.

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