Original article

SJWEH Suppl 2007;(3):54–59

Associations between eyestrain and neck–shoulder symptoms among call-center operators

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Wiholm C, Richter H, Mathiassen SE, Toomingas A. Associations between eyestrain and neck–shoulder symptoms among call-center operators. *SJWEH Suppl*. 2007;(3):54–59.

Objectives Few, if any, studies have investigated whether eyestrain and shoulder–neck symptoms are correlated, although functional links could be expected on the basis of neurophysiological evidence. This cross-sectional study assessed correlations between self-reported eyestrain and shoulder–neck symptoms among call center workers, while controlling for possible confounders for these ailments.

Methods A questionnaire concerning socioeconomic background, work conditions, and symptoms was mailed to 1531 employees at 28 different call centers during 2001–2003.

Results Altogether 21% of the responding participants (N=1183) reported both eyestrain and neck–shoulder symptoms, 46% reported neck–shoulder symptoms only, and 6% reported eye symptoms only; 27% were free from symptoms in these regions. A significant positive association was found between eyestrain and neck–shoulder symptoms. Significant covariates for shoulder–neck disorders were eyestrain (OR 1.6, P=0.007), gender (to be female) (OR 1.9, P<0.001), irritation index (OR 1.2, P=0.03), and feeling stressed (OR 1.2, P=0.001). In a multi-nominal regression analysis, gender (female) (OR 1.9, P=0.002), feeling stressed (OR 1.3, P=0.002), feelings of distress (OR 1.7, P<0.001), computer problems (OR 1.3, P=0.002), and social support (OR 0.6, P=0.003) were significant predictors of eye–neck symptoms.

Conclusions The results from this study suggest an association between self-reported eyestrain and shoulder–neck symptoms. However, no causal relations could be derived due to the cross-sectional design.

Key terms computer work; neck; shoulder symptom.

Few epidemiologic studies have focused on the association between eyestrain and neck and shoulder disorders in worklife, as well as on mechanisms and risk factors for combined eye, neck, and shoulder symptoms (1–2). Even though the literature supports the notion that eyestrain and musculoskeletal symptoms are common and coexisting complaints among employees in modern offices, the two symptom categories are often analyzed in isolation within disparate disciplines of applied or clinical science (3–8). Accordingly, the evidence for linkages between eyestrain and musculoskeletal complaints so far are limited and emanates mainly from workplace intervention studies, where decreases in eyestrain due to improvements in visual ergonomics have been reported to have a favorable influence on musculoskeletal symptoms (9–11).

Neurophysiological mechanisms of gaze control offer a theory of why and how dysfunctional interactions between eye function and head–neck–shoulder activity can be initiated. Among these, common drive mechanisms offer a particularly interesting explanatory scheme. A variation of oculomotor load was obtained by combining an alteration of visual distance and the application of minus lenses (12). Increases in electromyography (EMG) amplitudes were observed in the right frontalis, masseter, deltoid, middle trapezius, levator,

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and upper trapezius and upper neck muscles, including the splenius. A correlation between visual discomfort and pain in the neck and shoulder has been reported (13). This observation was attributed to the extraocular muscles being in a state of static stress to prevent fatiguing muscles from producing disturbing double vision and to the reflex optic paths being at the origin of, not only the ocular responses, but also those of the extraocular and the neck muscles. Furthermore, the cortical events underlying negative accommodation have been studied with brain-imaging technology (14). Negative accommodation is an antagonistic process steered in an optical direction opposite to the one employed in the response to visual stress during near-vision tasks. Such negative accommodation has the effect of shutting down the centrally controlled eye–head–neck–shoulder motor program responsible for posturing gaze. Both the primary motor cortex and the somatosensory cortex showed reduced blood flow during ongoing negative accommodation at somoatotopic coordinates that implicate the ipsilateral neck and contralateral shoulder area.

More specifically, during adverse visual work conditions, the assisting oculomotor drive, called upon to focus the triad of eye movements at the target in a tightly coupled fashion, is envisioned to "spill over" into motor tracts activating musculoskeletal pathways. The result is a "well-functioning" oculomotor system at the expense of considerable eye fatigue and eyestrain, coupled with irrelevant musculoskeletal activation (15).

With a basis in this model (figure 1), our present epidemiologic analysis investigated the hypothesis that subjective complaints from the eyes are associated with musculoskeletal complaints from the neck and shoulder region.

The aim of this study was to assess the joint occurrence of eyestrain and neck–shoulder symptoms and their possible association with individual and psychosocial work-related factors among professional computer users.

Study population and methods

A total of 1183 employees [age between 17 to 66 (mean 34) years] at 28 different call centers in Sweden participated. Altogether 72% were women, and 28% were men. Of the total study group, 1162 persons were included in the current analysis. The data were collected between 2001 and 2003.

The study had a cross-sectional design. The study base has been described previously (16). The participants answered a comprehensive questionnaire covering socioeconomic factors, organizational and psychosocial work conditions, and symptoms during the last month. The response rate was 77%. The studied variables were rated on 1–6 graded Likert scales, on which "very dissatisfied" or "never" were assigned the value 1 on the scale, and the value 6 denoted "very pleased" or "always". In addition, a continuous scale in percent (0–100%) was used for the independent variables, and for computer problems and competence utilization.

Derivation of the index variables

A neck–shoulder index was created from the questions on "neck symptoms" and "left or right shoulder symptoms", for which the index value was "yes" if the answer to one or more of the separate questions was "yes"; otherwise the value was "no". In addition an eye–neck index was created, based on the variables eyestrain and neck–shoulder symptoms for which each of the participants was classified into one of the following symptom groups: "no eye or neck–shoulder symptoms", "only eyestrain", only neck–shoulder symptoms", or "both eyestrain and neck–shoulder symptoms" (termed eye–neck). As expected, some of the items in the questionnaire were highly correlated. A factor analysis was conducted for some of the questions to reveal whether the questions seemed to reflect the same underlying factor. The results of the factor analysis indicated that questions concerning experiences of being irritated, worried, angry, uncertain, dejected or displeased to go to work appeared to be linked to the same underlying concept. Therefore, a score termed "distressed", based on the mean of these six questions, was constructed. The indices for social support and managerial support were created in a similar way.

Statistics

First, data were assessed for means, medians, and dispersion. In order to evaluate the association between eyestrain and neck–shoulder symptoms, a chi-square

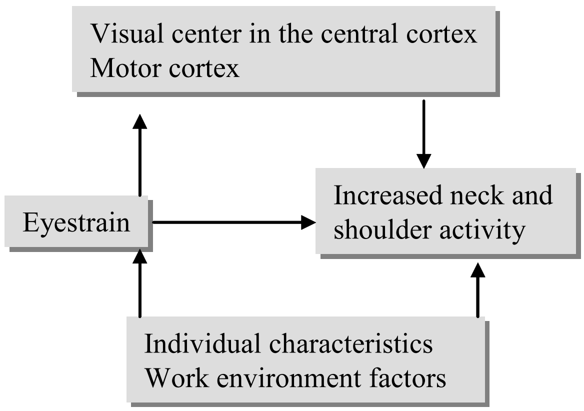

Figure 1. Schematic illustration describing the hypothesized association between eyestrain and neck or shoulder symptoms.

test was conducted. Considering eyestrain as a covarying variable for neck and shoulder symptoms, a logistic regression was performed with neck–shoulder symptoms as the dependent variable and eyestrain as the independent variable. In order to adjust for any confounding effect, we entered the variables listed in table 1 as covariates in the model. The possible covariates were gender, age, tenure in current job, as well as workhours per day, computer problems, education level and competence utilization, social and managerial support, and feeling stressed or distressed. The variables in the model (see table 1) were based on earlier reported evidence (2, 17–25). A multinominal regression analysis was conducted to evaluate which variables might indicate an increased risk of suffering from eyestrain only, neck symptoms only, or both eyestrain and shoulder symptoms

Table 1. Subset of variables and indices considered of interest for the study along with how the variables were measured. (Y = yes, N = no)

Question	Variable name	Unit
Age		Years
Gender		1 or 2
Educational level	Education	1–4
Tenure at work	Time at work	Days
How many hours do you work per week	Week hours	Hours
Computer disturbances and technical support	Computer problems	Likert scale 1–7
Solidarity, colleagues' support, get along with colleagues, understanding of my needs, fairly treated, open atmosphere	Social support (index)	Likert 1–6
Planning, encouragement, listener, support, constructive, problem solving, prerequisites, my development	Managerial support (index)	Likert 1–6
Stressed during work	Stressed	Likert 1–6
Irritated, worried, angry, uncertain, dejected, dis-pleased to go to work	Irritated (index)	Likert 1–6
Eyestrain		Y/N
Neck symptoms	Included in the neck index	Y/N
Symptoms in left shoulder	Included in the neck index	Y/N
Symptoms in right shoulder	Included in the neck index	Y/N

Table 2. Distribution of symptoms scored on a dichotomous scale; only eyestrain, only neck and shoulder symptoms, eyestrain and neck and shoulder symptoms, and no symptoms.

Eye	Neck–shoulder				Total	
	No		Yes			
	N	%	N	%	N	%
No	317	37.43	530	62.57	847	100
Yes	75	23.81	240	76.19	315	100
Total	392	33.73	770	66.27	1162	100

Results

The prevalence of eyestrain only was 6%, and neck or shoulder symptoms had a prevalence of 46%. Altogether 21% of the participants reported both eyestrain and neck–shoulder symptoms. The remaining 27% were symptom free in these regions (see table 2). Workhours in the respective symptom groups did not differ [mean 37.3–37.4 (SD 5.8) hours/week].

The association between eyestrain and neck–shoulder symptoms was significant (chi-square, $P<0.001$). When potential covariates were controlled in the logistic regression, neck–shoulder symptoms were clearly associated with eyestrain [odds ratio (OR) 1.57, 95% confidence interval (95% CI) 1.13–2.17, $P=0.007$]. The significant covariates for neck–shoulder symptoms were gender (OR 1.89, 95% CI 1.41–2.54, $P<0.001$), distress (OR 1.23, 95% CI 1.02–1.49, $P=0.03$), and feeling stressed (OR 1.24, 95% CI 1.10–1.40, $P=0.001$).

Workhours per week did not covary with any of the measured symptom categories.

The results of the multinominal regression analysis are presented in table 3, the covariates showing a P-value of less than 0.05 being regarded as significant. The odds ratios can be seen as an increase in the risk of entering the specified group when the specific independent variable is increased by 1 unit (see table 3). The reference group is the symptom-free group. As can be seen in table 3, some significant predictors showed up in all of the groups (distressed), some were only significant when eyestrain was at hand (age), and some only for neck–shoulder symptoms (stressed and gender). Technical problems were only significant for the group with both eye and neck–shoulder symptoms.

Discussion

In this study, we assessed the strength of the association between eyestrain and symptoms in the neck or shoulders among call-center employees, and we attempted to identify covariates for such combined symptoms. The results indicated that the participants reporting eyestrain had indeed an increased probability of also reporting neck and shoulder symptoms. Female gender, perceived stress and distress, social support and computer problems were associated with combined symptoms. This finding is in accordance with the results reported by other authors in isolated studies on eyestrain and neck and shoulder symptoms (26–28). The prevalence of eyestrain, not to be confused with measures of pain from an ocular disease, is known to range between 25% and 35% for professional computer users (5). Hence the observed 27% prevalence of eyestrain concurs with previous

Table 3. Odds ratios and 95% confidence intervals for the variables used in this study according to symptom group. [a]

Symptom group	Eyestrain only			Neck only			Eye–neck		
	Odds ratio	95% confidence interval	P-value	Odds ratio	95% CI	P-value	Odds ratio	95% confidence interval	P-value
Age	**1.03**	**0.999–1.052**	**0.064**	1.0	0.987–1.018	0.779	**1.02**	**1.004–1.042**	**0.018**
Gender (female)	1.07	0.603–1.908	0.811	**1.89**	**1.359–2.657**	**0.000**	1.98	1.296–3.036	0.002
Tenure (years)	0.99	0.991–1,001	0.082	0.99	0.997–1.001	0.243	**0.99**	**0.992–0.999**	**0.004**
Workhours/week	1.03	0.972–1,080	0.366	1.0	0.979–1.030	0.739	1.02	0.990–1.063	0.159
Computer problems	1.13	0.922–1.384	0.239	1.07	0.947–1.203	0.288	1.24	1.080–1.427	0.002
Competence utilization	0.98	0.894–1.082	0.726	1.0	0.949–1.058	0.944	1.05	0.982–1.124	0.151
Social support	0.65	0.411–1.034	0.069	**0.76**	**0.581–0.994**	**0.045**	**0.61**	**0.446–0.844**	**0.003**
Managerial support	1.17	0.835–1.632	0.364	1.1	0.911–1.331	0.319	1.12	0.892–1,409	0.328
Distressed	**1.70**	**1.182–2.449**	**0.004**	1.34	1.078–1.673	0.009	**1.68**	**1.306–2.168**	**0.000**
Stressed	0.88	0.689–1.123	0.305	**1.17**	**1.020–1.344**	**0.025**	**1.30**	**1.098~1.542**	**0.002**

[a] Significant values in bold face.

observations (29). However, why did musculoskeletal complaints occur together with eyestrain in 21% of the cases? There appears to be no previous reports that directly address this conundrum. It is possible that our findings reflect two phenomena that occur concomitantly and are physiologically dependent on each other. It is also possible that our findings reflect two parallel phenomena that occur concomitantly and are physiologically independent of each other. In a cross-sectional design, no formal analysis can settle this issue. However, even when eyestrain and musculoskeletal discomfort coexist in parallel, independently of each other, a change in posture in response to visual stress will occur at the expense of creating musculoskeletal difficulties or, in the worst case, may fail to alleviate visual fatigue and introduce additional postural discomfort.

Models for gaze control, originating from neurophysiology, functionally link the oculomotor system with the neck and shoulder muscles (12–14, 30). The expounded circuitry provides a physiologically plausible analytic framework that aids in the interpretation of the results from the multinominal regression analysis of the prevalence of self-reported symptoms of the neck and shoulders and its predictors. The results support the hypothesis of a joint occurrence of eyestrain and neck–shoulder symptoms that may be associated with each other.

The generation of new theories explaining dysfunctional eye–head–neck–shoulder interactions in work with computing systems may be important for several reasons. It has proved difficult to establish a quantitative relationship between physical load and shoulder–neck complaints for workers with low static load levels (31), although several models have been suggested to explain this relationship (32–35). While a close neurophysiological relationship seems plausible between visual demands and the activation of the trapezius muscle, the specific role of this link has not been addressed in the discussion of risk factors underlying work-related musculoskeletal disorders. This interaction, which is supported by our findings, should be acknowledged in pathophysiological models for the generation and persistence of eyestrain and neck–shoulder disorders in worklife. Notably, the interaction between the visual system and the musculoskeletal system can, in all likelihood, not be considered a simple one-way causal inference. Dynamic models of visual–musculoskeletal interactions are more plausible from a functional perspective and offer a richer theoretical framework for an interpretation of the results. Hence, what may have originated as a "parallel process" soon may change into a process of mutual reinforcement. Our findings and the linked theoretical model also imply that the effect of vision ergonomics and eye correction interventions on neck and shoulder symptoms among employees working in vision-demanding tasks is an appropriate issue for further research. However, considering the limitations of a cross-sectional study, the results of our study should only be seen as an explorative starting point.

Practical implications

EU directive 90/270/CEE and directives of the Swedish National Board of Occupational Safety and Health on computer work provide an ergophthalmologic approach (36) to visually demanding work environments in computerized workplaces. However, we would, on the basis of the results of this study, further stress that psychosocial factors should be taken into consideration in interventions aimed at reducing eyestrain in computer-intensive work environments.

Suggestion for future research

Dose–response relationships between the activation of the visual accommodative-vergence system and coactivation of muscles in the neck, shoulder, and upper back, and vice versa, should be experimentally quantified. The nature of this link should also be examined in age-matched symptom-free, naïve healthy controls, as well as in volunteers suffering from visual or musculoskeletal discomfort.

There is currently also a great need to launch new cross-disciplinary, epidemiologic, longitudinal protocols that focus on temporal variability in eyestrain and neck and shoulder complaints. An alternative is to investigate interventions aimed at improving the visual work environment, including lighting, eye examination, and optometrical corrections.

There is, furthermore, a need to differentiate between different sensations of asthenopia and to discriminate between conditions affecting the anterior ocular surface (dry eye conditions) and symptom factors preferentially related to oculomotor stress.

Acknowledgments

This work was conducted when Clairy Wiholm was a part-time guest researcher with the Centre for Musculoskeletal Research, University of Gävle, Sweden. Hans Richter was, in part, supported by a grant (2005–0488) from the Swedish Council for Working Life and Social Research. The Swedish Council for Working Life and Social Research financially supported the study.

We would like to thank Marcus Thuresson at Statisticon for his contribution to the statistical analyses.

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