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Workplace interventions to prevent musculoskeletal and visual symptoms and disorders among computer users

A systematic review

About this report:

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Foreword

In recent years, the Institute for Work & Health has been actively engaged in building relationships with Prevention System agencies and organizations in Ontario.

In these encounters, we often hear that potential research users want more evidence about the effectiveness of interventions aimed at protecting workers' health. We are also told that even when research evidence exists, it is often hard to access, difficult to understand and is not always presented in language and formats suitable to non-scientific audiences.

In response to these needs, the Institute for Work & Health has established a dedicated group to conduct systematic reviews of relevant research studies in the area of workplace injury and illness prevention. In instances where there are too few studies to conduct a full Systematic Review we may provide our audiences with a narrative review.

- Our systematic review team monitors developments in the international research literature on workplace health protection and selects timely, relevant topics for evidence review.
- Our scientists then synthesize both established and emerging evidence on each topic through the application of rigorous methods.
- We then present summaries of the research evidence and recommendations following from this evidence in formats which are accessible to non-scientific audiences.

The Institute will consult regularly with workplace parties to identify areas of workplace health protection that might lend themselves to a systematic review of the evidence.

We appreciate the support of the Ontario Workplace Safety & Insurance Board (WSIB) in funding this four-year Prevention Systematic Reviews initiative. As the major funder, the WSIB demonstrates its own commitment to protecting workers' health by supporting consensus-based policy development which incorporates the best available research evidence.

Many members of the Institute's staff participated in conducting this Systematic Review. A number of external reviewers in academic and workplace leadership positions provided valuable comments on earlier versions of the report. On behalf of the Institute, I would like to express gratitude for these contributions.

Dr. Cameron Mustard
President, Institute for Work & Health
January, 2006

1.0 Introduction

The most common occupational health complaints among computer users are visual symptoms and musculoskeletal disorders (Hagberg and Rempel 1997). The problems include eye discomfort, sustained pain in the neck and upper extremities, and regional disorders, such as wrist tendonitis, epicondylitis and trapezius muscle strain.

Workplace risk factors for these physical symptoms include: hours of computer use; sustained and/or awkward head and arm postures; poor lighting conditions; poor visual correction; and work organizational factors (Hales et al. 1994; Tittiranonda et al. 1999; Punnett and Bergqvist 1997; Palmer et al., 2001; Kryger et al., 2003; Lassen et al. 2004; Marcus et al., 2002; Gerr et al. 2002; Gerr et al. 2004; Cole et al. 2003; Daum et al. 2004; Andersen et al. 2003; Bergqvist et al. 1995; Hagberg and Rempel 1997; Sheedy and Shaw-McMinn 2003).

Recently, the Institute of Medicine called for more intervention research in this area. The goal of such research would be to provide scientifically credible evidence to practitioners about how to reduce health risks associated with computer work (NRC 2001).

The scientific literature regarding ergonomic interventions continues to expand. A broad literature search for participatory ergonomic interventions revealed a two-fold increase in number of articles from 1990 to 2004 (Cole 2005).

A number of studies, including research on the effects of workstation, eyewear and behavioral interventions on upper body disorders and visual symptoms, can be found in the ergonomics and health literature. However, these studies are of mixed quality (Karsh et al. 2001) and also employ a variety of research methods.

This methodological heterogeneity poses a challenge for researchers who would like to synthesize the evidence in this area by conducting a systematic review. The systematic review process provides a structured methodology for evaluating the literature and synthesizing evidence regarding prevention strategies (Slavin1995, Reeves 2002, Côté 2001, Franche 2004). Such reviews also point out gaps in the existing literature.

The purpose of this systematic review was to identify studies that evaluate the effects of a workplace intervention on visual or upper body musculoskeletal (MSK) symptoms/disorders among computer users.

Studies which met our design and quality criteria were evaluated in detail, and data were synthesized from these studies. The review included both

primary and secondary prevention studies. Based on our synthesis, we make recommendations about primary and secondary prevention of these work-related disorders. We also discuss the need for further, high quality intervention studies in this area of workplace health.

1.1 Organization of the report

Following this introduction, readers will find:

- a detailed description of the methods we used to search for and select relevant studies
- details about quality assessment, data extraction and best evidence synthesis of quantitative studies
- results of the systematic review, including information about: the number of studies found; the methodological quality observed; the types of interventions examined; and study characteristics
- results of our synthesis of evidence according to intervention categories
- conclusions about the levels of evidence
- messages about the current state of the peer-reviewed literature and recommendations for future ergonomic intervention research and evaluation

2.0 Materials and methods

Primary and secondary intervention studies were systematically reviewed using a consensus process developed by Cochrane (Cochrane 2005) and Slavin (Slavin 1995) and adapted by the review team.

A review team comprising nine researchers from the U.S and Canada was invited to participate in the process. Some reviewers were identified based on their expertise in conducting epidemiologic or intervention studies related to musculoskeletal or visual disorders among computer users. Some were recruited for their experience in conducting systematic reviews. Members of the review team had backgrounds in epidemiology, ergonomics, occupational medicine, safety engineering and optometry.

The basic steps of the systematic review process are listed below. The review team used a consensus process for each step of the review:

- formulation of research question and search terms
- identification of articles expected in literature search from all review team members
- international content experts contacted to identify key articles
- literature search conducted and articles pooled with those submitted by experts
- Level 1 review: Selection of studies for relevance, based on six screening criteria
- Level 2 review: Quality assessment of relevant articles with scoring on 19 criteria
- Level 3 review: Extract data from all relevant articles to compile data tables for synthesis
- synthesis of the evidence

The primary question addressed by this systematic review is: "Do office interventions among computer users have an effect on musculoskeletal and visual health status?" To address this question the review team considered studies with analyses that focused on specific intervention types (e.g. training, keyboard, glasses) and endpoints (e.g. musculoskeletal or visual health outcomes).

Three terms from the primary question, "Office," "Intervention" and "Health" were defined and used to develop the literature search criteria.

Office was defined based on work setting and technology. The definition includes traditional office settings where computers (either desktop or laptop) are used to process information. We excluded studies involving non-traditional office settings (e.g. airports, rent-an-office, home offices or

traveling offices of sales people) or settings where the work primarily involved manufacturing or material handling. Experiments conducted in a laboratory were also excluded. The review focused on health effects in these office settings.

Intervention was broadly defined by utilizing the traditional hazard control tiers of engineering controls (e.g. workstation adjustments), administrative controls (e.g. implementing rest breaks) and personal protective equipment use (e.g. screen filters or arm rests).

Health was defined broadly to include musculoskeletal and visual symptoms as well as clinical musculoskeletal and visual diagnoses. Visual diagnoses included: binocular disorders; accommodative disorders and conditions related to dry eye (if specific to computer uses in office environments). We excluded the following diagnoses: cataracts; retina disorders (e.g. diabetic retinopathy) and diagnoses related to infection (e.g. conjunctivitis and/or uveitis). Also excluded were studies that reported only data from OSHA 200/300 logs or from workers' compensation records. While muscle loading research was recognized as defining a plausible pathway, field studies with muscle loading as the outcome were excluded.

The review team considered articles published or in press in the English language, peer-reviewed, scientific literature from 1980 forward. (This year marks the time when computers started becoming more widely used in office settings.) Book chapters and conference proceedings were excluded. The primary reasons for these limitations were language proficiency of the team and time needed to complete the review.

2.1 Literature Search

Based on the research question, literature search terms were identified and combined to search the following databases: MEDLINE, EMBASE, CINAHL, and Academic Source Premier.

The search terms evolved into three broad categories: intervention, work setting, and health outcomes (see Table 1).

Overall the search categories were chosen to be inclusive. However within the work settings category some terms were exclusive (non-office based etc.). The specific disease terms "cataract, conjunctivitis, uveitis, diabetic retinopathy and neoplasms," as well as the term "muscle loading," were also used to exclude references. The search strategy combined the three categories using an AND strategy, while the terms within each category were OR'd.

Table 1: Search terms

Search strategy: terms within a row are combined with OR and between rows with AND.

Intervention terms	Intervention Studies, anthropometry, human engineering, ergonomic, human factor, forearm support, wrist rest, monitor, laptop computer, notebook computer, flat panel display, display, footrest, computer, workstation, training, exercise, VDT or VDU, progressive lens, bifocal, glasses, eyeglasses, spectacle, chair, equipment, lighting, keyboard, mouse, glare, computer terminals, "interior design and furnishings", "task performance analysis"
Work setting terms	Employ$, hospitals, company, worker, office, knowledge worker, white collar worker, call center or call centre, telemarketing, computerized office, engineer, reporter, newspaper, office worker, student, editor, information technology, insurance, government, universities, classroom, computer terminals, computers, computer user, VDU operator, computer peripherals
Health outcome terms	Arm injuries, cumulative trauma disorders, tendonitis, tenosynovitis, neck injuries, synovitis, muscle weakness, forearm injuries, wrist injuries, hand injuries, osteoarthritis, "sprains and strains", soft tissue injuries, arthralgia, finger injuries, tendon injuries, bursitis, nerve compression syndromes, myofascial pain syndromes, neuralgia, causalgia, radiculopathy, polyradiculoneuritis, polyneuritis, muscular diseases, carpal tunnel syndrome, shoulder impingement syndrome, thoracic outlet syndrome, tennis elbow, epicondylitis, cervico-brachial neuralgia, ulnar nerve compression syndrome, musculoskeletal diseases, repetitive trauma, musculoskeletal system, musculoskeletal injuries, musculoskeletal symptom, visual symptom, eye strain, headache, RSI, accommodation, asthenopia, eyestrain, binocular disorder, convergence, ocular, ocular motility disorders, presbyopia, convergence insufficiency, accommodative insufficiency, dry eye syndrome, myopia, hyperopia, astigmatism, refractive errors, visual acuity, diplopia, anisometropia, orthoptics, “vision, binocular”, eye protective devices, “adaptation, ocular”, ocular, photophobia, eye movements, vision disorders, posture, neck pain, back pain, computer vision syndrome, upper extremity/ AND pain, lower extremity/ AND pain

Prior to the literature search, the review team identified a list of 28 relevant articles which were used to test the sensitivity of our literature search. An initial search missed 13 of the 28 articles, due primarily to the absence of

keywords in the "work setting" category (Table 1). The search was expanded to include the terms "computer" and "computer user." A second search captured 25 of the 28 key articles and was, therefore, considered evidence that our search was sufficiently sensitive.

Content experts identified by the systematic review team were asked to submit relevant published articles or articles in press. We also requested articles accepted for review and grey literature articles (e.g. technical reports, book chapters, theses or dissertations and conference presentations). We asked for this literature so we could review the bibliographies for relevant peer-reviewed articles. Four outside experts provided 24 relevant articles that were not identified by the search strategy, and these were accepted for review. The reference lists of the reviewed articles were also checked to capture other relevant articles.

2.2 Level 1 - Selection for relevance

Our broad search strategy captured many studies that were not relevant to answering our research question. A Level 1 relevance review was designed to capture and exclude these as quickly as possible. Reviewers read the article title and abstract and, if necessary, the full article.

To increase the speed of the process, the Level 1 review was divided into two steps: an initial screening step (Level 1a) and a more detailed assessment (Level 1b). Article relevance at Level 1a was based on three criteria: that an intervention occurred, that the study took place in an office place, and that the intervention was related to computer use. Criteria for Level 1b relevance were based on eight article characteristics or qualities such as peer-review status and language as well as study design issues such as presence of a control group and type of outcomes (Table 2). One member of the research team reviewed each article at Level 1a, while two members reviewed each article at Level 1b. At Level 1b, articles were moved forward for further review when the two reviewers reached consensus that the criteria were met.

Since the Level 1a review was done by a single reviewer, there was a possibility for selection biases. Therefore a quality control (QC) check at this level was done with an independent reviewer (QC reviewer) with methodological and content Level 1a criteria. These included: whether an intervention took place, whether the intervention took place in an office setting (not lab) and whether the intervention involved computer work.

The studies reviewed by the QC reviewer were a randomly chosen set of ten studies from each of eight reviewers. The set of studies selected was to include five studies excluded at this level and five that would continue to subsequent levels of the review. The randomization process relied on the intervention question (Table 1) more heavily than the other two questions at

this level. Since there were far more studies excluded than included at this level, the tendency was to have more excluded studies than included studies for each reviewer. One reviewer (BA) only had excluded studies at this level therefore only five studies were included from this reviewer. One study was not transferred from the randomization file and therefore one reviewer (SM) has nine studies represented in the sample for comparison. The review team did not feel that these idiosyncrasies in the studies selected would bias the results of our assessment of agreement between the QC reviewer and the team.

Responses from the QC reviewer were entered into a spreadsheet with the data from the review team and a dataset was created. SAS (v9.0) was used to calculate the kappa scores. The level of agreement between the reviewers and the QC reviewer was examined for exclusion of studies. The Kappa score of 0.57 indicates moderate agreement (Landis and Koch, 1977). This level of agreement likely reflects the fact that the QC reviewer did not have access to the full articles while the review team did. Given this limitation the review team felt that the Level 1a review likely did not result in significant biases of study selection.

On further examination, the QC reviewer included five articles that the review team excluded and excluded six articles that the review team included. Upon inspection of the five articles included by the QC reviewer, in all cases the QC reviewer responded with "unclear" about some or all of the criteria. Of the six studies mentioned above, none made it past the Level 1b review. Therefore, we consider the quality of the Level 1a review process reasonable.

Table 2: Level 1 – screening questions and the response that leads to exclusion
An exclusionary response to any one question would exclude the article from further review. Level 1b required consensus between two reviewers.

LEVEL 1	
1. Did an intervention occur?	NO
2. Did intervention occur in office?	NO
3. Was intervention related to computer work?	NO
LEVEL 1b	
4. Peer reviewed or in press publication?	NO
5. From English language literature?	NO
6. Control group used?	NO
7. Individual health data?	NO
8. Outcome musculoskeletal or visual symptoms/disorders?	NO
9. Post only study?	YES
10. OSHA log outcome data only?	YES
11. Workers' compensation data only?	YES

2.3 Level 2 - Quality assessment

Articles that passed the Level 1 review were further evaluated by a methodological quality assessment which we called a Level 2 review. The team developed a list of 19 methodological criteria (Table 3) to assess article quality. Each article was independently reviewed by two team members and rated as either meeting or not meeting each criterion. To reduce bias, reviewers were randomly paired with at least two other team members. The reviewer pairs were required to reach consensus on quality criteria. Team members did not review articles they had consulted on, authored or co-authored.

Table 3: Level 2 - Quality appraisal questions and weights

Question	Weight
1. Was the research question/objective clearly stated?	2
2. Was the primary hypothesis clearly stated?	1
3. Was the intervention allocation randomized?	3
4. Was the length of follow-up one month or greater?	2
5. Were concurrent comparison (control) group(s) used?	3
6. Were sample inclusion/exclusion criteria described?	3
7. Was participation rate reported and greater than 40% for employees/workers?	3
8. Were baseline characteristics of study participants presented?	2
9. Were baseline characteristics presented by group?	3
10. Was the loss to follow up reported?	3
11. Were differences between those employees/workers who remained in the study and those who dropped out analyzed?	3
12. Was the intervention implementation described?	3
13. Was there confirmation the intervention took place?	1
14. Were the effects of the intervention on some exposure parameters documented?	1
15. Was the calendar duration of the intervention documented?	1
16. Was contamination between groups described or documented?	1
17. Were covariates/potential confounders for musculoskeletal or visual disorders ascertained (i.e., gender, age, eye wear, non-work activities)?	3
18. Was adjustment made for covariates/potential confounders?	2
19. Were statistical methods adequately described?	3

Reviewer pair disagreements were identified, and reviewers discussed their differences in order to come to a resolution. In cases where agreement could not be reached, a third reviewer was consulted to ensure consensus was obtained (see Appendix A for the Quality Appraisal (QA) guide to reviewers).

Methodological quality scores for each article were based on a weighted sum score of 19 quality criteria. The three-point weighting of each of the 19 criteria from “important” (1 point) to “very important” (3 points) was based on an *a priori* team consensus process (see Table 3). The highest weighted score possible was 43. Each article received a quality ranking score by dividing the weighted score by 43 and multiplying by 100%. The quality ranking score was used to group articles into high (85% to 100%), medium (50% to 84%) and low (0% to 49%) quality categories for data synthesis.

These categories were determined by consensus from the entire team with reference to the review methodology literature (Slavin 1995, Cochrane 2005, AHRQ 2005).

2.4 Level 3 - Data extraction/synthesis

Data were extracted by reading and recording details from each paper. The extracted data were used to build summary tables to help us carry out our data synthesis and then develop our overall conclusions.

The data extraction for each paper was performed independently by two reviewers. Reviewer pairs were rotated to reduce bias. Team members did not review articles they had consulted on, authored or co-authored. Differences in extracted data between reviewers were identified and resolved to reach consensus. In cases where agreement could not be reached, a third reviewer was consulted to ensure consensus was obtained.

The team developed standardized data extraction forms based on existing forms and data extraction procedures (Franche 2004; Smith 2000) (see Appendix B for the Data Extraction (DE) guide to reviewers).

The pairs of reviewers extracted data on: year of study; jurisdiction; study design; sample characteristics; length of follow-up; intervention; musculoskeletal and visual outcome measures; statistical analyses; covariates/confounders; and study findings (see Table 4 for complete list of the data extraction questions). When considering study findings, the review team decided to focus on the effects reported for the longest follow-up period in the study.

During the data extraction process, reviewers also reconsidered the methodological quality rating scores for each study. The in-depth data extraction process allowed us to reflect on the quality of the research. Any quality rating changes at this level were made with consensus from the entire review team.

Initially, we planned to calculate the effect sizes for each article in order to apply a uniform method to evaluating the strength of associations (Hall et al, 1994; Rosenthal, 1994; Fleiss, 1994; and Light et al, 1994). However, this plan was abandoned due to the heterogeneity of outcome measures and study methods, and also the lack of data necessary to calculate effect size for some studies.

Table 4: Data extraction items

1. State the research question/objective
2. State the primary hypothesis
3. State additional hypotheses not listed in question #2
4. Write the last name of the first author and the year of publication
5. List the jurisdiction where the study was completed
6. What industry/sector was the study conducted in?
7. Describe the job titles/classification of the participants that participated in the study.
8. List the inclusion and exclusion criteria described in the study
9. What is the study design?
10. What type of prevention did the study investigate?
11. What was the duration of the intervention in months/days/hours?
12. Indicate time period between the baseline measurement and all subsequent follow-up measurements
13. Describe intervention group
14. Describe the referent group
15. Describe overall (study) group - Answer only if paper did not provide information to answer questions 13 and 14
16. What was the intervention evaluated?
17. Describe the intervention
18. Was there confirmation the intervention occurred?
19. How long after the intervention did the confirmation occur?
20. Select from the list all types of covariates/confounders that were evaluated for inclusion in the final analysis
21. Provide a list of covariates/confounding variables that were controlled for in the final test of the intervention effectiveness
22. Describe the significant differences in covariates/confounders for those that participated in the study vs those that were invited but did not participate by experimental group
23. Describe the significant differences in covariates/confounders for those that participated in the study vs those that were lost to follow-up by experimental group.
24. Describe how the MSK health outcomes (symptoms) were measured
25. Describe whether musculoskeletal symptoms were measured consistently at the same time of day over different measurement periods
26. Describe whether musculoskeletal symptoms were measured consistently on the same day of the week over different measurement periods
27. Describe how the visual health outcomes were measured
28. Describe whether visual symptoms were measured consistently at the same time of day over different measurement periods
29. Describe whether visual symptoms were measured consistently on the same day of the week over different measurement periods
30. List all the non-MSK and non-visual outcomes and how they were measured
31. Check all body regions where specific clinical disorders were ascertained by physical examination or laboratory test
32. Was masking to physical assessment done?
33. Please check the type of analysis done for testing the observed effect of the intervention
34. Describe for each outcome of interest the observed intervention effect

The studies we reviewed were heterogeneous as they came from different countries, involved different kinds of interventions, focused on different systems (visual and musculoskeletal), used different health outcome measurements and involved substantially different kinds of statistical analyses.

Such a high level of heterogeneity required us to use a synthesis approach adapted from Slavin and others (Slavin 1995, Franche 2004, Côté 2001) known as "best evidence synthesis." The best evidence synthesis approach used here considers the quality of the articles, the quantity of articles and the consistency of the findings among the articles (Table 5). "Quality" refers to the methodological strength of the studies as discussed above. "Quantity" refers to the number of studies that provide evidence on the same health outcome. "Consistency" refers to the similarity of results observed across the studies on the same health outcome.

Our guidelines were adapted from those used in the systematic review of workplace-based return-to-work interventions (Franche 2004). These guidelines were themselves based on the review of prevention incentives of insurance and regulatory mechanisms for occupational health and safety (Tompa 2004). The review team decided to consider the levels of evidence for each of the intervention categories found in the studies reviewed. The review team classified a study with any positive results and no negative results (on a single intervention) as a positive effect study. A study with both positive effects and no effects (i.e. no differences between groups on a single intervention) was also classified as a positive effect study. A study with only no effects was classified as a no effect study. Synthesis of the reviewed evidence on a particular intervention category was ranked on a scale: strong evidence; moderate evidence; mixed evidence; insufficient evidence.

Here are some key details about how the best evidence guidelines were used in our systematic review:

- If a reviewed study did not have the primary outcome concerning musculoskeletal or visual primary symptoms but data was reported in either of these areas, we included this evidence in the synthesis.
- Where specific data values were not reported, we abstracted values from figures and indicated this in our report.
- When multiple findings were reported, we examined whether multiple comparisons were conducted appropriately.
- We considered significant trends but reported non-significant trends.
- Application of the evidence guidelines for each of the intervention categories relied on consensus within the review team.
- The synthesis conclusions were also accepted based on review team consensus.

Table 5: Best evidence synthesis guidelines

Level of evidence	**Minimum quality**	**Minimum quantity**	**Consistency**
Strong	High (>85%)	>=3 studies	All high quality studies converge on the same findings.
Moderate	Medium (50-85%)	>=2 studies	Majority of medium quality studies converge on the same findings.
Mixed	Medium (50-85%)	>=2 studies	Medium and better quality studies have inconsistent findings.
Partial	Low (0-50%)	>=2 studies	Majority of low quality studies converge on the same findings.
Insufficient	The above criteria are not met.		

3.0 Results

3.1 Literature search and selection for relevance

We identified 7313 articles in our literature search using the terms listed in Table 1. This reflects the total number of articles obtained after different databases were merged and duplicate articles were removed and after the articles supplied by content experts were included (Figure 1).

A total of 6948 articles were excluded during the Level 1 review because there was no evidence that an intervention was reported, or because there was no evidence that the intervention was in an office setting, or because there was no evidence the intervention was related to computer work.

A total of 365 articles proceeded to Level 1b review. Using the exclusion criteria (see Table 2) the articles were reviewed by two team members. This led to the exclusion of 334 articles. (For more details about the number of articles excluded by Level 1a and 1b criteria, see Appendices C and D: Tables 10 and 11.)

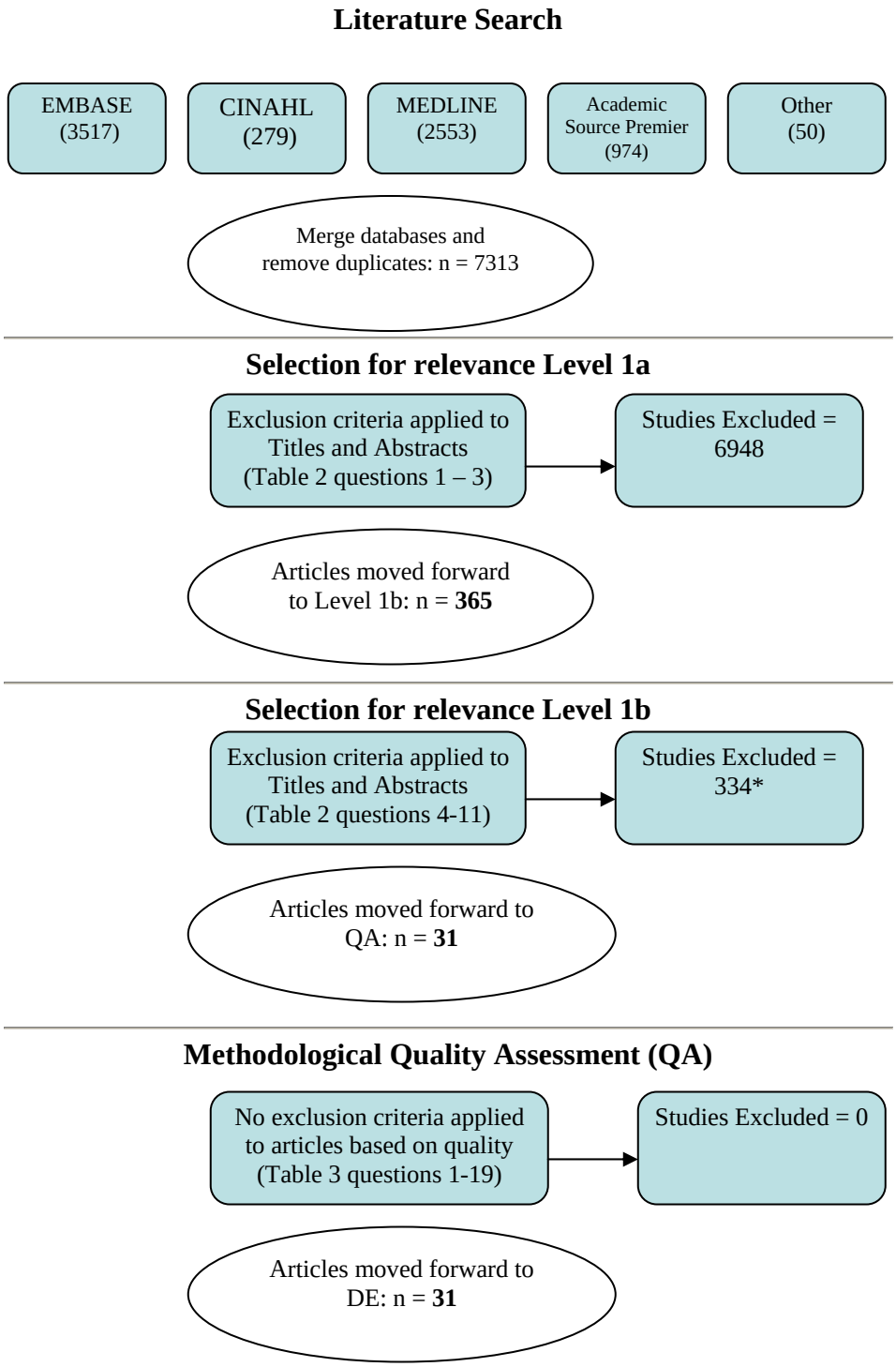
A total of 31 studies proceeded to Level 2 methodological quality assessment. These 31 studies were each reviewed by two reviewers using our quality assessment questions (see Table 3). The team completed data extraction for all studies evaluated for quality to develop a more complete picture of the state of the literature.

3.2 Methodological quality assessment

The 31 studies that met our relevance criteria were assessed for methodological quality using 19 quality criteria (Table 6). These criteria addressed important aspects of assessing internal and external validity. The criteria were weighted according to the importance of each item as decided by the entire review team.

The weighted criteria were used to develop a normalized quality score for each study. The studies were placed into three quality categories: high (85 – 100%), medium (50-85%) and low (0-50%) based on the weighted scores of the 19 quality criteria. Studies were not excluded from data extraction based on the quality scores.

Figure 1: Flow chart of systematic review process



* Two Aaras articles combined as they were determined to be reporting the same study.
* The Martin and Gatty articles were combined as the papers were determined to be reporting the same study.

High quality studies

We determined that nine studies were of high quality (Amick 2003, Brisson 1999, Feuerstein 2004, Gerr 2005, Ketola 2002, Rempel 2005, Rempel 1999, Tittiranondo 1999, van den Heuvel, 2003). The high quality studies were quite consistent in the quality scores obtained since they met between 11 and 13 of the 19 criteria. Despite being categorized as high quality, the studies generally did not state a hypothesis (seven of nine) or describe differences between participants and those lost to follow-up (seven of nine). The studies also did not consistently describe contamination between groups (four of nine).

Medium quality studies

We classified 22 of the studies as medium quality (Mekhora 2000, Martin 2003, Greene 2005, Bohr 2000, Skilling 2005, Aaras 2001, Peper 2004, Aaras 1999, Cook 2004, Kamwendo 1991, Mclean 2001, Horgen 2004, Butzon 1997, Henning 1997, Hladky 1998, Lintula 2001, Nelson 1998, Butzon 2002, Biswas 2003, Fostervold 2001, Galinsky 2000, Psihogios 2001). The medium quality studies often did not meet the criteria for differences between participants and lost to follow-up, contamination between groups, adjustment for covariates/confounders and reporting participation rates over 40 per cent. The medium quality studies also did not meet the criteria for: documenting the effects of intervention on exposure parameters; confirmation of intervention; presenting inclusion/exclusion criteria; and presenting baseline characteristics by group. (The high quality studies did meet these criteria.) Despite the classification of medium quality, these studies generally scored well on the criteria concerning: stating the research question; having concurrent comparison groups; presenting baseline characteristics; describing the intervention implementation; describing the duration of the intervention; ascertaining covariates/confounders; and describing statistical methods.

None of the studies were classified as low quality. This was not necessarily a surprising outcome, given that our relevance criteria (Level 1b) included some quality issues. Thus, lower quality studies did not progress past this early stage of the review process.

Table 6: Methodological quality assessment
Refer to table 3 for the QA criteria.

Criteria	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Quality Ranking
Author/Weight	2	1	3	2	3	3	3	2	3	3	3	3	1	1	1	1	3	2	3	
High Quality Ranking																				
Amick, 2003	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	93.0%
Brisson, 1999	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	93.0%
Feuerstein, 2004	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	93.0%
Gerr, 2005	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	88.4%
Ketola, 2002	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	93.0%
Rempel, 1999	1	0	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	90.7%
Rempel, 2005	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	95.3%
Tittiranonda, 1999	1	0	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1	1	1	86.0%
van den Heuvel, 2003	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	90.7%
Criteria Met	9	2	8	9	9	9	8	9	9	9	3	9	8	7	8	5	9	8	9	
Percent Criteria Met	90%	20%	80%	90%	90%	90%	80%	90%	90%	90%	30%	90%	80%	70%	80%	50%	90%	80%	90%	
Medium Quality Ranking																				
Aaras, 2001	1	1	0	1	1	0	0	1	1	1	1	1	1	1	1	0	1	0	1	74.4%
Aaras, 1999	1	0	1	1	1	1	0	1	1	0	0	1	0	0	0	0	1	0	1	65.1%

Criteria	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Quality Ranking
Author/Weight	2	1	3	2	3	3	3	2	3	3	3	3	1	1	1	1	3	2	3	
Biswas, 2003	1	1	1	1	1	1	0	1	1	0	0	1	0	0	0	0	0	0	1	60.5%
Bohr, 2000	1	0	1	1	1	1	0	1	0	1	0	1	0	1	1	0	1	1	1	74.4%
Butzon, 1997	1	0	0	0	1	1	1	1	0	1	0	1	0	1	1	0	1	0	1	65.1%
Butzon, 2002	1	0	0	0	1	1	0	1	0	1	0	1	0	0	1	0	1	1	0	53.5%
Cook, 2004	1	0	1	1	1	1	1	1	0	1	0	1	1	1	1	0	1	0	0	72.1%
Fostervold, 2001	1	1	1	1	1	0	0	0	1	0	0	1	0	1	1	0	1	0	1	60.5%
Galinsky, 2000	1	0	1	0	1	0	0	1	0	1	0	1	1	0	1	1	0	0	1	53.5%
Greene, 2005	1	1	1	0	1	1	0	1	1	1	0	1	1	1	1	1	1	0	1	79.1%
Henning, 1997	1	0	1	1	1	0	0	1	0	1	0	1	1	0	1	0	0	0	1	55.8%
Hladky, 1998	1	1	0	1	1	0	0	1	1	1	0	1	0	0	1	0	1	1	1	67.4%
Horgen, 2004	1	0	0	1	1	1	0	0	0	1	1	1	0	0	1	0	1	1	1	67.4%
Kamwendo, 1991	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	0	1	0	1	83.7%
Lintula, 2001	1	0	1	1	1	0	0	1	1	0	0	1	1	1	1	0	1	0	1	65.1%
Martin, 2003	1	1	1	1	1	1	0	1	1	1	0	1	1	1	1	0	1	0	1	81.4%
Mclean, 2001	1	1	1	0	1	1	0	1	1	0	0	1	0	1	1	0	1	0	1	67.4%
Mekhora, 2000	1	0	1	1	1	1	1	1	1	1	0	1	1	0	1	0	1	0	1	83.7%
Nelson, 1998	1	0	0	1	1	0	1	1	1	0	0	1	0	0	0	0	1	0	1	58.1%
Peper, 2004	1	0	1	1	1	0	0	1	1	1	0	1	1	1	1	0	1	0	1	72.1%
Psihogios, 2001	1	0	0	0	1	1	0	1	0	0	0	1	1	1	1	0	1	0	1	53.5%
Skilling, 2005	1	1	1	0	1	1	1	1	1	1	0	1	1	0	1	0	0	0	1	74.4%
Criteria Met	22	9	15	15	22	14	6	20	14	15	2	22	12	11	19	2	18	4	20	
Percent Criteria Met	100%	41%	68%	68%	100%	64%	27%	91%	64%	68%	9%	100%	55%	50%	86%	9%	82%	18%	91%	

3.3 Data extraction results

We extracted data from all 31 studies rated for methodological quality. To help organize the results, the review team decided to present the data extraction results according to intervention categories. The intervention categories were determined by grouping the interventions described in the studies. These categories were created with consensus from the review team. Table 7 shows the intervention categories and the detailed description of the intervention in each study reviewed.

Intervention categories

We found 16 different interventions in the studies we reviewed. Some studies looked at more than one intervention:

- The most commonly evaluated type of intervention involved some type of **training** (nine of 31 studies).
- Interventions of **workstation adjustment** were examined by six studies, while **rest breaks** were examined by four studies.
- Other categories of intervention included: **arm supports, pointing devices, alternative keyboards, screen filters, and VDT glasses** (two studies each).
- The remaining interventions were explored in single studies (see Table 7).

Within these intervention categories there was substantial heterogeneity with respect to the specific equipment employed, training methods, workstation adjustments targeted and intervention protocols.

Table 7: Description of interventions used in data synthesis

Intervention category	Author, year	Quality rating	Intervention description	Study design	Prevention Type
Training on exercises	Kamwendo, 1999	Medium	I_1: traditional neck school (4 h): four trainings by a physiotherapist on active and stretching exerces and muscle relaxation. I_2: traditional neck school plus reinforcement (2 h): physiotherapist visited the workplace to discuss ergonomic changes and provide written instructions and a psychologist interviewed the user to develop a personal coping strategy. C: received no intervention.	Randomized Trial	Both
Training on job stress Management	Feuerstein 2004	High	I: received a worksite checklist evaluation by health professional, workstation adjustments (no new equipment), stretching exercises and access to the ErgoClinic website. In addition they received an interactive job stress management education during two 70 minute meetings held 2 weeks apart followed by an email healthy computing tip every 2 weeks. C: received a worksite checklist evaluation by health professional, workstation adjustments (no new equipment), stretching exercises and access to the ErgoClinic website.	Randomized Trial	Secondary
Training on ergonomics	Brisson, 1999	High	I: received a training targeting 3 behaviors: adjusting the visual and postural components of the workstation and organizing work activities in preventive manner, in two 2 h sessions, two weeks apart, with workstation self-diagnosis between sessions. C: received the training at the end of the intervention.	Randomized Trial	Both
Training on ergonomics	Bohr, 2000	Medium	I_1: received a 2 hr participatory training with problem solving. I_2: received a 1 hr training consisting of lecture and handouts about office ergonomics. C: received no intervention.	Randomized Trial	Secondary
Training on ergonomics	Peper, 2004	Medium	I: received training of 6 weekly 2 h group sessions in ergonomic principles, psychophysiological awareness and control, sEMG practice at the workstation. C: received no intervention.	Randomized Trial	Primary
Training on ergonomics	Greene, 2005	Medium	I: received an active ergonomics training consisting of two, three hour training sessions in one week. IC: received the intervention after two weeks of follow-up. Both groups were followed for 1 year.	Randomized Trial with Delayed Intervention	Secondary
Training on ergonomics, new chair	Amick, 2003	High	I_1: received a highly adjustable chair and one time 90 m office ergonomics training workshop with 3 educational e-mail follow-ups I_2: received only the training workshop and e-mail follow-ups C: received the training session at the end of the intervention.	Non-Randomized Trial	Both

Intervention category	Author, year	Quality rating	Intervention description	Study design	Prevention Type
Training on ergonomics, workstation adjustment	Mekhora, 2000	Medium	I: received workstation adjustments based on anthropometry and software (IntelAd). IC: received the same after 12 weeks of follow-up and followed for an additional 13 weeks as a delayed intervention group.	Randomized Trial with Delayed Intervention	Secondary
Workstation adjustment	Ketola, 2002	High	I_1: received an ergo checklist and evaluated and adjusted their workstations with a physical therapist. New forearm and wrist rests were provided if needed. I_2: received the same ergo checklist and attended a 1 h group training session on ergonomics and rest breaks. C: received a leaflet on musculoskeletal health and VDT use.	Randomized Trial	Secondary
Workstation adjustment	Cook, 2004	Medium	I: received education about workstation set up and working posture and workstations were adjusted to support the forearm on the desk surface (no new equipment). Particpants were monitored for the first few hours to ensure that they were not adopting postures of trunk flexion, shoulder elevation or increased wrist extension. C: received education about workstation set up and working posture and where required, adjustments to desk, chair and monitor height were made according to Australian Standards.	Randomized Trial	Primary
Workstation adjustment	Gerr, 2005	High	I_1: received training and workstation adjustments based on protective factors identified from prior studies. I_2: received training and workstation adjustments based on OSHA, NIOSH and private industry standards. C: received no instruction, but received the same visits from the study staff.	Randomized Trial	Primary
Workstation adjustment (monitor position)	Psihogios, 2001	Medium	Participants were evenly dichotomized into two conditions based on normal (initial) gaze angle relative to horizontal (0° and -17.5°) I_1: the monitor was moved to shift gaze angle from -17.5° to 0° for two weeks. C_1: the monitor was maintained at a -17.5° gaze angle. I_2: the monitor was placed to shift gaze angle from 0° to -17.5° for two weeks. C_2: the monitor was maintained at a 0° gaze angle.	Quasi-Experimental within Subjects	Secondary
Arm support	Lintula, 2001	Medium	I_1: received one Ergorest arm support with a mouse pad for the hand that operated the mouse. I_2: received Ergorest arm supports for both hands and a mouse pad for the mousing hand. C: recieved no arm supports and was instructed not to change their workstations during the study period.	Randomized Trial	Primary

Intervention category	Author, year	Quality rating	Intervention description	Study design	Prevention Type
Pointing device, arm support	Rempel, 2005	High	I_1: received a trackball and ergonomics training I_2: received forearm support board and ergonomics training I_3: received forearm support board, trackball and ergonomics training C: received only the ergonomics training.	Randomized Trial	Both
Pointing device	Aaras, 1999 (Aaras, 2002)	Medium	I_1: received the Anir (3M) mouse designed to reduce pronation. C: received the mouse 6 months later.	Randomized Trial	Secondary
Alternative keyboard	Tittiranonda 1997	High	I_1: received Apple Adjustable Keyboard™ plus 1 h ergonomics training I_2: received Comfort Keyboard System™ plus 1 h ergonomics training I_3: received Microsoft Natural Keyboard™ plus 1 h ergonomics training C: received conventional keyboard plus 1 h ergonomics training	Randomized Trial	Secondary
Alternative keyboard	Rempel, 1999	High	I: received a keyboard with a keyswitch force-displacement profile having a greater travel distance until the key is "made" and greater "dampening" when the key reaches the bottom of its travel. C: received a conventional keyboard.	Randomized Trial	Secondary
Rest breaks, exercise	Henning, 1997	Medium	I_1: took 4 supplemental rest breaks every hour (three were 30 s and one was 3 min) for 4 weeks. Indicator lights prompted the user to take the break. I_2: same as I_1 plus a trainer instructed participants on stretching exercises that were done during the short breaks. C: received no intervention	Randomized Trial	Both
Rest breaks	Galinsky, 2000	Medium	IC: Workers alternated between an intervention and a control rest break schedule every 4 weeks. The control/conventional (C) schedule involved a break every 2 hours (15 min break in am and pm and 30 break for lunch). The intervention (I) schedule involved a break every hour (conventional schedule plus four 5 min breaks). Workers were prompted to take breaks by electrical timers.	Within Subject Repeated Measures with randomized order	Both
Rest breaks	McLean, 2001	Medium	I_1: received a workstation assessment and adjustments. Ergobreak software prompted users to take 30s break every 40 minutes. I_2: received a workstation assessment and adjustments. Ergobreak software prompted users to take 30s break every 20 minutes. C: received a workstation assessment and adjustments. Ergobreak software installed but provided no prompting; subjects told to take breaks whenever they wanted to.	Randomized Trial	Primary

Intervention category	Author, year	Quality rating	Intervention description	Study design	Prevention Type
Rest breaks, exercise	van den Heuvel, 2003	High	I_1: Break reminder software. Software prompted user to take a 5 min break after 35 min of continuous computer usage and a 7 s break after 5 min of continuous computer usage. Also workstation adjustment and training. I_2: Break reminder software plus exercise. Same as I1 plus software prompted user to take exercises during the breaks. Also workstation adjustment and training. C: only received workstation adjustment and training.	Randomized Trial	Secondary
Screen filters	Hladky, 1998	Medium	I: received anti-glare screen filters, placed on the VDU. C: received no filters	Non-Randomized Trial	Both
Screen filters	Fostervold 2001	Medium	I: received a multi-coated, grounded, glass filter mounted on the VDU screen. IC: after 2.5 months received a micromesh filter mounted on the VDU screen.	Non-Randomized Trial with Delayed Intervention	Secondary
Lighting, workstation adjustment, VDT glasses	Aaras, 2001 (Aaras, 1998)	Medium	I: Two groups (S&T) received a new lighting system and new table and chair which were adjusted to support forearms on the table, and single vision VDU glasses if necessary. C: received the lighting system after 3.5 years	Non-Randomized Trial	Both
New Office	Nelson, 1998	Medium	I: employees moved from old buildings to a new building with new lighting and equipment and received 1 h of ergonomics training. C: continued working in old buildings. Supervisors received ergonomics training.	Non-Randomized Trial	Both
Training on ergonomics & workstation adjustment	Martin, 2003 (Gatty, 2004)	Medium	I: received individualized training for 1 h per week for 4 weeks in body mechanics, workstations adjustments, task modification and stretches. C: received no intervention	Randomized Trial	Primary
Lens types (glasses)	Horgen, 2004	Medium	I_1: used Interview lens I_2: used Gradal RD lens I_3: used Technica lens C: used ordinary single vision lens (i.e., no progressives).	Randomized Trial	Primary

Intervention category	Author, year	Quality rating	Intervention description	Study design	Prevention Type
Lens types (glasses)	Butzon, 1997	Medium	IC: used the AO Technica™ VDT glasses (IC1) for three weeks then used the Datalite™ CRT trifocal (IC2) for three weeks.	Non-Randomized Crossover	Secondary
VDT glasses	Butzon, 2002	Medium	I: was fitted with one of four types of task-specific glasses by an optometrist: AO Technica™, Access™, bifocal, and Datalite™ CRT trifocals and worked at their VDT for three weeks. Ater 3 weeks this group used the ESAT intervention for 3 weeks. IC: was given an ergonomics self-assessment tool (ESAT) and their usual glasses for 3 weeks. The ESAT checklist determined likely environmental problems and suggested remedies. After 3 weeks this group used one of the 4, fitted, task-specific glasses for 3 weeks.	Crossover	Secondary
Herbal eye drops	Biswas, 2003	Medium	I_1: used herbal eye drops (two drops in both eyes four times daily for six weeks). I_2: used artificial tears (two drops in both eyes four times daily for six weeks). C: used a placebo solution (two drops in both eyes four times daily for six weeks).	Randomized Trial	Secondary
OtiZen eye drops	Skilling, 2005	Medium	I: used OptiZen™ eye drops twice a day for 5 days. C: used Visine® Original eye drops twice a day for 5 days.	Randomized Trial	Secondary

Table 8 shows some characteristics of the review studies that are important to consider when examining comparability and generalizability.

Countries of origin
The studies reviewed originated in different parts of the world: nine from European countries, two from Asian countries and one from Australia. However the majority of the studies were from the USA and Canada (n=19).

Types of industry/jobs
A variety of industries and job titles were represented; no single industry or job title was dominant across the studies. However, the primary job duties of most study participants involved data entry tasks.

Study designs
Our final set of studies included 20 randomized trials, five non-randomized trials, three cross-over or delayed intervention designs, and three quasi-experimental or within subject designs. Seven of the nine high quality studies were randomized trials and 13 (of 22) medium quality studies were randomized trials.

Sample sizes and numbers lost to follow-up
The sample sizes in the studies tended to be small but varied from 15 (McLean 2001) to 577 (Nelson 1998). Lost to follow-up details were often lacking in the study descriptions. When reported, the numbers lost to follow- up tended to be small but varied from 0 to 42 per cent.

Length of observation
Length of observation also varied greatly, from five days (Skilling 2005) to 18 months (Aaras 1998, Butzon 1997).

Overall there was a great deal of heterogeneity noted in these studies for the characteristics we considered. The studies were carried out in various jurisdictions, though most took place in North America. They were carried out in a wide variety of industries and many different jobs were represented. The most common study design was the randomized trial but other designs with concurrent comparison groups are also present. The sample sizes of the studies varied greatly but most tended to be relatively small studies with little loss to follow-up noted. The length of observation also varied greatly among the studies.

Table 8: Study description

Intervention category	Author, year	Country	Industry/Sector	Job titles	Study design	Sample size	Loss to follow-up	Length of observation
Training on exercise	Kamwendo, 1991	Sweden	Health Care and Social Assistance	Medical Secretaries	Randomized Trial	I_1 n=25, I_2 n=28; C_1 n=26	3.8% for Study	7 months
Training on stress management	Feuerstein, 2004	USA	Professional, Scientific or Technical Services	economists, computer specialists	Randomized Trial	I_1 n=46, C_1 n=47	I_1 n=12, C_1 n=11	12 months
Training on ergonomics	Brisson, 1999	Canada	Education	clerical, administration, teaching	Randomized Trial	I_1 n=284, C_1 n= 343	19%	6 months
Training on ergonomics	Bohr, 2000	USA	Centralized reservation center	Call center employees	Randomized Trial	$I_{1\ n}$=24%, I_2 n=23%, C_1 n=11%,		12 months
Training on ergonomics	Peper, 2004	Not Provided	Education Services	Not Provided	Randomized Trial	I_1 n=16, C_1 n=12	Not Provided	6 weeks
Training on ergonomics	Greene, 2005	USA	Education Services	Library, Cont Ed., Computer Networking, Family/consumer Science	Randomized Trial with Delayed Intervention	I_1 n=43, IC_1= 44	Not Provided	2 weeks
Training on ergonomics, new chair	Amick, 2003	USA	State dept of revenue services	sedentary computer-intensive jobs	Non-randomized Trial	I_1 n=87, I_2 n=52, C_1 n=53	12% (192-168)	12 months
Training, workstation adjustment	Mekhora, 2000	Thailand	Office Based Co.s	Word Processors and Data Entry	Randomized Trial with Delayed Intervention	I_1 n=np, IC_1 n=np, Study Total n = 85	Study Total n=5	23 weeks

Intervention category	Author, year	Country	Industry/Sector	Job titles	Study design	Sample size	Loss to follow-up	Length of observation
Workstation adjustment	Ketola, 2002	Finland	Public Administration	Secretaries, technicians, architects, engineers, draftspersons	Randomized Trial	I_1 n=39, I_2 n=35, C_1 n=35	I_1 n=5%, I_2 n=6%, C_1 14%	10 months
Workstation adjustment	Cook, 2004	Australia	Newspaper Call Center	Call center staff	Randomized Trial	I_1 n=30, C_1 n=29	I_1 n=11	12 weeks
Workstation adjustment	Gerr, 2005	USA	Insurance, Education, Financial	Not Provided	Randomized Trial	I_1 n=121(ah) &126(ns), I_2 n=130(ah) & 122(ns), C_1 n=119(ah) &113(ns)	I_1 n=83(ah) & 90(ns), I_2 n=89(ah) & 85(ns), C_1 n=87(ah) & 84(ns)	6 months
Monitor position	Psihogios, 2001	USA	Professional, Scientific or Technical Services	Software developers, QA analysts, Managers, Technical support	Quasi-experimental within subjects	I_1 n=8, I_2 n=8, C_1 n=2, C_2 n=2	Not Provided	4 weeks
Arm supports	Lintula, 2001	Finland	Not Provided	Office employees & researchers	Randomized Trial	I_1 n=7, I_2 n=7, C_1 n=7	Not Provided	6 weeks

Intervention category	Author, year	Country	Industry/Sector	Job titles	Study design	Sample size	Loss to follow-up	Length of observation
Pointing device (track ball), arm support	Rempel, 2005	USA	Health Care and Social Assistance	Customer Service Workers	Randomized Trial	I_1 n=45, I_2 n=46, I_3 n=45, C_1 n=46	I_1 n=4, I_2 n=1, I_3= 4, C_1=1	12 months
Pointing device, (mouse)	Aaras, 1999 (and Aaras 2002)	Norway	Not Provided	Software engineering, bookkeeping, secretarial work	Randomized Trial	I_1 n= 32, C_1 n= 35	Not Provided	12 months
Keyboard	Tittiranonda, 1999	USA	Professional, Scientific or Technical Services	Laboratory Workers	Randomized Trial	I_1 n=20, I_2 n=20, I_3 n=20, C_1 n=20	I_1 n=1, I_2 n=9, I_3 n=1, C_1 n=0	24 weeks
Alternative keyboard	Rempel, 1999	USA	Professional, Scientific or Technical Services	Administrative asst and Technical writers	Randomized Trial	I_1 n=10, C_1 n=10	I_1 n=2, C_1 n=2	12 weeks
Rest breaks	Henning, 1997	USA	Insurance	Claims processors	Randomized Trial	Study Total = 73	Not Provided	4 weeks
Rest breaks	Galinsky, 2000	USA	IRS	Seasonal Data Entry Operators	Within subjects repeated measures	IC_1 n=101	58%	16 weeks (only first 8 weeks used in analysis)
Rest breaks/ software	Mclean, 2001	Canada	Education Services	Not Provided	Randomized Trial	I_1 n=np, I_2 n=np, C_1 n=np and Study Total n=15	Not Provided	2 weeks

Intervention category	Author, year	Country	Industry/Sector	Job titles	Study design	Sample size	Loss to follow-up	Length of observation
Rest breaks/software	van den Heuvel, 2003	Netherlands	Public Administration	Not Provided	Randomized Trial	I_1 n=97, I_2 n=81, C_1 n=90	I_1 n=18, I_2 n=15, C_1 n=16	3 months
Screen filters	Hladky, 1998	Czech Republic	Professional, Scientific or Technical Services	Data Entry, Information Retrieval	Non-randomized Trial	I_1 n=40, C_1 n=20	0%	1 month
Lighting, workstation adjustment, VDT glasses	Aaras 2001 (Aaras, 1998)	Norway	Professional, Scientific or Technical Services	VDU Operators	Non-randomized Trial	I_1 n = 50, C_1 n = 50	I_1 n = 7; C_1 n = 6	18 months
Screen filters	Fostervold, 2001	Norway	Insurance	Office Clerks	Non-randomized Trial with Delayed Intervention	I_1 n=30, IC_1 n=44	Not Provided	5 months
New office	Nelson, 1998	USA	Public Administration	Clerical, Administrative	Non-randomized Trial	I_1 target n=1616, matched n=577, C_1 target n=187, matched n=55	I_1 n=42.2%	12 months
Training on ergonomics, workstation adjustment	Martin, 2003 (and Gatty 2004)	USA	Education Services	Clerical/Office Workers	Randomized Trial	I_1 = 7; C_1 = 8	I_1 = 0, C_1 = 1	5 weeks

Intervention category	Author, year	Country	Industry/Sector	Job titles	Study design	Sample size	Loss to follow-up	Length of observation
Lenses, VDT glasses	Horgen, 2004	Norway	Telecom	Not Provided	Randomized Trial	I_1 n= 35, I_2 n=34, I_3 n=36, C_1 n=34	I_2 n=1, I_3 n=2, not classified n=6	12 months
VDT glasses	Butzon, 1997	USA	Professional, Scientific or Technical Services	Research and development personnel,	Non-randomized Crossover	IC_1 n=24	Not Provided	18 months
VDT glasses	Butzon, 2002	USA	Employee benefits administration	Administrative assistant, claims processor, secretary and safety personnel	Cross-over	I_1 n=12, IC1 n=14	13%	6 weeks
Herbal eye drops	Biswas, 2003	India	Not Provided	Not Provided	Randomized Trial	I_1 = 44, I_2 = 37, C_1=39	Not Provided	6 weeks
OptiZen eye drops	Skilling, 2005	USA	Not Provided	Not Provided	Randomized Trial	I_1 n = 25, C_1 n =25	I_1 n=4%, C_1 n=4%	5 days

We extracted additional data from the studies beyond the characteristics presented in Table 8 and summarized above. These data can be found in detail in Appendices E to J, Tables 12 to 17. We summarize the details of that data extraction below.

Research question

All 31 studies presented some form of research question (Appendix E, Table 12). The clarity and detail of these questions varied in both the high and medium quality studies. A clear hypothesis statement was often missing: seven of the nine high quality studies and 13 of the 22 medium quality studies did not provide a clear primary hypothesis.

Inclusion/exclusion criteria

All nine of the high quality studies and 14 of the 22 medium quality studies provided some inclusion/exclusion criteria (Appendix E, Table 12). But overall the inclusion and exclusion criteria presented were often insufficient to clearly determine whether the intervention was primary or secondary (i.e. the injury status of the participants was not indicated). The heterogeneity in worker samples made comparisons across studies difficult.

Confirmation of the intervention

The review team considered whether the intervention was confirmed during the course of the study (Appendix F, Table 13). Confirmation of the intervention helps to establish whether the effects noted were actually related to the intervention. This is particularly important when researchers are comparing several different types of interventions (see Table 8). Eight of the nine high quality studies and 12 of the 22 medium quality studies confirmed that the intervention took place during the course of the study. Studies routinely got credit for confirmation if there were some measurements taking place during the intervention period.

Statistical Analysis

The sophistication of statistical analysis also varied across these studies; 12 of the studies (eight of nine high quality and four of 22 medium quality) chose to control for covariates in the final analysis.

Covariates and confounders

Data were extracted on the evaluation and control of covariates/confounders in each of the studies (Appendix G, Table 14). All nine high quality studies evaluated covariates/confounders in the analysis (or in design by careful matching); 18 of 22 medium quality studies evaluated covariates/confounders. The variables considered in these analyses varied greatly with little consistency across the studies.

Eight of nine high quality studies controlled for covariates/confounders in the analysis (or in one case matched design Rempel, 1999). Four of 22 medium quality studies controlled for covariates in the analysis (or design).

While the studies generally evaluated covariates/confounders, the medium quality studies often did not control for these variables in analysis (or design).

No studies provided information to establish whether there were differences between participants and non-participants for covariates/confounders. Two high quality studies (Feuerstein, 2004; Rempel, 1999) reported enough detail for us to examine differences between study participants and those lost to follow-up with respect to covariates/confounders.

Outcomes of interest

The outcomes of interest for this systematic review were musculoskeletal (MSK) or visual health outcomes associated with subjects involved in the studies (see Appendix H, Table 15). A total of 29 of 31 studies examined MSK outcomes; 15 studies examined visual outcomes; 13 studies examined both MSK and visual outcomes.

The reported outcomes varied by study. Most of the MSK outcomes were measures of symptoms in a specific body region(s) or in the body as a whole. Other MSK outcomes included disorders determined by physical examination, disorders as determined by self-report (case vs non-case), use of analgesics or medication, number of sick days taken, the results of nerve conduction studies and Phalen's test times. The visual outcomes were predominantly based on symptom reports from subjects, although some studies did incorporate a visual examination.

Measurement of outcomes

Evidence suggests that how and when MSK and visual health outcomes are measured is important (Amick, 2003). Therefore the reviewers extracted any data found in the studies regarding time of day, day of week and physical examinations (Appendix I, Table 16). Two of nine high quality studies (Amick 2003, Ketola 2002) provided information about when MSK symptom/disorder measurements were taken. Three of nine high quality studies (Amick 2004, Ketola 2002, Rempel 2005) provided information about day of week symptom/disorder measurements. However not all high quality studies examined MSK outcomes.

Two medium quality studies did not examine MSK outcomes. Seven of 20 medium quality studies provided information about the time of day that the symptoms/disorders were measured. Five of 20 medium quality studies provided information about the day of the week that the symptoms/disorders were measured.

One high quality study (Ketola 2002) examined visual outcomes and documented the time of day and day of week these outcomes were measured. Fourteen of 22 medium quality studies examined visual

outcomes; of those, six studies indicated the time of day and day of week that these measures were collected.

Three of nine high quality studies used a physical exam to identify disorders by body region. Masking was employed in two of the three high quality studies (Brisson 1999, Rempel 1999) that used physical exams. It was unclear whether the third (Rempel, 2005) employed masking.

Seven of 22 medium quality studies used a physical exam to identify disorders by body region; three of these seven employed optometric examinations. Masking was used in three of the seven studies that did some physical exam.

Other outcomes

Though not necessary to answer our question, outcomes other than those of interest to this review were documented in the data extraction (Appendix J, Table 17). Seven (of nine) high quality studies examined outcomes other than MSK outcomes or visual health. Fifteen of 22 medium quality studies examined outcomes other than MSK or visual health.

The primary data extracted to help us answer our question were the effects of the interventions on MSK or visual health outcomes. Table 9 presents a summary of the intervention effects as reported by the studies reviewed. For more details about the intervention effects reported, refer to Appendix H, Table 15.

3.4 Evidence synthesis

Table 9 presents a summary of the intervention effects as reported by the studies in our review. More details about the intervention effects can be found in Appendix H, Table 15. Details regarding the interventions for each study are described in Table 7. Since effect sizes could not be consistently calculated for the studies reviewed, we present the effects as they were reported by the studies. Using the effects reported for each study and grouping them according to the intervention categories, we use the algorithm from Table 6 to determine the level of evidence for effects of interventions on MSK or visual outcomes. The Brisson (1999), Mekhora (2000), and Horgren (2004) studies are not included in the evidence synthesis because they did not make statistical comparisons between groups only examining within group differences.

The findings for each intervention type are summarized following Table 9. In no case did the review team find a negative or adverse effect of the intervention on MSK or visual outcomes. Therefore, we consistently report positive effects or no effects from the interventions.

Table 9: Intervention effects on MSK and visual health outcomes as reported in the studies, studies ordered by intervention category
For greater detail on intervention effects see Appendix H, Table 15.

Intervention category	Author, year	QA	Effect (positive, no, negative) on: MSK health outcomes	Effect (positive, no, negative) on: visual health outcomes
Training on exercise	Kamwendo, 1991	M	no effect (I_1, I_2 vs C) on neck, shoulder and low back pain, neck or shoulder fatigue or headache	
Training on stress management	Feuerstein, 2004	H	no effect (I vs C) on level of pain and upper extremity symptom severity	
Training on ergonomics	Bohr, 2000	M	positive (I_1 vs C) on upper body pain/discomfort and total body pain/discomfort no effect on lower body pain/discomfort	
Training on ergonomics	Peper, 2004	M	positive (I vs C) on head, neck/shoulder, arms, wrists/hands symptoms, and overall tiredness no effect (I vs C) on back or leg symptoms	no effect (I vs C) on eye symptoms
Training on ergonomics	Greene, 2005	M	no effect (I vs IC) on symptoms of upper back or upper extremities	
Training on ergonomics, new chair	Amick, 2003	H	Training: no effect (I_2 vs C) on total body symptoms and symptom growth New Chair: positive (I_1 vs C) on total body symptoms and symptom growth	

Intervention category	Author, year	QA	Effect (positive, no, negative) on: MSK health outcomes	Effect (positive, no, negative) on: visual health outcomes
Training on ergonomics & workstation adjustment	Martin, 2003 (and Gatty, 2004)	M	positive (I vs C at 16 weeks) on elbow/forearm symptoms	positive (I vs C at 16 weeks) on headache intensity
Workstation adjustment	Ketola, 2002	H	no effect (I_1, I_2 vs C) on head, neck, area between neck and shoulders, shoulders, forearms, wrists, fingers, upper back, low back discomfort or overall MSK strain or pain	no effect (I_1, I_2 vs C) on eye discomfort
Workstation adjustment	Cook, 2004	M	no effect (I vs C) on neck, shoulder, forearm, wrist, back and "any" body regions	
Workstation adjustment	Gerr, 2005	H	no effect (I_1, I_2 vs C) for neck/shoulder and arm/hand MSK case	
Workstation adjustment (monitor position)	Psihogios, 2001	M	no effect (I vs C) on body part discomfort	no effect (I vs C) on visual discomfort or headache
Arm supports	Lintula, 2001	M	no effect (I_1 vs I_2 and I_1, I_2 vs C) on the neck/shoulder/arm region	
Arm supports, pointing device (track ball)	Rempel, 2005	H	Arm support: positive (arm supports vs no arm supports) on neck/shoulder pain and disorders and right upper extremity pain. No effect on left upper extremity pain. No effect (arm supports vs no arm supports) on days of pain medication use.	

Intervention category	Author, year	QA	Effect (positive, no, negative) on: MSK health outcomes	Effect (positive, no, negative) on: visual health outcomes
			Pointing device: positive on left upper extremity pain and disorders. No effect (trackball vs mouse) on neck/shoulder pain and disorders or right upper extremity pain. No effect (trackball vs mouse) on days of pain medication use.	
Pointing device (mouse)	Aaras, 1999, (and Aaras, 2002)	M	positive (I vs C) on neck, shoulder, forearm, and wrist/hand pain no effect (I vs C) on headache or MSK sick leave.	
Alternative keyboard	Tittiranonda, 1999	H	positive (I_3 vs C) on arm/hand symptoms and change in overall pain severity no effect (I_1, I_2 vs C) on arm/hand symptoms and change in overall pain severity	
Alternative keyboard	Rempel, 1999	H	positive (I vs C at 12 weeks) on hand pain reduction and on reducing Phalen's test time no effect (I vs C at 12 weeks) on nerve conduction	

Intervention category	Author, year	QA	Effect (positive, no, negative) on: MSK health outcomes	Effect (positive, no, negative) on: visual health outcomes
Rest breaks	Galinsky, 2000	M	positive (I vs IC) on symptoms in neck, back, R shoulder/upper arm, R elbow, R forearm hand, L shoulder/upper arm, L elbow, buttocks no effect (I vs IC) on left forearm hand symptoms	positive (I vs IC) on eye soreness no effect (I vs IC) on visual blurring
Rest breaks	Mclean, 2001	M	positive (I_2 vs C) on forearm/wrist and back discomfort no effect (I_2 vs C) on neck or shoulder discomfort no effect (I_1 vs C) on neck, shoulder, forearm/wrist, and back discomfort	
Rest breaks, exercise	Henning, 1997	M	no effect (I_1, I_2 vs C) on neck/shoulder, arm/hand, back, legs/feet discomfort	
Rest breaks, exercise	van den Heuvel, 2003	H	no (I_1, I_2 vs C) on symptom frequency/severity	
New office	Nelson, 1998	M	no effect (I vs C) on hand/arm symptoms, leg symptoms or neck/shoulder symptoms	

Intervention category	Author, year	QA	Effect (positive, no, negative) on: MSK health outcomes	Effect (positive, no, negative) on: visual health outcomes
Lighting, workstation adjustment, VDT glasses	Aaras, 2001 (Aaras,1998)	M	positive (I vs C) on shoulder pain (freq) no effect (I vs C) on neck, forearm/hand, or back pain	positive (I vs C) on visual discomfort (over last month and over last 6 months). no effect (I vs C) on headache, stinging/itching/irritation, sensitivity to light, redness, gravelly sensation, or blurred/double vision
Lens types (glasses)	Butzon, 1997	M	no effect (IC1 vs IC2) on frequency or intensity of neck/shoulder symptoms or back pain	positive (IC1vs IC2) on frequency and severity of blurred distance vision no effect (IC1vs IC2) on frequency or intensity of eyestrain, blurred intermediate vision, loss of focus, blurred near vision, dry eyes, double vision, or headache.
VDT glasses	Butzon, 2002	M	positive (I vs IC) on total symptom score (included MSK and visual outcomes)	positive (I vs IC) on total symptom score (included MSK and visual outcomes)
Screen filters	Hladky, 1998	M	positive (I vs C) on total body symptoms no effect (I vs C) on analgesic use	positive (I vs C) on total eye symptoms
Screen filters	Fostervold, 2001	M	no effect (I vs IC) on upper back/shoulders symptoms or fatigue	no effect (I vs IC) on ocular symptoms

Intervention category	Author, year	QA	Effect (positive, no, negative) on: MSK health outcomes	Effect (positive, no, negative) on: visual health outcomes
Herbal eye drops	Biswas, 2003.	M		positive (I_1 vs I_2 and C) on foreign body sensation and eyeache no effect (I_1 vs I_2 and C) on irritation, watering, redness, headache or tests/signs of examination
OptiZen eye drops	Skilling et al, 2005	M		no effect (I vs C) on visual/ocular discomfort

Exercise training
We found one medium quality study that evaluated exercise training (Kamwendo 1991). The training was a form of neck school. No effect on musculoskeletal outcomes was found. Since there was just this single study, we concluded there was **insufficient** evidence available to determine whether exercise training has an effect on MSK outcomes.

Stress management training
We found one medium quality study that observed no effect on MSK outcomes for a stress management training intervention (Feuerstein, 2004). Again, since there was just this single study we concluded there was **insufficient** evidence available to determine whether stress management training has an effect on MSK outcomes.

Ergonomics training
Four studies examined ergonomics Training; one was of high quality (Amick 2003) and three were of medium quality (Bohr 2000, Greene 2005, Peper 2004). The high quality study and one medium quality study (Greene 2005) found no effect, and the other two medium quality studies found both positive and no effects depending on the outcome variable. The four studies implemented different types of training ranging from a one-hour lecture on ergonomics to multiple participatory training sessions. The studies also measured different MSK endpoints. Taken together, the four studies provided **mixed** evidence that ergonomics training has an effect on MSK outcomes. One of the training studies (Peper 2004) also examined visual outcomes. There was **insufficient** evidence available from this single study to determine that ergonomics training has an effect on visual outcomes.

Ergonomics training plus workstation adjustment
One medium quality study examined training plus workstation adjustments (Martin 2003). The study reported a positive effect on MSK outcomes. Again with just a single study available, we concluded that there was **insufficient** evidence to determine that ergonomics training plus workstations adjustments together have an effect on MSK outcomes.

New chair
One high quality study (Amick 2003) found a positive effect on MSK outcomes with the introduction of a highly adjustable new chair combined with training on ergonomics and how to use the chair properly. Again, with just a single study available, we concluded there was **insufficient** evidence to determine that a new chair with training has an effect on MSK outcomes.

Workstation adjustments
Two high quality studies (Gerr 2005, Ketola 2002) and two medium quality studies (Cook 2004, Psihogios 2001) examined the effect of an array of workstation adjustments. The individual workstation adjustments were performed by a therapist or technician with the goal of reducing a range of

specific postural stresses. The control groups received ergonomics training or no intervention. All studies found no effect of workstation adjustments on MSK or visual outcomes. Taken together, these studies provide **moderate** evidence that workstation adjustments have **no** effect on MSK outcomes. Two studies (Ketola 2002, Psihogios 2001) examined visual outcomes and together provided moderate evidence that workstation adjustments have **no** effect on visual outcomes. (Some studies added new equipment such as arm supports, screen filters, keyboards or pointing devices, but we did not consider these to be workstation adjustments).

Lighting, workstation adjustment and VDT glasses

One medium quality study evaluated the effects of new lighting, workstation adjustment and VDT glasses (Aaras, 2001) and found either positive or no effects depending on the outcome variable. This single study provided **insufficient** evidence to determine that lighting, workstation adjustment and VDT glasses have an effect on MSK or visual outcomes. The study by Aaras (2001) evaluated a unique combination of interventions; however the team could not determine the independent effects of lighting, workstation adjustment or VDT glasses on MSK or visual outcomes.

Arm supports

There were two studies on arm supports; one high quality study (Rempel 2006) found positive effects on MSK outcomes, and one medium quality study (Lintula 2001) found no positive effects on MSK outcomes. These studies provided **mixed** evidence that arm supports have an effect on MSK outcomes.

Alternative pointing devices

Two studies examined the effect of alternative pointing devices on MSK outcomes. The high quality study (Rempel 2006) found positive effects on some MSK outcomes (and no effect on others) for a trackball compared to a conventional mouse. The medium quality study (Aaras 1999) found positive effects on MSK outcomes for an alternative mouse compared to a conventional mouse. Together these studies provided **moderate** evidence that pointing devices have a positive effect on MSK outcomes. While our findings suggest moderate evidence exists for alternative pointing devices improving musculoskeletal health, the team considers the devices (a trackball and Anir (3M) mouse) very different input technologies. While both are designed to reduce wrist pronation, Rempel (2006) found only positive effects for the left side of the body. Given right-handed dominance, the team does not consider the health effects as strongly as if they were on the right side of the body.

Alternative keyboards

Two high quality studies examined the effect of alternative keyboards on MSK outcomes (Rempel 1999, Tittiranonda 1999). One study (Tittiranonda 1999) study found positive effects for one split keyboard and no effects for

two other split keyboards when compared to a conventional keyboard. The other study (Rempel 1999) found positive effects for a keyboard with a new keyswitch force displacement. Together these studies provided **mixed** evidence that alternative keyboards have an effect on MSK outcomes. Although positive effects were found in both studies, the Tittiranonda study found no effects for two keyboards in independent comparisons with a placebo keyboard. Therefore we have a situation where two alternative keyboards in two different studies were shown to have positive effects and two keyboards from a single study were shown to have no effect. As a result the team felt these inconsistent results represented a mixed level of evidence.

Rest breaks

Four studies, one high quality (van den Heuvel, 2003) and three medium quality studies (Henning 1997, Galinsky 2000, Mclean 2001) evaluated the effects of rest breaks. The high quality study and one medium quality study (Henning 1997) found no effect on MSK outcomes. The break patterns evaluated in these two studies were as follows: a five-minute break every 35 minutes and a three-minute break every 60 minutes plus micro-breaks. The two other medium quality studies (Galinsky 2000, McLean 2001) found positive or no effects, depending on the time between rest breaks and MSK outcome. For the positive findings, the break patterns were as follows: a five-minute break every hour and a 30-second break every 20 minutes. Two studies used software to prompt breaks (van den Heuvel 2003 and McLean 2001), while two studies used timers (Henning 1997 and Galinsky 2000). Taken together, there was **mixed** evidence that rest breaks have an effect on MSK outcomes. Since only one study included visual outcomes (Galinsky 2000), there was **insufficient** evidence that rest breaks have an effect on visual outcomes.

Rest breaks and exercise

Two studies examined the effects of rest breaks combined with stretching exercises during the break. One high quality (van den Heuvel, 2003) and one medium quality study (Henning 1997) reported no effect on MSK outcomes. We concluded there was **moderate** evidence that rest breaks together with stretching exercises have **no** effect on MSK outcomes.

New office

A single medium quality study evaluated moving into a new office in a new building as an intervention (Nelson 1998). Besides a new building, the intervention also included new lighting, equipment and ergonomics training. We concluded this single study provided **insufficient** evidence to determine that a new office has an effect on MSK outcomes.

Screen filters
Two medium quality studies examined the effects of screen filters; one study (Hladky 1998) found a positive effect on MSK and visual outcomes, while the other (Fostervold 2001) found no effect. We concluded there was **mixed** evidence that screen filters have an effect on MSK or visual outcomes.

VDT glasses
One medium quality study examined the effect of VDT glasses on MSK and visual outcomes (Butzon, 2002). This study compared VDT glasses to usual glasses; both intervention groups also received ergonomic evaluation at different points in time. We concluded there was **insufficient** evidence to determine that wearing VDT glasses has a positive effect on MSK outcomes or visual outcomes compared to wearing usual glasses.

Lens types
One medium quality study examined the effect of lens type on MSK and visual outcomes (Butzon, 1997). In their design, one lens type (VDT glasses) was compared against another. We concluded there was **insufficient** evidence to determine whether a specific lens type has an effect on MSK outcomes or visual outcomes compared to another lens type.

Herbal eye drops
One medium quality study evaluated the effect of herbal eye drops compared to two other types of eye drops (Biswas, 2003). We concluded there was **insufficient** evidence to determine that herbal eye drops have an effect on visual outcomes compared to conventional eye drops.

OptiZen™ eye drops
One medium quality study evaluated the effect of OptiZen™ eye drops compared to another type of eye drop (Skilling et al, 2005). We concluded that there was **insufficient** evidence to determine that OptiZen™ eye drops have an effect on visual outcomes compared to conventional eye drops.

4.0 Conclusions

Our systematic review used a standard approach to review the literature, synthesize results and then answer the general question: "Do office ergonomic interventions have an effect on musculoskeletal and visual health?"

We found that the office ergonomic intervention literature is heterogeneous in terms of the interventions implemented, quality of the study designs, and outcomes measured.

From an initial pool of more than 7,000 articles, we identified 31 studies in which methodological quality was ranked as either high (nine studies) or medium (22 studies). Since three studies did not include between group statistical comparisons and were excluded, 28 studies were included in our data synthesis.

Based on our evidence criteria for data synthesis (Table 6), at least three high quality studies with consistent findings were needed to determine the existence of "strong evidence."

Across all studies, the results suggest a **mixed level of evidence** for the effect of ergonomic interventions on either MSK outcomes or visual symptoms. This means we found medium to high quality studies with inconsistent findings on the effects of the interventions on MSK or visual outcomes. The finding of mixed evidence may be due to the heterogeneity of intervention types grouped together across the studies reviewed. Importantly, we found no evidence that any office ergonomic intervention had a negative or deleterious effect on musculoskeletal or visual health. Furthermore, our conclusions do not change when we consider only high quality studies.

We found no strong evidence that any specific office ergonomic intervention categories had positive effects on either musculoskeletal or visual health. However there is considerable heterogeneity among interventions that are described with similar terms such as "workstation adjustment" and "office equipment". In addition, the varied MSK outcomes and visual outcomes need to be comparable before strong conclusions can be stated about effects.

A moderate level of evidence was found for three intervention categories:

- There was **moderate evidence** that **workstation adjustments as implemented in the studies reviewed** had NO effect on **MSK or visual outcomes.**

- There was **moderate evidence** that **rest breaks together with exercise during the breaks** had NO effect on **MSK outcomes.**
- There is **moderate evidence** that **alternative pointing devices** have a POSITIVE effect on **MSK outcomes**.

It should be noted the workstation interventions were usually compared to ergonomic training. The results should not discourage researchers and practitioners from continuing to develop different workstation adjustments or rest break patterns combined with exercises. However, care should be taken in making any generalizations about the role for either workstation adjustments alone or rest breaks plus exercises in improving musculoskeletal or visual health.

While moderate evidence exists for alternative pointing devices improving MSK outcomes, the evidence is aggregated across studies examining quite different pointing devices (an alternative mouse and a trackball). This suggests that care should be taken in making recommendations about specific alternative pointing devices to improve musculoskeletal health.

In order to advance the field and shift the level of evidence from moderate to strong, further research of these interventions should be of high methodological quality (see Table 3 for quality criteria).

Relatively few studies evaluated a single specific ergonomic intervention. We also encountered a diversity of office ergonomic interventions and MSK and visual endpoints, as well as a wide range of workplaces and geographical locations where the interventions were implemented.

Thus the review team concluded there was a mixed level of evidence (moderate and high quality studies with inconsistent findings) for a range of commonly discussed interventions:

- There was **mixed evidence** that **ergonomics training, arm supports, alternative keyboards** and **rest breaks** have an effect on **MSK outcomes**.
- There was **mixed evidence** that **screen filters** have an effect on **visual outcomes**.

The team considers the interventions with a mixed level of evidence to be of particular importance to researchers, funders, labour and employers participating in research. For several specific interventions, the addition of one or two high quality studies could have shifted the level of evidence from mixed to moderate or strong.

Finally, many office ergonomic interventions involve a unique combination of interventions (e.g. lighting, workstation adjustment, VDT glasses) or a

unique intervention (e.g. new chair). Such single studies provide an insufficient level of evidence for us to make general assertions about intervention effectiveness, regardless of the quality of the studies:

- There was **insufficient evidence** to determine an effect on MSK outcomes for any of the following interventions: **exercise training; stress management training; ergonomics training together with workstation adjustment; a new chair; lighting change plus workstation adjustment plus VDT glasses; a new office; lens type** and **VDT glasses.**
- There was **insufficient evidence** to determine an effect on visual outcomes for any of the following interventions: **ergonomics training; rest breaks; lighting change plus workstation adjustment plus VDT glasses; lens type; VDT glasses; herbal eye drops; and OptiZen™ eyedrops.**

Many interventions could provide fertile ground for additional high quality studies. However, researchers, funders, employers and organized labour should attend to the effects and study quality reported in Table 9 as one way to gauge level of interest and investment in further research. Clearly high quality studies are necessary to achieve the strong level of evidence we desire for these interventions.

The high quality studies reviewed shared certain common threads, regardless of the intervention or outcome. All had concurrent comparison groups and all but one were randomized trials. Each study was designed to limit threats to internal and external validity. However, few used similar MSK or visual outcomes, making it a challenge to integrate findings and calculate effect sizes for the intervention.

We also found it challenging, when multiple interventions occurred simultaneously, to determine what aspect of the intervention was driving the observed effects. For example in the Aaras (2001) study examining simultaneous lighting, workstation adjustment, and VDT glasses interventions it was difficult for us to determine which intervention component contributed to a beneficial effect on MSK and visual outcomes.

One potential action that stakeholders could take would be to convene a conference or series of position papers advocating standards for office ergonomic intervention research.

4.1 Strengths of conducting a systematic review

The number of studies published in any given field is more than most practitioners or researchers can easily keep track of or synthesize. This is particularly true in the field of ergonomics where evidence can be found across many different disciplines. Systematic reviews are useful tools to help

researchers, health and safety practitioners, employees, employers, and policy makers remain current with the evidence.

The systematic review process is designed to be transparent and reproducible. By following an explicit process of scrutinizing, tabulating, and integrating all relevant studies that address a specific research question, a systematic review aims to eliminate bias in the selection and synthesis of evidence. The goal is to produce an objective appraisal that can help practitioners and researchers resolve uncertainty. Such uncertainty often occurs when original studies and editorials disagree on the conclusions to be drawn from the evidence for a particular research question.

Another benefit of doing a systematic review is that it can help identify gaps in the quantity and quality of studies in a particular area. This can be used to suggest an agenda for further research and evaluation.

4.2 Limitations of this systematic review

We identified studies by searching the peer-reviewed literature contained in four electronic databases. We also scanned reference lists from selected studies and references suggested by our experts. A broader search of the grey literature, conference proceedings and dissertations might have yielded further relevant evidence on the effectiveness of office interventions on MSK and visual health outcomes.

Also, because of time constraints, the review team was unable to clarify specific questions with the study authors. The review was limited to articles published in the English language. Non-English articles were excluded before the quality of the studies could be assessed. It is possible that articles excluded on the basis of language might have provided relevant evidence that could have been used to answer the study question.

4.3 Strengths of this systematic review

The review team included members with varied backgrounds and specializations (e.g. expertise in the systematic review process, ergonomics, visual health, MSK health and safety and epidemiology). We believe this broad expertise contributed to the internal validity of our review.

We also contacted outside experts to request potentially relevant published articles, along with articles in press or in the grey literature. This provided another means to ensure that as much relevant literature as possible was reviewed.

The review team used a quality control process to assess the early phase of article exclusion. We also used a process of arbitrarily pairing reviewers at each phase to improve independent assessment by at least two team

members. Whenever possible, the reviewers used a transparent approach, and all decisions were made using consensus.

4.4 Next steps

The current review answers a general question about the effectiveness of office ergonomic interventions on musculoskeletal and visual health. The review team believes that the systematic review process should continue to develop in several ways when considering the office ergonomics literature:

- It is important to include non-English articles and grey literature in the process.
- If necessary, article authors should be contacted to clarify findings in the published studies.
- When possible studies where between-group comparisons were not made should be re-analyzed to provide evidence that can be included in data synthesis.
- In an effort to produce effect sizes, a full data set should be obtained from researchers.

The information from this review should be used to guide future research in office ergonomics interventions and alert stakeholders to the current state of the evidence.

5.0 Messages

Before making recommendations regarding policy and best practices, the review team felt there should be stronger levels of evidence. Such recommendations demand consistent findings from a number of high quality studies. Our review did not find this level of evidence among the studies reviewed.

We felt that with moderate levels of evidence we could make recommendations about "practices to consider." However in two intervention categories when the results demonstrated moderate levels of evidence, it was to support interventions having NO effect on musculoskeletal or visual outcomes. The third finding of moderate level of evidence suggested that alternative pointing devices have a positive effect on musculoskeletal outcomes. However, the category of alternative pointing devices is broad and aggregated results from an alternative mouse study and a trackball study make issuing practice recommendations difficult. Therefore the team cannot make specific recommendations about practices to consider for the interventions of workstation adjustments, rest breaks with exercise and alternative pointing devices.

An important message to all stakeholders is that the current state of the peer-reviewed literature provides limited high quality evidence to support the benefits of office ergonomic interventions on MSK or visual health.

Here are some issues to consider:

- Researchers should use concurrent control groups with a control intervention (e.g. brief training) so that the placebo effect is lessened and the intervention effect can be isolated. Study designs using true concurrent controls (instead of simulated controls or crossover groups) provide results that are more robust.
- Field studies should have adequate sample sizes.
- Rather than testing three or more treatment arms, if the sample size is limited, it is more valuable to test an intervention and a control.
- For musculoskeletal disorders we suggest studies last between four and 12 months so we can learn whether the effects, if any, are persistent. This time period appears adequate to observe changes; there is evidence that musculoskeletal symptoms may take weeks or months for change following an intervention. However, longer duration studies require more attention to other ongoing workplace changes which are potentially confounding.
- For visual symptoms, the time required to observe effects is uncertain. It may be that short duration studies are adequate to determine long-term effects.

The overwhelming message from our review is that more high quality research in this area is sorely needed. We require well-designed studies such as randomized controlled trials, with adequate sample sizes and study durations, before we can draw major policy conclusions regarding interventions.

We feel somewhat frustrated that this is the only clear message emanating from our systematic review. However, it is vital that we begin to generate the amount and quality of evidence required so others can make informed decisions about these interventions. With the continued emergence of the knowledge workforce and the ubiquity of computers, all stakeholders need to be diligent about developing and supporting high quality research.

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Appendices

Appendix A

Quality appraisal guide for reviewers

The guide is designed to provide all reviewers with the same information. Each reviewer should become thoroughly familiar the guide prior to conducting a quality assessment review. Inter-rater variability should be minimized by each rater's familiarity with the guide. The bolded materials below are included in the table in Memo 2 and in the SRS on-line form.

Questions 1–4 are designed to remove articles that could not be removed in Level 1 or Level 2 review due to lack of information. The reviewer is asked to apply the same criteria used in Level 1 and Level 2 review as an initial screen of the article.

If the reviewer answers "Yes" to either question 1 or question 3 then only questions 1–4 must be answered before submitting the review.

Q1. Should the paper have been excluded at Level 1?
The reviewer is first asked to determine if the paper should be excluded because it is not an intervention study. The reviewer must consider all three exclusion criteria. (1) If it is not an intervention study then the article is not relevant to the review. (2) If it is not an office-based intervention then it is not relevant. That is, if it was in an industrial setting it should be excluded. (3) Finally, if it was an office-based intervention, but not related to computer-work it should be excluded.

a) **Yes**
b) **Unclear**
c) **No**

Q2. If the answer to Number 1 above is "yes" then why (check all that apply).
So that the team can effectively summarize the state-of-the-art, the reviewer is asked to describe the exclusion criteria applied above in question 1.

a) **Did an intervention occur?**
b) **Did intervention occur in an office?**
c) **Was the intervention related to computer work?**

Q3. Should the paper have been excluded at Level 2?
The reviewer is asked to determine if the paper should be excluded because it does not meet minimal criteria for a well-designed intervention study. The criteria are stated in question 4 below and the reviewer is asked to complete a full assessment so that the team can effectively summarize the state-of-the-art.

a) **Yes**
b) **Unclear**
c) **No**

Q4. If the answer to Number 3 above is "yes" then why (check all that apply).
So that the team can effectively summarize the state-of-the-art, the reviewer is asked to describe the exclusion criteria applied above in question 3.

a) **Is the article from a peer reviewed journal?**
b) **Is the language of the article English, French, German or Japanese?**
c) **Is there a control group?**
d) **Does the study use a post only design?**
e) **Does the study report individual health data?**
f) **Is the reported outcome OSHA log data only?**
g) **Is the reported outcome workers' compensation data only?**
h) **Is outcome musculoskeletal or visual symptoms/disorders?**

If the reviewer answers "Yes" to either question 1 or question 3 then only questions 1–4 must be answered before submitting the review.

Q5. Was the research question/objective clearly stated?
If the aim of the study is not clearly stated then results are likely of limited value. A clear, explicit statement of objectives should be included in the study.

a) **Yes**
b) **Unclear**
c) **No**

Q6. Was a primary hypothesis clearly stated?
A clearly stated research question/objective does not mean a clearly stated primary hypothesis has been stated by the researchers. A well-designed intervention will have one clearly stated and testable primary hypothesis. There are many outcomes that can be considered and stated as secondary or post-hoc hypotheses, but a well-designed study is typically powered with a single hypothesis. This allows for the alpha region in the statistical test to be devoted to the single hypothesis test.

a) **Yes**
b) **Unclear**
c) **No**

Q7. Was an intervention allocation randomized?
A randomized allocation strategy is part of a strong research design. Randomization of intervention conditions is typically preferred because it avoids systematic confounding by known and unknown factors. Random allocation of treatment/intervention conditions is the preferred scientific method as it is most likely to control for confounding. If the group membership (intervention vs. non-intervention) was not random then the study must address potential group differences in analysis. Inadequate description of the intervention randomization allocation strategy makes it impossible to reproduce the intervention in another population. This should be clearly stated in the study to allow for interventions to be reproducible by others. If the researchers state they employed a

random allocation but it is unclear how this was done and thus not easily replicable the reviewer should endorse 'unclear'.

a) Yes
b) Unclear
c) No

Q8. Was the length of follow-up 1 month or greater?
If the length of follow-up post intervention was not at least one month (30 days) then there is little likelihood of observing substantively important change sin the health outcomes (either musculoskeletal or visual). Negative intervention studies with short follow-ups are likely to find no significant effects due to lack of a meaningful follow-up period. In synthesizing data form a range of intervention studies differences could be due to differences in length of follow-up.

a) Yes
b) Unclear
c) No

Q9. Were concurrent comparison (control) groups(s) used?
Inadequate comparison groups or not utilizing referents at all is an important problem, which may undermine the conclusions drawn from a study. Therefore, it is important for a study to provide adequate description of the types of comparison groups used, if any. Considering the importance of having a comparison group to document and account for the potential effects of unexpected secular changes, having a closely analogous referent group, with similar exposure to causal risk factors as the intervention subjects, is a major strength of a workplace intervention study.

a) Yes
At least, one comparison group was used against which intervention's effect were evaluated.
b) **Unclear**
c) No
No concurrent comparison groups were used in this study.

Q10. Please indicate which levels of recruitment were used (check all that apply).
Workplace intervention can typically occur at different levels. It is important to distinguish between the various levels so that results can be interpreted in relation to the level at which interventions were applied. Also, differences in recruitment strategies for individuals/groups/workplaces could lead to differences in characteristics of the participants.

a) Employees/workers
b) Departments/supervisors/work groups
c) Organizations/workplaces
d) Unclear
e) None

Q11. Were sample inclusion/exclusion criteria described?
In every study some potential participants are excluded because their participation could bias the findings. Furthermore, sample is often excluded at different stages of the study from pre-sampling through analysis that can bias the results. If there is no information on sample inclusion or exclusion criteria, then the generalizability of the conclusions may be challenged. Finally, with different sample inclusion/exclusion criteria (e.g. including those with the outcome vs. those without) synthesis of the literature may be difficult.

a) **Yes**
b) **Unclear**
c) **No**

Q12. Was participation rate reported and >40% for employees/workers?
The reviewer is being asked to determine if a participation rate was reported and the level of participation. If neither of these are reported or one is not reported then the answer is 'No'. By participation rate we mean those who were asked to sign inform consent and those who agreed and are participating. This is a single value reported prior to intervention. If participation rates were not reported then it is impossible to draw any conclusions about the validity of the study and thus study conclusions since we know nothing about those who participated and those who chose not to participate. We have set as a lower bound a 40% participation rate. The group asserts that any rate lower than 40% makes the study of limited validity. The greater rate of participation (or recruitment) reduces non-response bias.

a) **Yes**
b) **Unclear**
An unclear response can only be endorsed if some information is presented and thus researchers are trying to report rates, but do not provide the exact information we requested.
c) **No**

Q13. Were baseline characteristics of study participants presented?
In relation to each of the levels of recruitment identified above, please indicate if baseline characteristics are described, these may include job related factors, individual characteristics, and factors related to exposures and outcomes (for example baseline pain levels across groups).

a) **Yes**
b) **Unclear (only check if unsure for employees/workers, departments/supervisors/workgroups, and organizations/workplaces)**
c) **No**

Q14. Were baseline characteristics presented by group?
If there are no major significant differences between the groups on baseline characteristics or other demographic variables, one can be confident that selection bias to participate in the study was minimal and that the results obtained are not likely affected by these differences. Furthermore, there are often site or group differences that may be

important to consider that bias results. For example, in ergonomic interventions the differences between supervisors in supporting the intervention could influence the intervention's success. If a study has been randomized the researchers should have a table showing that there are no differences between groups and that randomization worked. If there are differences then the group differences must be accounted for in analysis.

d) Yes
e) Unclear
f) No

Q15. Was the loss to follow up reported (if Yes, indicate the number/percentage reported in the comment box)?
There should be adequate follow up rate for each of the levels of recruitment identified. If the lost to follow up is substantial, it introduces the potential for exclusion bias, reduces the available sample size, and reduces the confidence in the results obtained. It may require an 'intent to treat' analysis. At this stage of the review, the group did not consider the extent of loss-to-follow-up an exclusionary criteria, but rather would like to document the loss.

a) Yes; (number/percentage reported)
b) No
c) Not Applicable

Q16. Were differences between those employees/workers who remained in the study and those who dropped out analyzed?
Differential attrition of subjects poses a major threat to internal validity. Exclusion bias can result if certain subjects are systematically more likely to be lost to follow-up than others. Comparisons should be made for dropouts and remaining participants on baseline characteristics or other demographic variables, as available. When there are no statistical differences between these groups, one can be more confident that attrition bias did not occur.

a) Yes
b) Unclear
c) No

Q17. Was the intervention implementation described?
Inadequate description of the intervention strategy and implementation makes it impossible to reproduce the intervention in another population. The setting of the intervention, i.e. where it was carried out, and specifically what was changed and how, are important aspects to document. Furthermore, if training was part of the intervention how was the training done in a constant way across subjects. If placebos were used, was their implementation described.

a) Yes
All or most aspects of the intervention are clearly described.
b) Unclear
There is not enough information provided, the intervention implementation process is not clearly described.
c) No
The intervention process is not described.

Q18. Was there confirmation the intervention took place?
Examining the intensity with which the intervention is implemented within the organization is an important part of an evaluation, which has not been extensively documented in the literature.

a) Yes
b) Unclear
c) No

Q19. Were the effects of the intervention on some exposure parameters documented?
Another way the intensity of an intervention can be assessed is by looking at the extent to which ergonomic changes were actually implemented because of the intervention process. Do the researchers report process outcomes? For example did muscle loading change or did behaviors change because of training. These are a few of the process outcomes. For this reason documenting the changes is of key importance, particularly if one wishes to understand the pathway leading from the intervention to changes in health outcomes. Most importantly, if the process outcomes don't reflect the hypothesized changes then health effects may be due to toher factors and not the intervention.

a) Yes
b) Unclear
c) No

Q20. Was the calendar duration of the intervention documented?
The calendar duration refers to the number of months or years over which the intervention took place. The duration of the intervention is an important aspect to document. Interventions of short duration (i.e., a couple of months) could have insufficient time between evaluations to allow the changes to exert their effects particularly with respect to musculoskeletal health outcomes that take a long time to develop. Conversely, interventions that take too long (i.e., 5 yrs) may also hinder the evaluation. As workplaces are dynamic environments and many other changes may have taken place during a long period of follow-up, other than the intervention itself, which can confound the results.

a) Yes
b) Unclear
c) No

Q21. Was contamination between groups described or documented
Contamination can occur when the interventions assigned to participants in one group are also used by some or all members of the other groups. This can introduce bias in the results if comparison groups; for example, have been exposed to some of the interventions intended for the study group, unbeknownst to the researchers. This is an issue particularly when a study uses controls from the same workplace as the intervention group.

a) **Yes**
b) **Unclear**
c) **No**
d) **Not applicable**
If no comparison/referent group was used then select not applicable.

Q22. Were covariates/potential confounders for musculoskeletal or visual disorders ascertained (i.e., gender, age, eye wear, non-work activities, education)?
Ascertainment of covariates and potential confounders is important to allow the researcher to rule out plausible alternative explanations for observed health differences. Physical risk factors for musculoskeletal disorders include: force, repetition, static loading, time spent in awkward postures, etc. Psychosocial and organizational risk factors can include: social support, job satisfaction, control over one's job, etc. As changes in exposures are believed to be on the pathway leading to changes in health outcomes, if no changes in risk factors occur, but perhaps covariates or confounders have changed, this can provide important information regarding why health outcomes have or have not changed.

a) **Yes**
b) **Unclear**
c) **Not Measured**

Q23. When were potential confounders/effect modifiers measured (check all that apply)?

a) **Baseline**
Confounders/effect modifiers were assessed before the intervention took place (or at the beginning stages of the intervention).
b) **Follow up**
Confounders/effect modifiers were measured after (or towards the end) the intervention.
c) **Unsure**
d) **Not measured**

Q24. Was adjustment made for covariates/potential confounders?
Without appropriate multivariate adjustment the conclusions may not be valid.

a) Yes
Statistical method used to adjust for confounders is explained and appropriately conducted
b) Unclear
c) No
d) Not Measured

Q25. Were statistical methods adequately described?
The reviewer must use his or her knowledge of statistics to comment on the analysis.

a) Yes
Statistical methods are described sufficiently, and the methods used were appropriate and properly applied.
b) Unclear
c) No

Q26. Are there any other potential primary studies listed in this reference list which should be retrieved for consideration (if yes, please include reference ID or author/year/publication, etc.)?
It is important to look in the reference section of relevant studies because usually other studies that may be of potential use for this review are cited, which could have been missed in our search strategy.

a) Yes
b) No

Q27. Should article proceed to data extraction?
Our goal is to give the reviewer the opportunity to move articles forward to data extraction even if the study had not met many quality criteria.

a) Yes; because it has met enough of the quality criteria
b) Yes; even though it has not met many of the quality criteria (please justify in comment)
c) **No**

Appendix B

Guide to the data extraction form for reviewers

Please read this guide before beginning the data extraction. It may be helpful to print this guide and have it available to refer to while doing the data extraction. Please extract the data from the articles you review by completing the form on SRS and entering text in the provided areas. Please read the questions carefully especially the instructions in italics which provide details on how to enter the data. In the table below, the blue text provide some additional instructions that will help to ensure that the answers from different reviewers are consistent – please read this before beginning the data extraction. Also the text in red font provide some examples to illustrate specific responses.

All of the questions in the SRS form should have an answer when you are complete. If an article does not have the information necessary to answer a particular question then enter "**not provided**" in the text box for that question. It is important that all questions have answers because we will not know if an article did not have the information or a reviewer forgot to enter it if we allow blank answers. Remember, try not to interpret or extrapolate just provide the data that is presented in the article.

1. State the research question/objective. Please use the exact wording from the article or enter "not provided"

2. State the primary hypothesis. Please use the exact wording from the article or enter "not provided"

3. State additional hypotheses not listed in question #2 (list all and number)
Please use the exact wording from the article or enter "not provided"

4. Write the last name of the first author and the year of publication (Author's last name, yyyy). Give the first author's last name and the year (4 digits) the article was published

5. List the jurisdiction where the study was completed (Provide information regarding the country, region, province, city, etc. where the study was carried out - enter "Not Provided" where information is not available in article)

Country
Province
Region (Eg. Mid-western USA)
State
City

6. What industry/sector was the study conducted in? (Check all that apply) Provide details in the comment boxes to support your response. Please refer to the NAICS 2002 classification system so that all reviewers are responding to this question in the same way. http://www.statscan.ca/english/Subjects/Standard/naics/2002/naics02-menu.htm.

Insurance
Public Administration
Professional, Scientific or Technical Services
Education Services
Other Services
Municipality
Health Care and Social Assistance
Unknown or Missing
Other

7. Describe the job titles/classification of the participants that participated in the study. Provide the level of detail given in the study or enter "not provided"

8. List the inclusion and exclusion criteria described in the study. (List inclusion and exclusion criteria, clearly)

Inclusion criteria:
Exclusion criteria:

9. What is the study design? (Choose only one). Please describe any unique characteristics verbatim about the study design in the comment boxes beside the choice you make.

Randomized Clinical Trial
Non-randomized Clinical Trial
Randomized Cross-Over
Non-randomized Cross-Over
Other
Unknown

10. What type of prevention did the study investigate? (Choose only one). Indicate whether the study evaluated a primary, secondary or both types of prevention. If you choose other please provide details.

Primary prevention
Secondary prevention
Both
Other

11. What was the duration of the intervention in months/days/hours? (Note this is not the follow-up time but the actual duration of the intervention). Indicate in months if possible, if not in weeks, days etc. or enter "not provided".

Eg. Baseline data collected on May 1st, 2000. Intervention implemented June 1st, 2000 continues until June 1st 2001. Follow-up data collected on May 1st 2002. Note this information may be presented in a number of ways (tables, figures, timelines etc). In this example the duration of intervention is 12 months.

12. Indicate the time period between the baseline measurement and all subsequent follow up measurements that were taken. (Use months to indicate the length of follow up. For example: Questionnaires were administered at 6, 12, and 18 months). Indicate in months if possible, if not in weeks, days etc. or enter "not provided". Please make sure that you describe all intervention groups and all referent groups. Please use the same group names throughout the data extraction forms.

Eg. Baseline data collected on May 1st, 2000. Intervention implemented June 1st, 2000 continues until June 1st 2001. Follow-up data collected on May 1st 2002. Note this information may be presented in a number of ways (tables, figures, timelines etc). In this example the length of follow-up is 24 months.

13. Describe the Intervention Group (Provide answer for each category - enter "not provided" in all comment boxes where information is not available in article).

Sample Size	*Eg: Group 1 = , Group 2 = , …*
Age (mean, SD, range)	*Eg: Group 1 = , Group 2 = , …*
% female	*Eg: Group 1 = , Group 2 = , …*
Loss to Follow up (% or N)	*Eg: Group 1 = , Group 2 = , …*

14. Describe the Referent Group (Provide answer for each category - Enter "not provided" in all comment boxes where information is not available in article).

Sample Size	*Eg: Group 1 = , Group 2 = , …*
Age (mean, SD, range)	*Eg: Group 1 = , Group 2 = , …*
% female	*Eg: Group 1 = , Group 2 = , …*
Loss to Follow up (% or N)	*Eg: Group 1 = , Group 2 = , …*

15. Describe overall (study) group - Answer only if paper did not provide information needed to answer questions 13 and 14. (Provide answer for each category - use "Not Provided" where applicable). Place "not provided" in all comment boxes where information is not available in article. If this information is provided in questions 13 & 14 then enter "see Q13 & 14" in EACH comment box.

Sample Size
Age (mean, SD, range)
% female
Loss to Follow up (% or N)

16. What was the intervention evaluated? (Check all that apply) (Equipment includes keyboard, mouse, chair, arm supports, s etc. Training includes symptoms/symptom management, work org, workstation, etc.) (If control group received an intervention (eg, training) that would not be checked). Provide details in the comment boxes to support your response(s)

New Office
Workstation Adjustment
Eye Drops
Equipment
Training
Exercises
Refraction devices (glasses, lens, etc)
Lighting (or anti-glare etc)
Other

17. Describe the intervention (Provide details in the text box about the intervention type). Provide all details about the intervention that are not covered in the questions above that you feel are important.

18. Was there confirmation the intervention occurred? (Check only one) Provide details in the comment box to support your response.

Observation
Self Report
None

19. How long after the intervention did the confirmation occur? Place "not provided" in text box if this information is not available in article.

20. Select from the list all types of covariates/confounders that were evaluated for inclusion in the final analysis. (Check all that apply). Please give details or examples for each response. Provide details and names of variables if you select other.

Physical/biomechanical work conditions (force, repetition, static loading)
Psychosocial/Cognitive work conditions (include social support here)
Organizational environment (e.g. specific policies or practices or safety climate)
Workstation Adjustment
Medical Conditions (diseases & disorders)
Mental & Physical Health Status
Legal
Family environment
Demographics (include income here)
Non-work activities
Other

21. Provide a list of covariates/confounding variables that were controlled for in the final test of the intervention effectiveness. Enter "none" in text box if no covariates controlled for. (Ascertainment of covariates and potential confounders is important to allow the researcher to rule out plausible alternative explanations for observed health differences. Covariates include gender, age, non-work activities, education etc. Physical risk factors for musculoskeletal disorders include: force, repetition, static loading, time spent in awkward postures, etc. Psychosocial and organizational risk factors can include: social support, job satisfaction, control over one's job, etc. If many variables considered, may be entered in categories (e.g. demographic (5), medical (3), etc.))

22. Describe the significant differences in covariates/confounders for those that participated in the study vs those that were invited but did not participate by experimental group. Enter "not provided" in text box if this information is not available in article.

23. Describe the significant differences in covariates/confounders for those that participated in the study vs those that were lost to follow-up by experimental group. Enter "not provided" in text box if this information is not available in article.

24. Describe how the musculoskeletal health outcomes (symptoms) were measured (check all that apply, check no MSK if question does not apply). Give details if you select "other". If there is more than one MSK outcome identified please indicate a name for each outcome in the comment box beside your measurement choice. Please use these names in the comment boxes of question 34 if applicable. If you select threshold describe the threshold by describing the range and the cut-point.

A single time point
Multiple time points assessed between 1 and 2 months and then averaged
Multiple time points assessed between 1 and 3 weeks and then averaged
Multiple time points assessed between 1 and 2 months and then a threshold applied
Multiple time points assessed between 1 and 3 weeks and then a threshold applied
Other
No MSK outcome

25. Describe whether musculoskeletal symptoms were measured consistently at the same time of day over different measurement periods (Check only one). Indicate the consistency of symptom measurement by checking the appropriate response.

Measured at a consistent time of day (put time of day in comment box)
Not measured at a consistent time of day
Unclear or unknown time of day
No MSK outcome

26. Describe whether musculoskeletal symptoms were measured consistently on the same day of the week over different measurement periods (Check only one). Indicate the consistency of symptom measurement by checking the appropriate response.

Measured on a consistent day (put day(s) in comment box)
Not measured at a consistent day of week
Unclear or unknown day of week
No MSK outcome

27. Describe how the visual health outcomes (symptoms) were measured (check "no visual" if question does not apply) check all that apply. Give details if you select “other”. If more than one visual outcome is identified please indicate a name for each outcome in the comment box beside your measurement choice. Please use these names in the comment boxes of question 34 if applicable. If you select threshold describe the threshold by describing the range and the cut-point.

A single time point
Multiple time points assessed between 1 and 2 months and then averaged
Multiple time points assessed between 1 and 3 weeks and then averaged
Multiple time points assessed between 1 and 2 months and then a threshold applied
Multiple time points assessed between 1 and 3 weeks and then a threshold applied
Other

28. Describe whether visual symptoms were measured consistently at the same time of day over different measurement periods (Check only one). Indicate the consistency of symptom measurement by checking the appropriate response.

Measured at a consistent time of day (put time of day in comment box)
Not measured at a consistent time of day
Unclear or unknown time of day
No visual outcome

29. Describe whether visual symptoms were measured consistently on the same day of the week over different measurement periods (Check only one). Indicate the consistency of symptom measurement by checking the appropriate response.

Measured on a consistent day (put day(s) in comment box)
Not measured at a consistent day of week
Unclear or unknown day of week
No visual outcome

30. List all the non-MSK and non-visual outcomes and how they were measured - enter "none" if not applicable (Please number each outcome listed along with measurement i.e. 1. Absenteeism measured full days away from work, 2. Productivity change, etc.). Please list all other outcomes and how they were measured in the text box provided please number the outcomes and name them consistently.

31. Check all body regions where specific clinical disorders were ascertained by physical examination or laboratory test (check all that apply). Provide details in the comment box to support your response. Give specific details if you select “other”

Hand/wrist/elbow
Neck/shoulder
Lower back
Visual disorders
Other

32. Was masking of physical examination done? Provide details in the comment box to support your response.

Yes
No
Unclear
Not Applicable

33. Please check the types of analysis done for testing the observed effect of the intervention from the list below and provide details about the analysis in the comment box. (You should select the one that represents the final test not the preliminary analyses.). Provide details in the comment box to support your response. Give details if you select “other”.

ANOVA
MANOVA
Regression
Multilevel
Survival
Other

34. Describe, for each outcome of interest (MSK and Visual), the observed effect of the intervention. (Be brief and concise i.e. enter “effect size”, "risk ratio", "rate differences,"mean differences" etc, the actual number and associated outcome). If there is more than one outcome of interest please number and identify them using the same names you used in Questions 24 and 27 above.

35. Remark on the findings or enter information that is unique about the study that may not be adequately captured in the other DE categories. Be clear and concise.

36. Check the names of both DE reviewers for this article
BA, SB, KC, KD, FG, EI, DR, SM, DV

37. Is this the consensus version of the DE form (Final version)? Please select "no" until consensus has been completed.

Yes
No

Appendix C

Table 10: Exclusions at Level 1a: i) Did intervention occur? ii) Did intervention occur in office? iii) Was intervention related to computer work?

Review phase	Total	By criteria		
		i) intervention	ii) office	iii) computer
Level 1a	6948	5563	6497	6402

Appendix D

Table 11: Exclusions at Level 1b

Review phase	Total	By criteria								
		Peer reviewed	Non English language	Control group	Post only	Individual health data	OSHA logs or WCB data only	No MSK or visual outcome	Article < 2 pages or review	Combined studies
Level 1b	334	35	86	204	114	106	9	90	13	2

Total exclusions: Level 1a + Level 1b (6948 + 334 = 7282)
7313 – 7282 = 31 articles that we reviewed at QA and DE phases

Appendix E

Table 12: Research question, hypotheses stated (y/n) and inclusion/exclusion criteria described by the studies reviewed

Intervention category	Author, year and QA rating	Research question	Hypothesis clearly specified	Inclusion/exclusion criteria
Training on exercises	Kamwendo, 1991 Medium	"... to conduct a controlled study of the effects of neck school as a preventative intervention on neck and shoulder disorders."	Yes	Inclusion: 1) experienced pain in neck or shoulder region during previous year, 2) estimated average time spent sitting during working hours to be a minimum of five hours daily, 3) worked at least 30 hours per week, and 4) not presently under, or in need of, medical treatment for neck and shoulder problems." Exclusion : none
Training on stress management	Feuerstein, 2004 High	Evaluate effect of individual-focused job stress management on upper extremity pain, symptoms, functional limitations, job stress, and ergonomic risk exposures.	Yes	Inclusion: 1) employees working on computers a minimum of 3-4 hours per day 2) employed > 32 h per week, 3) experienced symptoms in upper extremities or neck in past 12 months. Exclusion: 1) diagnosed with WRUED, 2) symptoms related to accident or injury, 3) pregnant.
Training on ergonomics	Brisson, 1999 High	To evaluate the effect of an ergonomic training program on the prevalence of postural stressors and appropriate features of workstations and the prevalence of musculoskeletal disorders among VDU users at a university.	No	Inclusion: 1) work >= 5 hours per week with VDU Exclusion: not provided
Training on ergonomics	Bohr, 2000 Medium	"... to investigate the efficacy of worker education programs in preventing musculoskeletal injuries in a population of reservation center employees who spend the majority of their workdays using the computer."	Not clearly stated	Inclusion: 1) volunteers, 2) 5 hours of computer work a day Exclusion: none

Intervention category	Author, year and QA rating	Research question	Hypothesis clearly specified	Inclusion/exclusion criteria
Training on ergonomics	Peper, 2004 Medium	"...to determine if healthy computing concepts taught in a group setting would reduce symptoms and improve work style."	No	Inclusion: 1) not receiving medical treatment for Repetitive Stress Exclusion: not provided
Training on ergonomics	Greene, 2005 Medium	Evaluate the effectiveness of an active ergonomics training program in computer users.	Yes	Inclusion: 1) work at a computer at least 10 hrs per week Exclusion: 1)diagnosed by a physician as having an acute MSK injury or trauma to the trunk or upper extremities within the previous six months, 2) receiving treatment for cervical or upper extremity disorders.
Training on ergonomics, new chair	Amick, 2003 High	"A study was designed to assess how well a highly adjustable chair and office ergonomics training could affect ergonomic knowledge, postural behavior, health and productivity."	Yes	Inclusion: not provided Exclusion: 1) part-time employment, 2) incomplete Daily Symptom Survey (DSS) data, 3) workers' compensation claim within the last 6 months.
Training, workstation adjustment	Mekhora, 2000 Medium	... to determine the effect of ergonomic intervention for workstation set-up on computer users who had tension neck syndrome.	No	Inclusion: 1) age between 18 and 60 years, 2) work experience with computer for at least the previous year, 3) working with computers at least 4h a day, 4) total discomfort rating scores within one standard deviation above the group mean Exclusion: 1) history of surgery or accident related to the head, neck or trunk, 2) neurological diseases and/or spinal disorders, 3) receiving medical treatment, 4) improvement in symptoms within previous 3 months, 5) discomfort or pain due to work which did not recover overnight.

Intervention category	Author, year and QA rating	Research question	Hypothesis clearly specified	Inclusion/exclusion criteria
Workstation adjustment	Ketola, 2002 High	To study the effects of an intensive participatory ergonomics approach and education on the level of musculoskeletal discomfort and strain and prevalence of pain.	No	Inclusion: 1) MSK symptoms (neck, shoulders, or upper limb region) in at least one and at most 8 anatomical regions (out of 11); 2) Mouse use >5% of VDU worktime; 3) age < 61 years Exclusion: Not provided
Workstation adjustment	Cook, 2004 Medium	"... to determine whether adjusting a conventional workstation to enable forearms support during computer use decreases reports of neck/shoulder or wrist/hand musculoskeletal discomfort in intensive computer users in a field setting."	No	Inclusion: 1) employed at least 15 hours per week. Exclusion: 1) Receiving treatment for musculoskeletal discomfort, 2) planned > one week of leave during study.
Workstation adjustment	Gerr, 2005 High	"...to assess the effects of postural and workstation interventions..."	No	Inclusion: 1) new hires, 2) work 15 hrs or more per week at single work station, 3) workstation use similar to previous job Exclusion: 1) Upper extremity MSK symptoms in neck/shoulder and hand/arm intensity of 6 or greater on a VAS, 2) took analgesics for MSD, 3) used home computer more than 20 hrs per week, 4) used laptop at work, 5) were out town
Workstation adjustment (monitor position)	Psihogios, 2001 Medium	The primary questions of the study were: (1) Do field results verify lab results, in terms of induced postures and subjective references, for eye level and mid-level monitor locations? (2) Are visual and musculoskeletal discomfort outcomes different between the lab and field, given the longer exposure time in the field study?	No	Inclusion: 1) monitors and keyboards aligned with the mid-sagittal plane of their trunks, 2) gaze angle as they normally worked approximated either eye level (0 degrees) or mid-level (-17.5 degrees). Exclusion: 1) No bifocals. Excluded data if: 1) Viewing angles measured during the first two weeks of this study were not consistent with screening measurements made prior to the start of the study.

Intervention category	Author, year and QA rating	Research question	Hypothesis clearly specified	Inclusion/exclusion criteria
Arm supports	Lintula, 2001 Medium	"...assess the effects of ErgorestJ arm supports on EMG activity of the upper trapezius muscles and extensor digitorum muscles on both sides of the body, wrist position and perceived musculoskeletal strain in the neck-shoulder-arm region during VDU work with the use of a mouse and keyboard."	No	Inclusion: VDU users without acute musculoskeletal symptoms Exclusion: not provided
Arm supports, pointing device (trackball)	Rempel, 2005 High	"... to determine whether two simple workstation interventions, a forearm support or a trackball, when used by computer based customer service workers, would reduce the incidence of upper body musculoskeletal disorders and pain severity. Secondary purposes included estimating the effects of the intervention on productivity and costs."	No	Inclusion: subjects 1) "performed customer service work > 20 hours/week;" 2) "no active workers' compensation claim of neck, shoulders, or upper extremities;" 3) "completed at least four weekly surveys." Exclusion: not provided
Pointing device (mouse)	Aaras, 1999 & Aaras, 2002 Medium	1) "Will participants having pain in the forearm/hand and shoulder experience a change in the development of musculoskeletal pain in the upper part of the body when starting to use the Anir mouse compared to the traditional mouse?" and 2) "will pain development be less when using a mouse with a more neutral position of the wrist than pain development when using a traditional mouse with a more pronated forearm?"	No	Inclusion: 1) Pain intensity more than 25mm on 100mm VAS, 2) used a "traditional" mouse for at least 2 years and at least 2 hours per day, 3) No intervention of lighting, optometric correction, work table, or chair occurring in last six months prior to start of study. Exclusion: 1) Left handed persons (because intervention pointing device was designed for right handed users, only.

Intervention category	Author, year and QA rating	Research question	Hypothesis clearly specified	Inclusion/exclusion criteria
Alternative keyboard	Tittiranonda, 1999 High	... to determine whether computer users with musculoskeletal disorders can gain health benefit from long-term use of alternative geometry keyboards.	No	Inclusion: 1) full time employees with possible carpal tunnel syndrome (CTS) and/or tendonitis as determined by review of workers' compensation injury and illness database, 2) employed on current jobs for > 3 months, 3) used computer keyboard for 4 h/day or 20 h/week or more, 4) not exposed to alternative geometry keyboards prior to the study. Exclusion: 1) previous hand/wrist surgeries, 2) diagnosed with CTS and/or tendonitis > 2 years prior to review date.
Alternative keyboard	Rempel, 1999 High	This randomized clinical trial evaluated the effects of keyboard keyswitch design on computer users with hand paresthesias.	No	Inclusion: 1) Full time employee, 2) hand or wrist symptoms reported to occupational medicine clinic 6 months of start of study, 3) used computer keyboard >= 2 h/day or 10 h/wk, 4) employed in current job for >= 3mo, 5) met criteria for "possible carpal tunnel syndrome", 6) had no prior surgery of the hands or wrists. Exclusion: 1) Prior surgery on the hands or wrists.
Rest breaks, exercise	Henning, 1997 Medium	"... to determine if the previously reported beneficial effects of frequent, short rest breaks on worker productivity and well-being hold true for workers performing existing computer-mediated tasks in an actual workplace."	No	Inclusion: not provided Exclusion: not provided Excluded data if: 1) workplace attrition over the 6-week period, including transfers to other division of company, 2) < 10% compliance rate to added breaks, as reported on exit survey, 3) failure to complete mood and musculoskeletal discomfort surveys 4) incomplete company records of worker productivity.
Rest breaks	Galinsky, 2000 Medium	Develop and evaluate a supplementary rest break strategy	No	Inclusion: None Exclusion: None

Intervention category	Author, year and QA rating	Research question	Hypothesis clearly specified	Inclusion/exclusion criteria
Rest breaks	Mclean, 2001 Medium	... to investigate myoelectric signal (MES) activity and perceived discomfort in areas of common CTD complaints: the neck, the low back, the shoulder region, and the wrist. In particular, the first objective was to determine the effect of 'microbreak' protocols on muscle activation behavior. The second objective was to determine the effect of 'microbreaks' on perceived discomfort. The third objective was to determine the effect of 'microbreaks' on worker productivity.	Yes	Inclusion: 1) performance of jobs that involved sustained sitting postures in conjunction with keying and data entry tasks. Exclusion: 1) required to be free from acute episodes of pain at the time of participation (therefore considered to be 'normal'), 2) presence of known neuromuscular, musculoskeletal or other conditions that might negatively impact study results or an individual's well being.
Rest breaks, exercise	van den Heuvel, 2003 High	... to evaluate the effectiveness of a software program that stimulates extra breaks and exercises on the recovery from neck and upper-limb complaints among computer workers. In addition, effects on sick leave and productivity were studied."	No	Inclusion: 1) working >= 4 days a week, 2) involved in computer work at least 5 hours a day, 3) had their own personal computer at work, 4) current complaints in neck, shoulders, arms, wrists, hands, or fingers for at least 2 weeks, 5) considered complaints work-related, 6) not under medical treatment for these complaints. Exclusion: 1) employees needing treatment for complaints, according to physician; 2) employees with other health problems (including medication intake) that may affects behavior at work, 3) age not between 18 and 50 years
Screen filters	Hladky, 1998 Medium	… whether screen filters actually do relieve the symptoms of eye strain in computer workers, and result in better visual conditions which in turn help maintain good working posture, and reduce musculoskeletal strain.	Yes	Inclusion: not provided Exclusion: not provided

Intervention category	Author, year and QA rating	Research question	Hypothesis clearly specified	Inclusion/exclusion criteria
Screen filters	Fostervold, 2001 Medium	"... to investigate whether or not VDU-screen filters influence subjective symptoms and other healthy indicators, and to study the stability of any changes over a longer time interval than commonly used."	Yes	Inclusion: 1) must be employees Exclusion : not provided
Lighting, workstation adjustment, VDT glasses	Aaras, 1998 & Aaras, 2001 Medium	To investigate how improved lighting, improved workplaces, and optometric corrections influence the visual discomfort, headache and musculoskeletal pain.	Yes	Inclusion: Not provided Exclusion: Not provided
New office	Nelson, 1998 Medium	The current study examines associations between musculoskeletal symptoms and individual and office workplace characteristics in an attempt to identify factors associated with lower rates of disorder. This study examines symptom rates in office workers at two points in time (before and after the group was moved from nine separate buildings to a single new facility).	Yes	Inclusion: not provided Exclusion: not provided

Intervention category	Author, year and QA rating	Research question	Hypothesis clearly specified	Inclusion/exclusion criteria
Training on ergonomics & workstation adjustment	Martin, 2003 & Gatty 2004 Medium	"1) To what extent did outcome measures differ significantly between clerical and office staff who received WIPP (work injury prevention program) and those who did not? 2) To what extent did outcome measures differ significantly from baseline measures for the clerical/office staff who received WIPP? 3) "The purpose of Phase II (Gatty) was to describe group differences at weeks 16 and 22". In addition, "The control group (in Phase I) received intervention in Phase II during weeks 18-21; pre and post measures were compared for members within this group."	Yes	Inclusion: 1) female, 2) full time clerical/office worker Exclusion: 1) no newly diagnosed MSD (within last 3 months)
Lens types (glasses)	Horgen, 2004 Medium	" ... to determine whether specially designed VDU progressive lenses created a difference in the development of visual discomfort compared with single vision lenses for presbyopic VDU users" and, "Would VDU users acknowledge the increased range of clear vision when changing from single vision lenses to VDU progressive lenses?"	No	Inclusion: 1) presbyopic addition, minimum of +1.50D, 2) experienced VDU users wearing single vision lenses as correction for workplace Exclusion: 1) spectacle correction stronger than -6.00D, 2) no active eye disease or systemic disease with eye complications nor taking drugs that may influence eye or muscle functions, 3) not have work tasks that make it impossible to use either of the lenses in the study and, 4) physical handicaps making measurements difficult

Intervention category	Author, year and QA rating	Research question	Hypothesis clearly specified	Inclusion/exclusion criteria
Lens types (glasses)	Butzon, 1997 Medium	"... to determine the most prevalent visual and physical symptoms experienced by the moderate-to-advanced ametropic presbyope while working at a VDT workstation and to perform comparative analysis to determine the benefits of use of either of the just mentioned lens designs- especially in reduction or elimination of visual and physical symptoms."	Yes	Inclusion: 1) 47 years of age or older, 2) wear a full-time multifocal lens, 3) minimum of 4 hours a day of VDT work, 4) working and present during the 10-week study, 5) agreed to be videotaped, observed, and complete questionnaires, 6) meet [optometric] criteria of: add power of +1.50 D or higher, normal stereopsis and fusion skills, no significant change from pre-existing distance or near spectacle prescription, spectacle correction within the lens parameters of two lens designs used for the study, normal medical history, correctable vision of 20/25 or better in each eye, 7) have a refractive error with need for correction for distance viewing (uncorrected distance acuity of 20/40 was selected since it is the acuity level used by many states for driving), 8) minimum of 50% of symptom reported by subjects in initial survey also reported on pre-assessment symptom questionnaire ("validating the authenticity of symptoms reported by subjects.") Exclusion: not provided
VDT glasses	Butzon, 2002 Medium	This study investigates the effectiveness of computer glasses in reduction of patient symptoms.	No	Inclusion: 1) at least 37 years old, 2) 4 or more hours computer work, 3) wore glasses while working at computer, 4) had current optical prescription (within 12 months), 5) experienced visual or physical discomfort at computer, 6) available for 6 week course of study Exclusion: 1) already wore occupational lenses specifically designed for computer use

Intervention category	Author, year and QA rating	Research question	Hypothesis clearly specified	Inclusion/exclusion criteria
Herbal eye drops	Biswas, 2003 Medium	"... to find out the efficacy of Itone [herbal eye drop] for Computer Vision Syndrome in comparison to placebo and artificial tear."	No	Inclusion: 1) attending one of five ophthalmology clinics, 2) computer use for at least 2 hours continuously per day, 3) experiencing symptoms of irritation, foreign body sensation, watering, redness, headache, eye ache and signs of conjunctival congestion, mucous/debris, corneal filaments, corneal staining, or lachrymal lake. Exclusion: 1) Uncontrolled hypertension, 2) diabetes mellitus, 3) impaired renal function, 4) severe clinically relevant hepatitis, 5) cardiac dysfunction, 6) pregnant and lactating women, and 7) reproductive age women not using oral contraceptives
OptiZen eye drops	Skilling et al, 2005 Medium	"… to test the hypothesis that repeated treatment in healthy subjects with OptiZen would be as effective as Visine Original in alleviation of visual discomfort symptoms in VDT users and would be associated with fewer adverse events."	Yes	Inclusion: 1) ages 18 to 65 yrs, 2) non-smokers, 3) eye and/or visual symptoms of discomfort attributed to VDT use, 4) daily computer use >= 4hrs/day; Exclusion: 1) use of contact lenses during study, 2) use of antihistamines, cold remedies, decongestants for 7 days before the prescreening questionnaire or study duration, 3) use of eye drops other than study medication for 1 day before the beginning of the study and continuing for the duration of the trial, 4) history of 22 acute ocular conditions, 5) pregnancy, 6) current medication history of isoretinoin, steroids, or other immunosuppressive drugs

Appendix F

Table 13: Intervention confirmation details described by the studies reviewed

Intervention category	Author, year and QA rating	Intervention confirmation?	Confirmation details
Training on exercises	Kamwendo, 1991 Medium	Yes	Self report: changes implemented and equipment acquired was documented by questionnaire at 6 months.
Training on stress management	Feuerstein, 2004 High	Yes	Observation: at 3 and 12 month ergonomic assessments Self report: using the Job Requirements and Physical Demands Survey
Training on ergonomics	Brisson, 1999 High	Yes	Observation: observed workstation adjustments at 6 months using a grid and 3 stressors; twisted neck, inappropriate height of visual target and broken hand/wrist line.
Training on ergonomics	Bohr, 2000 Medium	Yes	Observation: at baseline, 3 months, 6 months, 12 months Self report: at baseline, 3 months, 6 months, 12 months
Training on ergonomics	Peper, 2004 Medium	Yes	Self Report: at unknown time
Training on ergonomics	Greene, 2005 Medium	Yes	Observation: RULA score taken at 1 week
Training on ergonomics, new chair	Amick, 2003 High	No	
Training, Workstation adjustment	Mekhora, 2000 Medium	Yes	Observation: Investigator confirmed workstation modifications were maintained prior to each follow-up (Weeks 4, 6, 10, 14, 16, 18, 22, 26) by inspecting tape marks made on workstation at the time of workstation adjustment.
Workstation adjustment	Ketola, 2002 High	Yes	Observation: by video recordings at 2 and 10 month follow-up.
Workstation adjustment	Cook, 2004 Medium	Yes	Observation: Weekly visits were made to check compliance
Workstation adjustment	Gerr, 2005 High	Yes	Observation: at 3 days and 1 week post intervention

Intervention category	Author, year and QA rating	Intervention confirmation?	Confirmation details
Workstation adjustment (monitor position)	Psihogios, 2001 Medium	Yes	Observed one day per week
Arm supports	Lintula, 2001 Medium	Yes	Observation: At one week participants interviewed and workstation modifications made if needed.
Arm supports, pointing device (trackball)	Rempel, 2005 High	Yes	Observation: Unannounced visit at one month
Pointing device (mouse)	Aaras, 1999 & Aaras, 2002 Medium	No	
Alternative Keyboard	Tittiranonda, 1999 High	Yes	Observation: unannounced visits were made mid and post intervention
Alternative keyboard	Rempel, 1999 High	Yes	Observation: workstations visited at unannounced times throughout the study to ensure that the assigned keyboard was used.
Rest breaks, exercise	Henning, 1997 Medium	Yes	Self Report: At the end of the study (4 weeks), participants completed an exit survey and reported their level of compliance to the break schedule and their activities during computer breaks.
Rest breaks	Galinsky, 2000 Medium	Yes	Self Report: workers completed questionnaires following intervention on Tuesdays and Thursdays.
Rest breaks	Mclean, 2001 Medium	No	
Rest breaks, exercise	van den Heuvel, 2003 High	Yes	Observation: a program was installed to continuously track computer usage. Self report: workers responded to questions about what they did after each break.
Screen filters	Hladky, 1998 Medium	No	

Intervention category	Author, year and QA rating	Intervention confirmation?	Confirmation details
Screen filters	Fostervold, 2001 Medium	No	
Lighting, workstation adjustment, VDT glasses	Aaras, 1998 & Aaras, 2001 Medium	Yes	Observation: The lighting intervention was evaluated by post-intervention measurements of illuminance and lumination levels at unknown times. There was no reported confirmation of the use of new corrective lenses or the workstation changes.
New office	Nelson, 1998 Medium	No	
Training on ergonomics & workstation adjustment	Martin, 2003 & Gatty 2004 Medium	Yes	Self Report: at one week
VDT glasses	Horgen, 2004 Medium	No	
Lens types (glasses)	Butzon, 1997 Medium	No	
VDT glasses	Butzon, 2002 Medium	No	
Herbal eye drops	Biswas, 2003 Medium	No	
OptiZen eye drops	Skilling, 2005 Medium	Yes	Observation: weighed eye drop bottles at unknown times Self report:

Appendix G

Table 14: Covariates/confounder evaluated and controlled for in the studies reviewed

Intervention category	Author, year and QA rating	Types of covariates/confounders - evaluated for	Covariates/confounders - controlled for:
Training on exercises	Kamwendo, 1991 Medium	Other: daily ratings of workload	None
Training on stress management	Feuerstein, 2004 High	Physical/biomechanical work conditions (force, repetition, static loading) Organizational environment (specific policies, practices, safety climate) Medical Conditions (diseases & disorders) Mental & Physical Health Status Demographics	1) Baseline pain, 2) Baseline symptoms, 3) Baseline function, 4) Baseline general function, 5) Baseline mental health
Training on ergonomics	Brisson, 1999 High	Physical/biomechanical work conditions (force, repetition, static loading) Psychosocial/cognitive work conditions (include social support here) Organizational environment (specific policies, practices, safety climate) Medical Conditions (diseases & disorders) Demographics Non-work activities Other: smoking history	1) Age

Intervention category	Author, year and QA rating	Types of covariates/confounders - evaluated for	Covariates/confounders - controlled for:
Training on ergonomics	Bohr, 2000 Medium	Workstation Adjustment Mental & Physical Health Status	1) Health status
Training on ergonomics	Peper, 2004 Medium	Physical/biomechanical work conditions (force, repetition, static loading)	Not Provided
Training on ergonomics	Greene, 2005 Medium	Physical/biomechanical work conditions (force, repetition, static loading) Workstation Adjustment Medical Conditions (diseases & disorders) Demographics Non-work activities Other: ergonomics, efficacy, outcome expectation	1) Baseline pain

Intervention category	Author, year and QA rating	Types of covariates/confounders - evaluated for	Covariates/confounders - controlled for:
Training on ergonomics, new chair	Amick, 2003 High	Physical/biomechanical work conditions (force, repetition, static loading): Psychosocial/cognitive work conditions (include social support here) Organizational environment (specific policies, practices, safety climate) Workstation Adjustment Mental & Physical Health Status Demographics Other:	1) Time spent in office chair during a typical day of the week, 2) Repetitiveness of hand/wrist activity, 3) General health, 4) Job level, 5) Time of day
Training on ergonomics, workstation adjustment	Mekhora, 2000 Medium	Mental & Physical Health Status Other:	None
Workstation adjustment	Ketola, 2002 High	Physical/biomechanical work conditions (force, repetition, static loading) Other: baseline values of outcomes	1) Baseline ergonomic level of workstation (ratings of video analysis) 2) Baseline daily workload (computer usage) 3) Baseline MSK pain
Workstation adjustment	Cook, 2004 Medium	Physical/biomechanical work conditions (force, repetition, static loading) Workstation Adjustment	None

Intervention category	Author, year and QA rating	Types of covariates/confounders - evaluated for	Covariates/confounders - controlled for:
Workstation adjustment	Gerr, 2005 High	Physical/biomechanical work conditions (force, repetition, static loading) Psychosocial/cognitive work conditions (include social support here) Workstation Adjustment Medical Conditions (diseases & disorders) Mental & Physical Health Status Demographics Non-work activities Other: job category	1) Gender, 2) Age, 3) Hours keying during the previous week
Workstation adjustment (monitor position)	Psihogios, 2001 Medium	Psychosocial/cognitive work conditions (include social support here) Organizational environment (specific policies, practices, safety climate) Other: time of day	None
Arm supports	Lintula, 2001 Medium	None	Not Provided

Intervention category	Author, year and QA rating	Types of covariates/confounders - evaluated for	Covariates/confounders - controlled for:
Arm supports, pointing device (trackball)	Rempel, 2005 High	Psychosocial/cognitive work conditions (include social support here) Medical Conditions (diseases & disorders) Mental & Physical Health Status Demographics Non-work activities Other: Right handed mouse use; Worksite A; Job title (registered nurse); Seniority; Typing speed; Work hours per week; Computer use hours per week; Total break minutes per day	List of variables controlled for in at least on of four analyses: 1) Pre-intervention mean neck-shoulders pain value, 2) Age, 3) Gender, 4) Composite psychological strain, 5) Iso-Strain, 6) Ethnicity, 7) Pain medication, 8) Current smoker, 9) Hand intensive activity outside of work, 10) Pre-intervention mean RUE pain value, 11) Seniority, 12) Total break minutes per day, 13) Educational level, 14) Pre-intervention mean LUE pain value, 15) Job title, 16) Typing speed, 17) BMI, 18) Low back pain score, 19) Previous surgery in neck, shoulders or upper extremities, 20) Weekly exercise.
Pointing device (mouse)	Aaras, 1999 & Aaras, 2002 Medium	Physical/biomechanical work conditions (force, repetition, static loading) Psychosocial/cognitive work conditions (include social support here) Mental & Physical Health Status Family environment Other: screen contrast, glare from luminaries or work surfaces	1) Baseline health.
Alternative keyboard	Tittiranonda, 1999 High	Psychosocial/cognitive work conditions (include social support here) Demographics Other: hours of computer use	By study design - they ascertained (using regression) that the randomization process was adequate to ensure there were no covariates/confounders to adjust for.

Intervention category	Author, year and QA rating	Types of covariates/confounders - evaluated for	Covariates/confounders - controlled for:
Alternative keyboard	Rempel, 1999 High	Physical/biomechanical work conditions (force, repetition, static loading) Medical Conditions (diseases & disorders) Family environment Demographics Other: number of hours worked	Groups were considered equal on covariates of interest by matching
Rest breaks, exercise	Henning, 1997 Medium	None	Not provided
Rest breaks	Galinsky, 2000 Medium	None	None
Rest breaks	Mclean, 2001 Medium	Other: productivity	Not Provided
Rest breaks, exercise	van den Heuvel, 2003 High	Demographics	1) Age 2) Gender
Screen filters	Hladky, 1998 Medium	Workstation Adjustment Medical Conditions (diseases & disorders) Demographics Other: time of day, day, number of hours worked	1) Time of day 2) Day 3) Number of hours worked
Screen filters	Fostervold, 2001 Medium	Demographics	None

Intervention category	Author, year and QA rating	Types of covariates/confounders - evaluated for	Covariates/confounders - controlled for:
Lighting, workstation adjustment, VDT glasses	Aaras, 2001 & Aaras, 1998 Medium	Workstation Adjustment	None
New office	Nelson, 1998 Medium	Physical/biomechanical work conditions (force, repetition, static loading) Psychosocial/cognitive work conditions (include social support here) Medical Conditions (diseases & disorders): Family environment Demographics Non-work activities Other: hours worked per week, hours worked at VDT, # of times leave building	None
Training on ergonomics & workstation adjustment	Martin, 2003 & Gatty 2004 Medium	None	None
Lens types (glasses)	Horgen, 2004 Medium	Psychosocial/cognitive work conditions (include social support here) Organizational environment (specific policies, practices, safety climate) Family environment	Not clearly indicated
Lens types (glasses)	Butzon, 1997 Medium	None	None

Intervention category	Author, year and QA rating	Types of covariates/confounders - evaluated for	Covariates/confounders - controlled for:
VDT glasses	Butzon, 2002 Medium	None	Not applicable
Herbal eye drops	Biswas, 2003 Medium	None	None
OptiZen eye drops	Skilling, 2005 Medium	None	None

Appendix H

Table 15: MSK and visual outcomes and observed effects as described by the studies reviewed
This table is in the same order as Table 9 of the report, moving the Brisson, Horgren, and Mekhora studies to the end of the table.

Intervention category	Author, year	MSK outcomes	Visual outcomes	Observed effects
Training on exercises	Kamwendo, 1991	Self report, daily (VAS) for: M1) neck and shoulder muscle fatigue M2) neck and shoulder pain Self report (VAS) at pre, post and follow-up for: M3) headache M4) low back pain	No visual outcomes :	At post: M1 (at noon - chi square approx = 6.24, p = 0.4). I_1 significantly larger decrease in M1 than C_1 (z = -2.58, p = 0.01). No significant differences between I_2 and C_1 or between I_1 and I_2. M4 (chi square = 12.33, p = 0.002), significant improvement from pre to post test for I_1 compared with I_2 (z = -2.90, p = 0.004) and C_1 (z = -3.04, p = 0.002) but no significant difference between I_2 and C_1. At follow-up no significant between group differences in M4 were seen.
Training on job stress management	Feuerstein, 2004	Self report (VAS) at 3 and 12 months for: M1) Pain Self report (DASH) for: M2) DASH Symptom severity	No visual outcomes :	Symptoms, upper extremity function, general health not different by group, but no overall numbers reported.
Training on ergonomics	Bohr, 2000	Self report at unknown time of: M1) pain/discomfort in upper body (composite score including neck, upper back, shoulder/upper arm, forearm, wrist/hand)	No visual outcomes :	M1) significant differences across the groups [F(2,151) = 4.86, p< .01)] as C_1 reported higher frequency of M1 than did either I_1 & I_2. There was no significant difference in M1 scores between I_1 and I_2, although there was a noted timeXgroup interaction for the intervention groups [F=(6,453) = 2.78, p<.01].

Intervention category	Author, year	MSK outcomes	Visual outcomes	Observed effects
		M2) pain/discomfort in lower body (composite score including lower back, hip/buttocks, knees feet/ankles) M3) pain/discomfort in total body (composite score of all areas)		M2) no significant difference across study groups. M3) A significant difference was noted [F=(2,151) = 3.16, p <.05)
Training on ergonomics	Peper, 2004	Self report at unknown time of: M1 Head discomfort M2 neck/shoulder discomfort M3 arm discomfort M4 wrist/hand discomfort M5 back discomfort M6 leg discomfort M7 overall tiredness M8 work related symptoms	Self report at unknown time of: V1) eye symptoms	After 6 weeks: I_1 reported a significant reduction in M8 as compared to C_1 [F(8,19) = 3.254, p <.01] I_1 reported significant reductions (vs C_1) in: M1) t(23) =2.24 p<.05 M2) t(19)=2.98, p<.01 M3) t(22)=2.16, p<.05 M4) t(22)=3.02, p<.01 M7) t(24)=2.35,p<0.05 I_1 reported non-significant reductions (vs C_1) in: V1) t(23)=.69, p>.05 M5) t(23), =1.63, p>.05 M6) t(22)=1.60, p>.05
Training on ergonomics	Greene, 2005	Self report at 1 week post for: M1a) intensity, b) frequency, c) duration of symptoms for upper extremity M2a) intensity, b) frequency, c) duration of symptoms for upper back	No visual outcomes :	No significant difference between groups for M1 &2 a) or M1 &2 b) or M1 & 2 c); 1 week post intervention.
Training on ergonomics, new chair	Amick, 2003	Self report daily surveys at -2, -1, 2, 6, & 12 months for: M1) body pain score M2) growth in symptoms	No visual outcomes :	The I_1 group experienced a statistically significant reduction in M1 post-intervention compared with C_1 (bchair*intervention*time of day = 0.78, z = 2.502; p= 0.461). However, I_2 did not experience a similar reduction (btraining*intevention*time of day = 0.26; z = 0.737; p = 0.461) compared to the C_1.

Intervention category	Author, year	MSK outcomes	Visual outcomes	Observed effects
				The differences in log likelihoods of models 1 and 2 [13.46, p = 0.001] indicate the hypothesized intervention effects significantly improve model fit. The I_1 group experiences a reduction in growth of symptoms over the day compared to either the C_1 or the I_2. The difference between the I_1 and I_2 groups was statistically significant (function result - 1.044, chi square = 11.508, $p < 0.001$). Separate analyses of the 3-, 6-, and 12-month postintervention data indicate the coefficient for the three-way interaction term 'chair*intervention*time of day' became larger and increasingly significant with time. Postintervention differences in the average pain levels between the I_1, I_2, and C_1 groups were examined. Using the predictive model to obtain estimated pain levels at each time of day, the beginning of the day decrease in pain from preintervention to postintervention averaged 0.98points for the I_1, 1.0 point for I_2, and -0.56 points for the C_1. The end of the day decrease in pain from preintervention to postinterventin averaged 4.3, 2.2, and 1.2 points for the I_1, I2, and C_1 groups, respectively. Both the beginning (bchair*intervention = -1.539, chi square = 15.207; $p < 0.001$) and end of day (bchair*intervention + 2bchair*intervention*time of day = -3.106, chi square = 52.363; $p < 0.001$) differences are significant for the I_1 compared to C_1. The I_2 group difference is significant at the beginning (btraining*intervention = -1.560; chi square =

Intervention category	Author, year	MSK outcomes	Visual outcomes	Observed effects
				12.199; $p < 0.001$), and at then end of the day as well (btraining*intervention + 2btraining*intervention*time of day = -1.308; chi square = 4.600; $p = 0.032$).
Training on ergonomics & workstation adjustment	Martin, 2003 & Gatty, 2004	Self report of frequency (# of days with symptoms) and intensity (Likert scale) for: M1a) frequency, b) intensity of neck ache/pain M2a) frequency, b) intensity of shoulder ache/pain M3a) frequency, b) intensity of elbow/forearm ache/pain M4a) frequency, b) intensity of wrist/hand ache/pain M5a) frequency, b) intensity of upper back ache/pain M6a) frequency, b) intensity of lower back ache/pain M7a) frequency, b) intensity of whole body ache/pain	Self report of frequency (# of days with symptoms) and intensity (Likert scale) for: V1a) frequency, b) intensity of Headache/pain V2a) frequency, b) intensity of Eyestrain/fatigue	At 5 weeks, no significant ($p<0.05$) or near significant ($p<0.10$) differences in either outcome was observed for: M1 to M7. At 16 weeks: M3a & b were statistically significantly lower for I_1 vs C_1 [M3a I_1 mean(sd)=0.0 (0.0), C_1 mean(sd)=1.0 (1.83)], [M3b I_1 mean(sd)= 1.0 (0.0), C_1 mean(sd)= 1.4 (0.53)]. V1b) was statistically significantly greater for I_1 vs C_1 [I_1 mean(sd) =2.5 (1.22), C_1 mean(sd) =1.4 (0.53)] V1a) was greater among members of I) frequency, b) intensity, but did not achieve statistical significance.
Workstation adjustment	Ketola, 2002	Self report - daily diary (3 entries per day over 2 weeks) at 0, 2, and 10 month for: M1) head discomfort M2) neck discomfort, M3) discomfort in area between neck and right shoulder, M4) discomfort in area between neck and left shoulder, M5) right shoulder discomfort M6) left shoulder discomfort M7) right forearm discomfort	Self report at 0, 2, 10 months for: V1) Adjusted eye discomfort	1) Outcomes M1-M14 and V1: At 2month follow-up, both I_1 and I_2 had significantly less discomfort than C_1 in M2, M3, M13. I_1 had significantly less discomfort in M5, M6, & M12 than C_1. I_2 had significantly less discomfort in M11 than C_1. No significant differences were found between either I_1 or I_2 and C_1 at 10-month follow-up. 2) Outcome M15: At 10 month follow-up, no significant difference was found between either I_1 or I_2 and C_1.

Intervention category	Author, year	MSK outcomes	Visual outcomes	Observed effects
		M8) left forearm discomfort M9) right wrist discomfort M10) left wrist discomfort M11) right fingers discomfort M12) left fingers discomfort M13) upper back discomfort M14) low back discomfort Self report at 0, 2, 10 months for: M15) MSK strain M16) MSK pain		3) Outcome M16: At 10 month follow-up, no significant difference was found between either I_1 or I_2 and C_1.
Workstation adjustment	Cook, 2004	Self report at 6 and 12 weeks for: M1) Symptoms (dichotomized, present or absent) for neck, shoulder, forearm, wrist, back and "any" body regions.	No visual outcomes :	M1) Non-significant reductions seen in symptoms of neck, shoulder, forearm, wrist, back and "any" among I vs C at week 6.
Workstation adjustment	Gerr, 2005	Self report, weekly (VAS) for: M1) neck/shoulder MSK case M2) arm/hand MSK case Case defined as any VAS score greater than or equal to 6 or reporting taking medication on the day any discomfort reported (reported as count).	No visual outcomes :	proportional hazards M1) I_1 (neck/shoulder) hr = 1.07 (CI 0.64-2.18); C_1 hr = 1 (CI 0.6-1.68). M2) I_1 (arm/hand) hr = 0.92 (CI 0.49-1.71); C_1 hr = 1.05 (CI 0.58-1.9) Kaplan-Meier logranks: I_1 (arm/hand) 0.75; and I_1 (neck/shoulder) 0.84 indicating no differences between groups
Monitor position	Psihogios, 2001	Self report (Borg CR-10 scale) daily (2 times/day) plus weekly (2 times/week) discomfort survey for: M1) MSK discomfort by body part M2) headache	Self report (presence of symptoms y/n) plus weekly (2 times/week) discomfort survey for: V1) Visual discomfort	M1) No analyses of M1 reached significance, either assessed by part, or as a sum total of discomfort. M2) There was no significant difference in M2 reporting between conditions. Mean intensity ratings were 0.7 and 0.5 for I_1 and I_2, respectively."

Intervention category	Author, year	MSK outcomes	Visual outcomes	Observed effects
				V1) The quantities of V1reported for the two monitor locations were equally low. No differences between test conditions or trends within participants were found.
Arm supports	Lintula, 2001	Self report (VAS) at unknown time for: M1) MSK strain of neck/shoulder/arm region	No visual outcomes :	M1) No statistically significant changes were observed in the M1 between groups (I_1, I_2, C_1) or within groups.
Arm supports/ pointing device (trackball)	Rempel, 2005	Self report (Likert scale), weekly, 4 weeks prior to 52 weeks post intervention for: M1) Pain level for a) neck/shoulder, b) right upper extremity, c) left upper extremity Count of pain reports over 5 on 10-point scale and physical examination for: M2) Disorders for a) neck/shoulder, b) right upper extremity, c) left upper extremity Count of: M3) days of medication use	No visual outcomes :	63 subjects qualified as incident cases: M1) the beta coefficients (p-values) for the adjusted regression model were: I_1: N/S = -0.27 (0.16), RUE = -0.29 (0.17), LUE = -0.35 (0.04); I_2: N/S = -0.48 (0.01), RUE = -0.66 (0.002), LUE = -0.30 (0.08). At the end of the study, subjects in the intervention groups reported 'decreased pain' in comparison to the control group (p=0.001): C_1 = 5 (11%), I_1 = 14 (31%), I_2 = 29 (63%), I_3 = 20 (44%). Significant differences noted for M1a and M1c M2) The number and percent of cases by treatment group were: C_1 N/S = 19 (44%), RUE = 7 (17.5%), LUE = 7 (17%); I_1 N/S = 6 (17%), RUE = 8 (21%), LUE = 3 (7.5%); I_2: N/S = 6 (15%), RUE = 7 (20%), LUE = 4 (10%); I_3: N/S = 8 (20%), RUE = 7 (18%), LUE = 3 (7%). Since the interaction term between the armboard

Intervention category	Author, year	MSK outcomes	Visual outcomes	Observed effects
				and trackball interventions was not significant in any of the models, the interventions were evaluated independently. The hazard ratio (p-value) from the final, adjusted models were: I_1: N/S = 0.62 (0.19); RUE = 1.26 (0.58), LUE = 0.19 (0.04); I_2: N/S = 0.49 (0.04), RUE = 0.64 (0.29), LUE = 0.29 (0.06). Significant differences noted for M2a and M2b M3) I_2 reported a mean reduction of 0.31 days of medication but the difference between groups was only marginally statistically significant (p = 0.08). I_1 reported no difference in days of medication usage (p = 0.66).
Pointing Device (mouse)	Aaras, 1999, & Aaras, 2002	Self report at 0 & 6 months for: M1) neck pain in last 6 months M2) shoulder pain in last 6 months M3) forearm pain in last 6 months M4) wrist/hand pain in last 6 months M5) headache in last 6 months M6) MSK sick leave	No visual outcomes :	Statistically significant differences between groups were observed for: M1, M2, M3, M4 but not for M5 and M6. M6) trend -differences between groups indicated beneficial effect of the intervention.
Keyboard	Tittiranonda, 1999	Self report at 0, 6, 12, 18, & 24 weeks for: M1) arm/hand symptoms M2) change in overall pain severity	No visual outcomes :	M1) a significant trend of reduced M1 in I_1, I_2, I_3 groups, with significant reductions in M1 in I_3 at 24 weeks (1.21 +/- 3.1) compared to C_1 (-0.29 +/- 1.5) (post-hoc Dunnett's test, one-sided, mean > control, $P < 0.05$). M2) at 6-weeks - ANOVA comparing M2 between I_1, I_2, I_3, C_1, was of borderline significance (P=0.06). Each group demonstrated a reduction in pain at 6 weeks, after which the mean pain scores reversed back toward baseline for I_2 and placebo,

Intervention category	Author, year	MSK outcomes	Visual outcomes	Observed effects
				but continued to decrease for I_1 and I_3 at 12 weeks. For the C_1, posthoc Tukey-Kramer procedure (p=0.05) indicated a significant pain decrease from baseline at 6 weeks for C_1, but no difference at later weeks. For I_3, M2 was statistically significant at 18 and 24 weeks for I_3 (P=0.05). Within both of these time periods, M2 for I_3 was significantly lower than the C_1 (post-hoc Tukey-Kramer procedure, P=0.05).
Keyboard	Rempel, 1999	Self report at 0, 6, 12 weeks for: M1) Hand Pain Physical examination/tests for: M2) Phalen's test time M3) Nerve conduction	No visual outcomes :	M1) no significant differences between I_1 and C_1 at 6 weeks. At 12 weeks I_1 significantly greater reduction in M1 (means 2.7 to 1.9) than C_1 (means 2.6 to 4.3) (P=0.05). M2) at 0,6,12 weeks differences were significant (p=0.006): I_1 (28s, 48s, 52s) > than C_1 (35s, 31s, 37s), M2 improved significantly from week 0 to week 12 in I_1 (means 27s to 52s)(P=0.0004). No significant difference noted in C_1 (means 35s to 37s). M3) no significant differences in M3 between I_1 and C_1 for R CTS (p=0.81) or L CTS (p=0.13).

Intervention category	Author, year	MSK outcomes	Visual outcomes	Observed effects
Rest breaks	Galinsky, 2000	Self report, daily (3 times/day) for: M1) neck discomfort M2) back discomfort M3) Rt shoulder/upperarm discomfort M4) Rt elbow discomfort M5) Rt forearm/hand discomfort M6) Lt shoulder/upper arm discomfort M7) Lt elbow discomfort M8) Lt forearm/hand discomfort M9) buttocks	Self report, daily (3 times/day – Likert scale) for: V1) Eye soreness V2) Visual blurring	I_1 significantly lower symptoms than C_1 ($p<0.05$) for: M1) neck (F=20.65) M2) back (F=10.20) M3) right shoulder/upper arm (F=6.60) M4) right elbow (F=7.90) M5) right forearm/hand (F=6.04) M6) left shoulder/upper arm (F=7.70) M7) left elbow (F=6.64) M8) left forearm/hand non-significant M9) buttocks (F=11.70) V1) eye soreness (F=6.09) V2) visual blurring non-significant
Rest breaks/ software	Mclean, 2001	Self report (VAS) for 2 days at end of each week for: M1) neck discomfort M2) back discomfort M3) shoulder discomfort M4) forearm/wrist discomfort	No visual outcomes :	No significant differences found between I_1 and C_1 for M1 – M4 or between I_2 and C_1 for M1, M2. Significant (interaction for protocol vs time) differences found between I_2 and C_1 for M3, M4.
Rest breaks	Henning, 1997	Self report, daily (3 times/day – Likert scale) for: M1) back discomfort M2) legs and feet discomfort M3) hands and arms discomfort M4) neck and shoulders discomfort	Self report, daily (3 times/day – Likert scale) for: V1) eye discomfort	At both sites, there was no observed effect of the interventions on MSK discomfort in the M1) back M2) legs and feet M3) hands and arms M4) neck and shoulders
Rest breaks/ software	van den Heuvel, 2003	Self report (Likert scale) post intervention for: M1) perceived overall recovery from complaints M2a) frequency of complaints b) severity of complaints	No visual outcomes :	M1) in both I_1 and I_2 was significantly greater than C when those that reported decrease in complaints are compared independently from those who report no change or increase and the two interventions did not differ; numbers reported are adjusted mean differences pre and post for each group: C_1 3.7; CI 3.5-4.0), I_1 3.3 (CI 3.0-3.5); I_2 3.3 (CI 3.0-3.6). They were not statistically different.

Intervention category	Author, year	MSK outcomes	Visual outcomes	Observed effects
				M2a) No difference between groups M2b) No difference between groups
New office	Nelson, 1998	Self report at unknown time for: M1) all hand/arm pain symptoms: a) numbness, b) pain, c) woke at night, d) arm pain M2) leg pain symptoms M3) all neck/shoulder/back pain symptoms: a) neck/shoulder pain, b) back pain	No visual outcomes :	No difference between groups in comfort and musculoskeletal symptom rates.
Lighting & workstation adjustment & VDT glasses	Aaras, 2001 & Aaras, 1998	Self report (VAS) at various times post interventions for: M1) Neck pain M2) Shoulder pain M3) Pain in the forearm and hand M4) Back pain in lumbar region	Self report (VAS) at various times post interventions for: V1) Lighting and Visual Conditions V2) Glare Conditions V3) Visual discomfort over last month V4) Visual discomfort over last 6 months V5) Headache over last month V6) Feeling of Tired Eyes V7) Stinging or itching and irritation V8) Sensitivity to light V9) Redness of the eyes V10) Gravelly sensation of the eyes V11) Blurred or double vision	MSK HEALTH OUTCOMES: M2) After optometry intervention, I_1T reported significantly less shoulder pain frequency compared to C_1 ($p=0.02$). No significant differences between groups for M1, M3 or M4. VISION HEALTH OUTCOMES V1) After the lighting intervention, I_1T and I_1S reported significantly more satisfying visual conditions compared with C_1 ($p<0.0001$). V2) After lighting intervention, I_1T and I_1S reported significant reductions in glare problems compared with C_1 ($p<0.0001$). V3) A reduction in visual discomfort was found for I_1T and I_1S groups compared with C_1 after the optometric intervention ($p=0.0001$). At 6 years, no significant difference among the three groups ($p=0.1$).

Intervention category	Author, year	MSK outcomes	Visual outcomes	Observed effects
				V4) After the optometry intervention for I_1T and I_1S, a significant reduction in visual discomfort was found for I_1T and I_1S groups compared with C_1 ($p<0.05$). At 6 years, no significant difference among the three groups ($p>0.05$). V5) There was no difference among the three groups at the 6 year follow-up ($p=0.176$). No significant differences between groups for V7, V8, V9, V10, & V11.
Lens types (glasses)	Butzon, 1997	Self report daily (presence of symptoms y/n) plus frequency and severity rating of symptoms (Likert scales) for: M1a) frequency, b) severity of neck/shoulder ache M2a) frequency, b) severity of back pain	Self report daily (presence of symptoms y/n) plus frequency and severity rating of symptoms (Likert scales) for: V1a) frequency, b) severity of eyestrain V2a) frequency, b) severity of blurred intermediate vision V3a) frequency, b) severity of loss of focus V4a) frequency, b) severity of blurred near vision V5a) frequency, b) severity of blurred distance vision V6a) frequency, b) severity of dry eyes V7a) frequency, b) severity of double vision V8a) frequency, b) severity of headache	V5a) Mean (SD)=1.96 (2.92) for IC_12 glasses, and 5.26 (4.05) for IC_11. The mean frequency of blurred distance vision was significantly greater for the IC_11 than the IC_12. V5b) Mean (SD)=1.09 (1.53) for IC_12, and 4.09 (3.59) for IC_11. The mean severity of blurred distance vision was significantly greater for the IC_11than the IC_12. No significant differences between groups for all other MSK and visual outcomes.

Intervention category	Author, year	MSK outcomes	Visual outcomes	Observed effects
VDT glasses	Butzon, 2002	Self report at 0, 3, & 6 weeks (Likert scale) for: M1) neck and shoulder ache M2) back ache M3) hand or wrist ache M4) total symptoms score	Self report at 0, 3, & 6 weeks (Likert scale) for: V1) eyestrain or tired eyes V2) headache V3) irritated or sore eyes V4) dry eyes V5) lighting or glare discomfort V6) blurred distance vision V7) blurred intermediate vision (computer distance) V8) blurred near vision V9) double vision V10) colour vision problems	M4) Main effect for treatment group was significant, $F(1,24)=5.98$, $p=0.022$. Averaged across 3 phases of intervention, I_1 (Mean=19.0, SD=17.9) had less severe symptoms than IC_1 (Mean=33.1, SD=21.5). Main effect for phase of intervention was also significant, with M4 decreasing significantly from baseline to follow-up. $F(2,48)=29.14$, $p<0.0001$. Scores across intervention phases were as follows: Baseline (mean=39.3, SD=18.2), after 1st treatment (mean=24.7, SD=19.8), after 2nd treatment (mean=15.8, SD=18.6). There was a significant interaction between treatment groups across intervention phases: $F(2,48)=5.31$, $p<.008$. The greatest reduction in M4 occurred after computer glasses were prescribed (I_1), with little reduction after ESAT (IC_1) is used.
Screen filters	Hladky, 1998	Self report (over multiple time points) for: M1a) intensity b) occurrence, c) duration at specific time points of MSK symptoms M2) analgesic usage	Self report (over multiple time points) for: V1a) intensity b) occurrence, c) duration at specific time points of eye symptoms	Greater reduction in eye and musculoskeletal symptom severity in I (vs C) controlling for hours worked, day and time of day. V1a) are significantly less in I_1 than C_1 M1a) are significantly less in I_1 than C_1 M2) taking analgesics no significant differences between groups but trend shows lower use in I_1.
Screen filters	Fostervold, 2001	Self report at 0, 2.5, & 5 months for: M1) aggregate MSK symptom measure (Tenderness and stiffness from the left and right side of the upper back and shoulders)	Self report at 0, 2.5, & 5 months for: V1) Ocular symptoms	For M1 & V1 no significant differences between I and IC, either at the post-test 2, or over the entire study period.

Intervention category	Author, year	MSK outcomes	Visual outcomes	Observed effects
Eye drops	Biswas, 2003.	No MSK outcome :	Self report bi-weekly for: Symptoms: V1) irritation V2 foreign body sensation* V3) watering V4) redness* V5) headache V6) eyeache** Signs: V7) conjunctival congestion V8) mucous/debris V9) conjunctival staining V10) lacrimal lake V11) break-up time V12) Schinner's test V13) orthoptic work-up V14) flurorescein staining V15) Rose Bengal staining.	I_1 significantly better than I_2 and C_1 for V2* (F=7.81, p<0.01): I_1 0.31+/-0.56 vs I_2 1.00+/-0.86* and V4 (F=28.6, p< 0.01): I_1 0.13+/-0.35 vs I_2 1.15+/-1.11* I_1 was found to be significantly better than C_1 for: V6** (F=3.98, p<0.05): I_1 0.04 +/-0.21 vs I_2 0.38 +/-0.57 vs C_1 0.47+/-0.66 ** For V1, V3, V5, and all signs outcomes V7 - V15: no significant differences found
Eye drops	Skilling, 2005	No MSK outcome :	Self report (Likert scale dichotomized) at unknown time for: V1) visual/ocular discomfort	V1) No difference between I_1 and C_1 for V1: OR I_1=1.23, C_1=1.00, CI=0.63 to 2.42, n=24, 25).
Training on ergonomics	Brisson, 1999	Self report of symptoms at 6 months for: M1) disorder prevalence based on symptoms Physical exam at 6 months for: M2) disorder prevalence based on physical exams	No visual outcomes :	No formal analysis done of differences between groups.

Intervention category	Author, year	MSK outcomes	Visual outcomes	Observed effects
Training, workstation adjustment	Mekhora, 2000	Self report (VAS) at multiple time points between 2 and 26 weeks for: M1) left shoulder discomfort M2) left arm discomfort M3) upper back discomfort M4) neck discomfort M5) right shoulder discomfort M6) right arm discomfort M7) lower back discomfort	Self report VAS at multiple time points between 2 and 26 weeks for: V1) eye discomfort	Data for groups 1 and 2 are combined and it is strictly a pre-post comparison. NO differences between groups reported.
VDT glasses	Horgen, 2004	Self report at 0, 6, & 12 months for: M1a) frequency, b) intensity of headaches M2a) frequency, b) intensity of neck pain M3a) frequency, b) intensity of shoulder pain M4a) frequency, b) intensity of forearm pain M5a) frequency, b) intensity of wrist pain	Self report at 0, 6, & 12 months for: V1a) frequency of visual problems in the previous month, b) Intensity of visual problems in the previous month	NO differences between groups reported. V1b) “only small changes” M1b) Mean intensity changed from 23.5 to 15 during the 12 month period. M2a & b) means changed from 28.1 to 19 and 30.1 to 19.6, respectively, for I_1 over 12 months. M3a & b) shoulder - non-significant. M4a & b) forearm - non-significant. M5a & b) wrist pain - non-significant.

Appendix I

Table 16: MSK and visual outcome measurement and physical examination description as described by the studies reviewed

Intervention category	Author, year and QA rating	MSK outcome measurement	Visual outcome measurement	Physical examination or laboratory tests performed for specific body regions	Physical examination masking?
Training on exercises	Kamwendo, 1991 Medium	Measured at a consistent time of day: "Depending on whether the subject worked part-time or full-time, ratings were carried out 3 or 4 times daily - reported as 'morning', 'noon', 'afternoon', and 'leaving work.' Unclear or unknown day of week	No visual outcome	No physical exam or tests	Not Applicable
Training on stress management	Feuerstein, 2004 High	Unclear or unknown time of day Unclear or unknown day of week	No visual outcome	No physical exam or tests	Not Applicable
Training on ergonomics	Brisson, 1999 High	Unclear or unknown time of day Unclear or unknown day of week	No visual outcome	Hand/wrist/elbow: on reduced sample Neck/shoulder: on reduced sample Lower back: on reduced sample	Yes
Training on ergonomics	Bohr, 2000 Medium	Unclear or unknown time of day Unclear or unknown day of week	No visual outcome	No physical exam or tests	Not Applicable
Training on ergonomics	Peper, 2004 Medium	Unclear or unknown time of day Unclear or unknown day of week	Unclear or unknown time of day Unclear or unknown day of week	Hand/wrist/elbow Neck/shoulder Lower back Visual disorders Other: Tiredness	No

Intervention category	Author, year and QA rating	MSK outcome measurement	Visual outcome measurement	Physical examination or laboratory tests performed for specific body regions	Physical examination masking?
Training on ergonomics	Greene, 2005 Medium	Unclear or unknown time of day Unclear or unknown day of week	No visual outcome	No physical exam or tests:	Not Applicable
Training on ergonomics, new chair	Amick, 2003 High	Measured at a consistent time of day: at the beginning, middle, and end of the workday Measured on a consistent day: for 5 days during a workweek	No visual outcome	No physical exam or tests	Not Applicable
Training on ergonomics, workstation adjustment	Mekhora, 2000 Medium	Measured at a consistent time of day: between 2:00-3:00 pm on evaluation day. Unclear or unknown day of week	Measured at a consistent time of day: between 2:00-3:00 pm on evaluation day. Unclear or unknown day of week	No physical exam or tests	Not Applicable
Workstation adjustment	Ketola, 2002 High	Measured at a consistent time of day: 3 time periods: 1) start of workday; 2) at noon; 3) end of workday Measured on a consistent day: Daily for 2 week period at baseline, 2 mo- and 10-mo. follow-up.	Measured at a consistent time of day: 3 time periods: 1) start of workday; 2) at noon; 3) end of workday Measured on a consistent day: Daily for 2 week period at baseline, 2 mo- and 10-mo. follow-up.	No physical exam or tests	Not Applicable
Workstation adjustment	Cook, 2004 Medium	Unclear or unknown time of day Unclear or unknown day of week	No visual outcome	No physical exam or tests	Not Applicable
Workstation adjustment	Gerr, 2005 High	Unclear or unknown time of day Unclear or unknown day of week	No visual outcome	No physical exam or tests	Not Applicable

Intervention category	Author, year and QA rating	MSK outcome measurement	Visual outcome measurement	Physical examination or laboratory tests performed for specific body regions	Physical examination masking?
Workstation adjustment (monitor position)	Psihogios, 2001 Medium	Measured at a consistent time of day: same a.m. and p.m. hours of the day for a given individual throughout the study Measured on a consistent day: same day of the week for a given individual throughout the study.	Measured at a consistent time of day: same a.m. and p.m. hours of the day for a given individual throughout the study Measured on a consistent day: same day of the week for a given individual throughout the study.	No physical exam or tests	Not Applicable
Arm supports	Lintula, 2001 Medium	Measured at a consistent time of day: "measurements were carried out at the same time of day before and after the intervention" - but exact time not given Unclear or unknown day of week	No visual outcome	Hand/wrist/elbow: EMG Neck/shoulder	No
Arm supports, pointing device (trackball)	Rempel, 2005 High	Unclear or unknown time of day Measured on a consistent day: End of week	No visual outcome	Hand/wrist/elbow: Right and Left sides Neck/shoulder	Unclear
Pointing device (mouse)	Aaras, 1999, & Aaras, 2002 Medium	Unclear or unknown time of day Unclear or unknown day of week	No visual outcome	No physical exam or tests	No
Alternative keyboard	Tittiranonda, 1999 High	Unclear or unknown time of day Unclear or unknown day of week	No visual outcome	Hand/wrist/elbow:	Yes: examiners were masked to previous medical history and keyboard assignments

Intervention category	Author, year and QA rating	MSK outcome measurement	Visual outcome measurement	Physical examination or laboratory tests performed for specific body regions	Physical examination masking?
Alternative keyboard	Rempel, 1999 High	Unclear or unknown time of day Unclear or unknown day of week	No visual outcome	Hand/wrist/elbow: Physical examination and sensory nerve conduction measures.	Yes: medical personnel masked to keyboard assignments
Rest breaks, exercise	Henning, 1997 Medium	Measured at a consistent time of day: beginning, prior to lunch, end of day Measured on a consistent day: Every day Monday-Friday	Measured at a consistent time of day: beginning, prior to lunch, end of day Measured on a consistent day: Every day Monday-Friday	No physical exam or tests	Not Applicable
Rest breaks	Galinsky, 2000 Medium	Measured at a consistent time of day: measured at start of day, right before lunch, right after lunch and mid afternoon Measured on a consistent day: daily Monday to Friday	Measured at a consistent time of day: measured at start of day, right before lunch, right after lunch and mid afternoon Measured on a consistent day: daily Monday to Friday	No physical exam or tests	Not Applicable
Rest breaks	Mclean, 2001 Medium	Unclear or unknown time of day: Measured on a consistent day: Thursdays & Fridays	No visual outcome	No physical exam or tests	Not Applicable
Rest breaks, exercise	van den Heuvel, 2003 High	Unclear or unknown time of day Unclear or unknown day of week	No visual outcome	No physical exam or tests	Not Applicable

Intervention category	Author, year and QA rating	MSK outcome measurement	Visual outcome measurement	Physical examination or laboratory tests performed for specific body regions	Physical examination masking?
Screen filters	Hladky, 1998 Medium	Measured at a consistent time of day: morning arriving at work, at noon before lunch, in the afternoon before leaving Measured on a consistent day: 3 times a week day 1,2,3 - no indication which days of the week	Measured at a consistent time of day: morning arriving at work, at noon before lunch, in the afternoon before leaving Measured on a consistent day: 3 times a week day 1,2,3 - no indication which days of the week	No physical exam or tests	Not Applicable
Screen filters	Fostervold, 2001 Medium	Unclear or unknown time of day Unclear or unknown day of week	Unclear or unknown time of day Unclear or unknown day of week	Neck/shoulder Upper back	Yes
Lighting, workstation adjustment, VDT glasses	Aaras, 1998 & Aaras, 2001 Medium	Unclear or unknown time of day Unclear or unknown day of week	Unclear or unknown time of day Unclear or unknown day of week	Visual disorders: All subjects were given a complete optometric examination.	Unclear
New office	Nelson, 1998 Medium	Unclear or unknown time of day Unclear or unknown day of week	No visual outcome	No physical exam or tests	Not Applicable
Training on ergonomics & workstation adjustment	Martin, 2003 & Gatty 2004 Medium	Unclear or unknown time of day Unclear or unknown day of week	Unclear or unknown time of day Unclear or unknown day of week	No physical exam or tests	Not Applicable
Lens types (glasses)	Horgen, 2004 Medium	Unclear or unknown time of day Unclear or unknown day of week	Unclear or unknown time of day Unclear or unknown day of week	No physical exam or tests:	Not Applicable

Intervention category	Author, year and QA rating	MSK outcome measurement	Visual outcome measurement	Physical examination or laboratory tests performed for specific body regions	Physical examination masking?
Lens types (glasses)	Butzon, 1997 Medium	Unclear or unknown time of day Unclear or unknown day of week	Unclear or unknown time of day Unclear or unknown day of week	No physical exam or tests	Not Applicable
VDT glasses	Butzon, 2002 Medium	Unclear or unknown time of day Unclear or unknown day of week	Unclear or unknown time of day Unclear or unknown day of week	Visual disorders: subjects assessed for prescriptive computer glasses by optometrist.	Not Applicable
Herbal eye drops	Biswas, 2003 Medium	No MSK outcome	Unclear or unknown time of day Unclear or unknown day of week	Visual disorders	Yes
OptiZen eye drops	Skilling, 2005 Medium	No MSK outcome	Measured at a consistent time of day: pre computer work, 2 hrs computer work, 4 hrs computer work, end of day Measured on a consistent day	No physical exam or tests	Not Applicable

Appendix J

Table 17: Non-MSK or visual outcomes (and method of measurement) described by the studies reviewed

Intervention category	Author, Year and QA rating	Other outcomes - method of measurement
Training on exercises	Kamwendo, 1991 Medium	1) Sick leave - Information was obtained from the Swedish Social Insurance Service after permission from the secretaries. Diagnoses, number of sick leave occasions, and number of days on sick leave were registered. 2) Ergonomical knowledge - multiple choice questionnaire 3) Changes implemented - self report at follow up 4) Acquired equipment - self report at follow-up 5) Programme adherence (group B) - observation and self report 6) Number of health care visits - interview concerning the number of visits they had paid to a physician, physical therapist, or chiropractor, etc. for shoulder pain or headache, since the completion of the four-week programme.
Training on stress management	Feuerstein, 2004 High	1) Ergonomic measures - observed and self-report 2) Work stress - job stress subscales of LSRES 3) Function scores - Pransky scale, DASH, SF-12
Training on ergonomics	Brisson, 1999 High	1) Postural stressors assessed 2) Appropriate workstation adjustment - used a standard set of criteria
Training on ergonomics	Bohr, 2000 Medium	1) APGAR score - measurement not described 2) Work area configuration composite 3) Worker postures composite 4) Total Score (composite)
Training on ergonomics	Peper, 2004 Medium	None
Training on ergonomics	Greene, 2005 Medium	1) Workstation changes - self reported 2) Workstation score - RULA 3) Ergonomic knowledge - self reported (quiz) 4) Self-efficacy - self reported 5) Outcome expectation - self reported
Training on ergonomics, new chair	Amick, 2003 High	None
Training on ergonomics, workstation adjustment	Mekhora, 2000 Medium	1) Workload - questionnaire 2) Work duration - questionnaire 3) Treatment for disorders - self report 4) Workstation changes - self report
Workstation adjustment	Ketola, 2002 High	1) Type of ergonomic changes - number of changes made in 6 categories: screen height, keyboard desk height, chair adjustment, mouse location, wrist support acquisition, forearm support acquisition 2) Mean ergonomic workstation ratings - from video recordings 3) Number of participants in each group that sought ergonomic consultations with occupational physiotherapist - observation
Workstation adjustment	Cook, 2004 Medium	None
Workstation adjustment	Gerr, 2005 High	None

Intervention category	Author, Year and QA rating	Other outcomes - method of measurement
Workstation adjustment (monitor position)	Psihogios, 2001 Medium	1) Workstation preferences (Hi or Mid) and advantages and disadvantages of each monitor location - questionnaire 2) Posture measures: A) eye–ear line relative to horizontal (EEL-h), B) neck angle relative to vertical (NA-v), C) trunk angle (TA), thoracic bending (TB), and D) gaze angle relative to horizontal (GA-h) - goniometer
Arm supports	Lintula, 2001 Medium	1) Wrist position - goniometers used for average wrist joint angle (degrees) 2) Usability of arm supports - measure not provided
Arm supports, pointing device (trackball)	Rempel, 2005 High	1) Subjective rating of the intervention - exit questionnaire 2) Reason for dropout - exit questionnaire 3) Effect of the intervention on employee productivity - employer tracked measures of productivity
Pointing device (mouse)	Aaras, 1999 & Aaras, 2002 Medium	1) Musculoskeletal sick leave - "days during the last 6 months".
Alternative keyboard	Tittiranonda, 1999 High	1) Function status - questionnaire 2) Keyboard preference - questionnaire
Alternative keyboard	Rempel, 1999 High	1) Hand function - questionnaire
Rest breaks, exercise	Henning, 1997 Medium	1) “Operator mood" - assessed through ratings of twelve mood items (tense, on edge, clam, relaxed, energetic, full of pep, vigorous, fatigues, exhausted, sluggish, bored, and active). 2) “Productivity for each operator" - calculated as the number of claims processed per the number of hours available for claims processing obtained from company records. 3) Level of compliance to break schedule and activities during computer breaks - exit questionnaire
Rest breaks	Galinsky, 2000 Medium	1) Productivity 2) Typing accuracy
Rest breaks	Mclean, 2001 Medium	1) Productivity - word counts 2) Myoelectric signal activity - EMG
Rest breaks, exercise	van den Heuvel, 2003 High	1) Productivity - (mean key strokes per day and accuracy rate) as [1-(number of backspace+delete key strokes)/total number of key strokes] 2) Compliance with breaks and exercises - self report 3) Sick leave for their complaints and estimated number of days of sick leave - self report
Screen filters	Hladky, 1998 Medium	Self assessment of ergonomic layout
Screen filters	Fostervold, 2001 Medium	1) Sick leave - three measures (total percentage of sick leave, short-time sick leave and short-time sick leave with personal note) 2) Productivity - unclear how measured

Intervention category	Author, Year and QA rating	Other outcomes - method of measurement
Lighting, workstation adjustment, VDT glasses	Aaras, 2001 & Aaras, 1998 Medium	1) Lighting illuminances - measured with LMT pocket luxmeter 2) Lighting luminance - measured with Hagner luminance meter 3) Postural load of neck and shoulder muscles - EMG recordings of descending part of trapezius muscle 4) Workload on local body structures - measured by recording body movements and posture at workplace, using static (0.1), median (0.5) and peak (0.9) values of APDF 5) Postural angle of muscles relative to vertical plane - measured by attaching inclinometers to upper arm, head and back 6) Six psychosocial factors (a. Amount of VDU work (i.e., how often the VDU was used, total amount of time per day, length of periods without break), b. Other work tasks compared with VDU work and the variation of the work as a whole, c. Job control, d. Opportunity to make contact with colleagues, e. Self-realization in terms of learning, increased skills and utilization of own capability, f. Basic need satisfaction (such as the time at own work disposal and work burden at home).
New office	Nelson, 1998 Medium	1) Psychosocial aspects of A) good supervision, B) clear expectations, C) work hard/fast, D) job satisfaction, E) influence workplace, F) conflicting demands, G) high concentration, H) salary satisfaction - questionnaire
Training on ergonomics & workstation adjustment	Martin, 2003 & Gatty 2004 Medium	1) "Average weekly stress" - questionnaire 2) "Average weekly energy" - questionnaire 3) Average sick days per employee per month - not stated how this was ascertained
Lens types (glasses)	Butzon, 1997 Medium	1) posture while wearing lenses - video
VDT glasses	Butzon, 2002 Medium	1) Upset stomach - questionnaire 2) Estimate the percent reduction in pre-study symptoms attributable to each treatment - 'post-comparative' questionnaire 3) treatment felt to be most effective - 'post-comparative' questionnaire 4) Subjects were presented with 3 possible environmental sources of symptoms (lighting, workstation design, and visual status) and were asked to apportion the percentage of contribution that each made to pre-study symptoms - 'post-comparative' questionnaire 5) Difficulty adjusting to the ESAT intervention - 'post-comparative' questionnaire 6) Difficulty adjusting to the computer glasses intervention - 'post-comparative' questionnaire 7) Whether the ESAT was a valuable screening tool for existing deficiencies in lighting, workstation design, and visual status -'post-comparative' questionnaire The 'post-comparative' questionnaire was administered at the completion of the study (6 wks).
VDT glasses	Horgen, 2004 Medium	1) Duration of use of intervention lenses - questionnaire
Herbal eye drops	Biswas, 2003 Medium	None

Intervention category	Author, Year and QA rating	Other outcomes - method of measurement
OptiZen eye drops	Skilling, 2005 Medium	None