The duration of computer use as a risk factor for hand-arm and neck-shoulder symptoms

S. IJmker[a,b,c], M.A. Huysmans[a,d], B.M. Blatter[a,c], A.J. van der Beek[a,b]
W. van Mechelen[a,b], P.M. Bongers[a,b,c]

[a] *Body@Work TNO VUmc, Research Centre Physical Activity Work and Health, the Netherlands*
[b] *Department of Public and Occupational Health, Institute for Research in Extramural Medicine, VU University Medical Centre, Amsterdam, the Netherlands*
[c] *TNO Quality of Life, the Netherlands*
[d] Institute for Fundamental and Clinical Human Movement Sciences (IFKB), Faculty of Human Movement Sciences, Vrije Universiteit, Amsterdam, the Netherlands

Abstract

Worldwide, millions of office workers use a computer. This systematic review summarizes the evidence for a relation between the duration of computer use and the incidence of hand-arm and neck-shoulder symptoms and disorders. The strength of the evidence was based on methodological quality and consistency of the results. Nine articles based on longitudinal studies were identified, of which six were rated as high quality. Moderate evidence was concluded for a positive association between the duration of mouse use and hand-arm symptoms. For this association, indications for a dose-response relationship were found. Risk estimates were generally stronger for the hand-arm region than for the neck-shoulder region, and stronger for mouse use than for total computer use and keyboard use. A pathophysiological model focussing on the overuse of muscles during computer use supports these differences. Future studies could improve our understanding of safe levels of computer use by measuring the duration of computer use in a more objective way, differentiating between total computer use, mouse use and keyboard use, and by collecting data on disability resulting from symptoms. Efforts targeted on the reduction of the duration of mouse use might be a promising option in the prevention of hand-arm symptoms among office workers.

Keywords: upper extremity disorders, computer use, literature review

1. Introduction

The large-scale introduction of computers in the workplace has led to hundreds of millions of computer users worldwide [1,2]. In many countries the widespread use of computers resulted in considerable media attention concerning potential adverse health effects. In the scientific literature, the rise and fall of an epidemic of "repetitive strain injuries" (i.e. workers reporting and claiming compensation for disorders of arm, shoulder or neck) in Australia during the 1980s has been fuelling the debate whether computer use at work is a potential occupational hazard [3]. Proponents stated that repetitive movements and static load due to constrained working postures caused the "injuries". Critics focussed on the absence of objective clinical signs among patients and the role of a liberal compensation system, offering large sums of money to workers who felt unable to work due to arm, shoulder or neck symptoms [4]. Some authors argued that lost lawsuits of workers against their employers were a main contributing factor to the decline of the epidemic [5]. In 1988, Bammer and Martin [4] concluded that the debate was characterized by a lack of empirical evidence to support many of the assertions made by both the proponents and the critics of the work-relatedness of repetitive strain injuries.

In this review, we will focus on the empirical evidence available for an association between the duration of computer use at work and arm, shoulder

or neck symptoms and disorders. Previous reviews suggest that an association between the duration of computer use and disorders of arm, shoulder or neck is present. There are also indications that computer use is more strongly related to disorders of the hand and arm, than to disorders of the neck and shoulders [6,7,8,9]. However, the limitation of these reviews is that they are mainly based on cross-sectional studies [6,7,8]. Cross-sectional studies cannot disentangle causes and effects and are therefore considered to be inferior to longitudinal studies [10]. The recent narrative review by Wahlström [9] includes only part of the available longitudinal studies.

In order to get a more conclusive insight in the relationship between the duration of computer use and the incidence of hand-arm and neck-shoulder symptoms and disorders, a systematic review of longitudinal studies was performed. Since information on potential dose-response relationships is lacking, specific attention will be paid to this issue.

2. Methods

2.1 Search strategy

Longitudinal studies evaluating the association between the duration of computer use and the incidence of arm, shoulder and neck symptoms were retrieved by a computerised search of the following databases: MEDLINE (from 1950 to November 2005), NIOSHTIC 2, CISDOC, HSELINE, MHIDAS, OSHLINE (all from 1985 to April 2005) and PSYCINFO (from 1967 to April 2005). The databases were searched up to 6 November 2005. Two reviewers (SIJ and MAH) independently selected relevant articles

2.2 Quality assessment

All included articles were evaluated for methodological quality. We used a quality assessment list for prospective cohort studies, based on previous systematic reviews of risk factors for musculoskeletal disorders, see table 1.

Two reviewers (SIJ and MAH) independently assessed the quality of the studies. All items were scored as positive, negative or unclear (i.e. meaning that insufficient information was available). For each item, the scoring of the two reviewers was compared. In case of disagreement, consensus was reached during a meeting. If agreement could not be reached, a third reviewer (AvdB) decided in the matter. Subsequently, the first author of the included articles was contacted to provide an opportunity to discuss the quality assessment of their article(s). Methodological quality assessment was based on the percentage of positive items over the total number of items. A high quality study was defined if it scored positive on more than 50% of the items.

Table 1. Quality assessment list for prospective cohort studies.

Study design
1. Was the participation rate at baseline at least 80% OR, if participation rate was < 80%, not selective regarding exposure (i.e. duration of computer use) and potential confounders (i.e. at least for gender and age)?
2. Was the response at follow-up at least 80% OR, if the response was < 80%, not selective regarding exposure (i.e. duration of computer use), potential effect modifiers (i.e. at least gender and age) and outcome (i.e. arm, shoulder and neck symptoms or disorders)?
Exposure assessment
3. Were the data on duration of computer use collected using standardised methods of acceptable quality? *
4. Were the data on ergonomic factors collected using standardised methods of acceptable quality? *
5. Were the data on psychosocial factors collected using standardised methods of acceptable quality? †
6. Were data on physical factors during leisure time collected and used in the analysis?
7. Were data on exposure change regarding the duration of computer use during the follow-up period (for example due to job change) collected and used in the analysis?
Outcome assessment
8. Were the data on outcome collected using standardised methods of acceptable quality? ‡
Data analysis
9. Was the statistical method used appropriate for the outcome studied and was a measure of association presented, including confidence intervals or p-value?
10. Was the statistical analysis tested for confounding by gender and age?
11. Was the number of subjects in the multivariate analysis at least 10 times the number of independent variables?

* ICC > 0.60 or Kappa > 0.40 for test-retest reliability or interobserver reliability. Additionally for self-reports: ICC > 0.60 or Kappa > 0.40 or r > 0.75 for agreement with observation or direct measurement.

† ICC > 0.60 or Kappa > 0.40 for test-retest reliability. Additionally for self-reports, in the case of using scales: Cronbachs alpha > 0.70 for the majority of scales used.

‡ ICC > 0.60 or Kappa > 0.40 or r > 0.75 for test-retest reliability or interobserver reliability, or if (modified) Nordic questionnaire was used [11,12,13].

2.3 Levels of evidence

In order to summarize the results of the studies, we used levels of evidence. *Strong evidence* was defined as consistent results for all tested associations, including at least two high quality studies. We anticipated that one article could present multiple associations for different case definitions and that multiple articles could present associations for the same cohort of workers. Therefore, multiple positive associations from the same cohort of workers were counted as one study.
The criterion for the consistency of the results was met if at least 75% of all tested associations for the risk factor was positive (i.e. a statistically significant risk estimate, or a risk estimate larger than 2.0 or smaller than 0.5).
Moderate evidence was defined as consistent results for all tested associations (with a minimum of three associations tested) or consistent results for at least two high quality studies, irrespective of the findings from medium quality studies for that association. *Insufficient evidence* was defined as inconsistent results for all tested associations, including the situation in which less than three associations were evaluated.

2.4 Dose-response analysis

The dose-response relationship was evaluated if at least moderate evidence was available for an increased risk of developing hand-arm or neck-shoulder symptoms or disorders. We assessed dose-response qualitatively by plotting the point estimates against the exposure categories.

3. Results

3.1 Search results

The search strategy resulted in 277 hits. Applying the selection criteria resulted in nine articles. The final set of articles was based on five cohorts of workers: 1) the BIT-study [14,15], 2) the NUDATA study [16,17,18,19], 3) Bergqvist et al. [20], 4) Marcus et al. [21], and 5) Korhonen et al. [22].

3.2 Methodological quality assessment

The kappa coefficient for the agreement between the ratings of the individual items (positive versus negative or unclear) of the two reviewers was 0.91 (disagreement on 5 out of 108 scored items). One item needed a decision of the third reviewer (AvdB); agreement on the other items was reached during the consensus meeting. Eight out of nine corresponding authors replied to our invitation to discuss the quality assessment. Based on this additional information, five unclear scores were replaced by positive scores. Six studies had a quality score exceeding 50%, see table 2.

Table 2. Results of the methodological quality assessment.

COHORT FIRST AUTHOR	STUDY DESIGN		EXPOSURE AND OUTCOME ASSESSMENT						DATA ANALYSIS			
	1. PARTICI-PATION RATE	2. RESPONSE AT FOLLOW- UP	3. DURATION COMPUTER USE	4. ERGONOMIC FACTORS	5. PSYCHOSO-CIAL FACTORS	6. PHYSICAL FACTORS	7. EXPOSURE CHANGE	8. OUTCOME	9. STATISTICAL MODEL	10. CON-FOUNDING	11.STATIS-TICAL POWER	Score * (%)
BIT												
- Jensen [14]	? †	?	?	?	?	-	+	+	+	+	+	**45**
- Juul-Kristensen [15]	?	?	?	?	?	-	+	+	+	+	+	**45**
NUDATA												
- Andersen [16]	?	+	?	?	?	+	+	+	+	+	+	**64**
- Kryger [17]	?	+	?	?	?	+	?	+	+	+	+	**55**
- Brandt [18]	?	+	?	?	?	+	?	+	+	+	+	**55**
- Lassen [19]	?	+	?	?	?	+	?	+	+	+	+	**55**
Bergqvist et al.												
- Bergqvist [20]	+	+	?	?	?	?	+	?	+	-	+	**45**
Marcus et al.												
- Marcus [21]	+	+	?	+	?	+	+	?	+	+	+	**73**
Korhonen et al.												
- Korhonen [22]	+	?	?	?	?	+	?	+	+	+	+	**55**
Positive (%)	**33**	**67**	**0**	**11**	**0**	**67**	**56**	**78**	**100**	**89**	**100**	

* the percentage of positive items over the total number of items
† + = positive, - = negative and ? = unclear (insufficient information available)

3.3 Levels of evidence

Risk estimates were generally larger for mouse use than for total computer use and keyboard use. For neck-shoulder symptoms and disorders, fewer associations were positive than for hand-arm symptoms and disorders.

For hand-arm symptoms and disorders, moderate evidence was concluded for the association with duration of mouse use, since all studies showed a positive association, including three high quality studies based on the NUDATA cohort [16,17,19]. However, these were counted as one study. For the duration of total computer use and the duration of keyboard use insufficient evidence was concluded, since inconsistent results were found. For the duration of total computer use, associations from three cohorts were available. Only the NUDATA cohort investigated the duration of keyboard use.

For neck-shoulder symptoms and disorders, insufficient evidence was concluded for the duration of mouse use and the duration of keyboard use, since inconsistent results were found. For both mouse and keyboard use only the NUDATA cohort investigated the association with neck-shoulder symptoms and disorders. For the duration of total computer use, all tested associations failed to show a positive association. Four cohorts investigated total computer use, including two high quality studies [21,22].

3.4 *Dose-response analysis*

Following the criteria set on beforehand, we analyzed the relationship between the duration of mouse use and the incidence of hand-arm symptoms. In general, an increase in risk over duration categories can be observed from figure 3.

4. Discussion

4.1 Summary of results

The results of this review of longitudinal studies confirm the finding of previous reviews. The duration of computer use was more consistently associated with hand-arm than with neck-shoulder symptoms and disorders [6,9]. In addition, our review adds to the existing literature the observation that the duration of mouse was more strongly and more consistently associated with the incidence of hand-arm symptoms than the duration of total computer use and keyboard use.

4.2 Methodological considerations

The studies included in this review all have substantial methodological quality, since they were based on longitudinal study designs and all but one scored positive on the quality items concerning data analysis. Still, the design of future studies might be improved by taking into account the methodological limitations that are still present in the published studies.

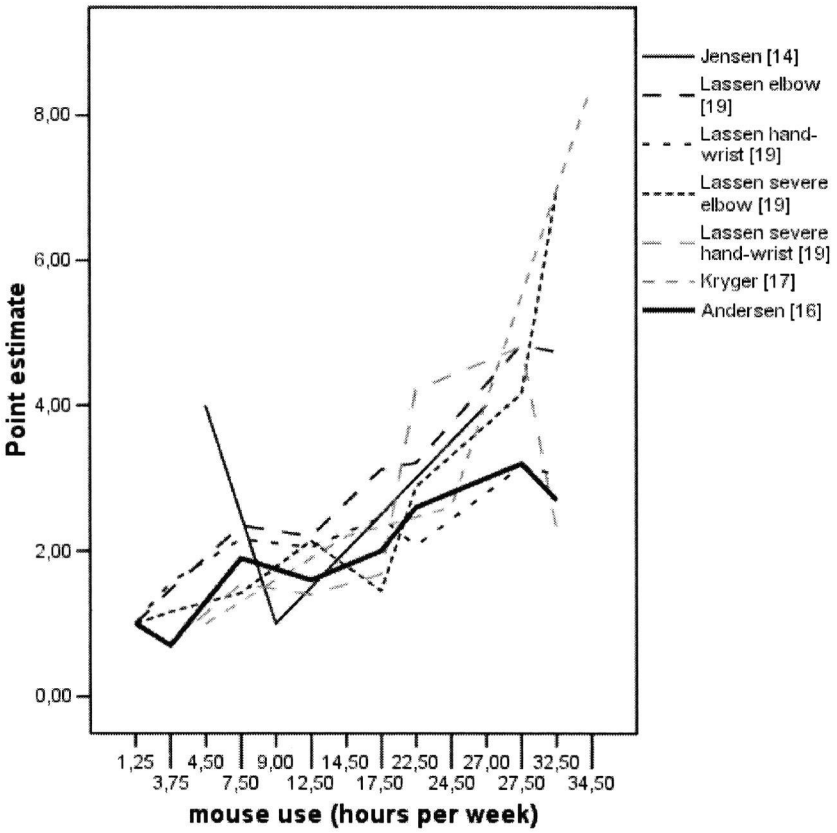

Figure 3. Point estimates for the association between the duration of mouse use and hand-arm symptoms.

Future studies should focus on measuring the duration of computer use in a more objective way. All included studies in this review measured the duration of computer use with self-reports, which might have lead to underestimation of the true association due to misclassification [23,24,25]. In addition, future studies should try to differentiate between total computer use, mouse use and keyboard use, in order to understand more about the underlying mechanism causing arm, shoulder and neck symptoms.
Finally, data on disability caused by symptoms should be collected. It is difficult to select the group of workers severely affected by arm, shoulder and neck symptoms based on self-reported symptoms only. In addition, physical examination might not have sufficient interobserver reliability [26] and information on validity is largely unknown [27]. Based on these drawbacks of currently used methods, we suggest to record disability caused by symptoms.

4.3 Sensitivity analysis

The levels of evidence proposed in this review might have been influenced by arbitrary decisions concerning the criteria used in the methodological quality assessment. However, shifting the cut-off point for the methodological quality assessment to 40 or 60% did not change our conclusion, except for the association between the duration of mouse and hand-arm symptoms. Strong evidence instead of moderate evidence would have been concluded, if the cut-off point would have been set at 60%.

4.4 Biological plausibility

The studies in this review that investigated the effects of the same exposure contrast on both the hand-arm and the neck shoulder region, generally showed stronger risk estimates for the hand-arm region than for the neck-shoulder region. Studies on muscle activity during computer use are in line with these findings, since they indicate a higher loading of the hand-arm region (extensors of the wrist) [28,29,30] and less EMG gaps in the hand-arm region [31] compared to the neck-shoulder region (trapezius muscle). In addition, in line with the findings of this review, less variation in working postures has been observed during mouse use in comparison to keyboard use [28,32], potentially leading to a longer duration of continuous muscle loading [33]. These data support a general hypothesis, which attributes a central role to the overuse of muscles and the physiological consequences of this overuse in the pathophysiological mechanism underlying arm, shoulder and neck symptoms and disorders [34]. However, caution is needed. The central role of muscles in the pathophysiological mechanism(s) underlying arm, shoulder and neck symptoms has been criticized [35].

4.5 Limitations of this review

It should be kept in mind that the evidence found in this review for and against associations, was based on a limited number of studies. This might limit the generalizability of our findings. In addition, our review focused on only one contributing factor to the incidence of hand-arm and neck-shoulder symptoms and disorders among computer users (i.e. duration of computer use). This does not represent the general concept of a multifactorial origin of musculoskeletal disorders [6,9]. However, post-hoc comparisons showed that the duration of mouse use was overall more strongly and more consistently associated with hand-arm symptoms than other factors, such as non-neutral working postures, psychosocial factors and individual factors.

4.6 Conclusion

This review showed moderate evidence for an association between the duration of mouse use and the incidence of hand-arm symptoms. Indications for a dose-response were found. In addition, the neck-shoulder region seemed less susceptible to exposure to computer use than the hand-arm region. Both findings are supported by a pathophysiological mechanism based on the overuse of muscles during computer use. Based on the results of this review, reducing the duration of mouse use might be a promising (additional) intervention to prevent hand-arm symptoms among office workers.

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