ORIGINAL ARTICLE

A comparison of methods for the assessment of postural load and duration of computer use

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Aim: To compare two different methods for assessment of postural load and duration of computer use in office workers.

Methods: The study population existed of 87 computer workers. Questionnaire data about exposure were compared with exposures measured by a standardised or objective method. Measuring true exposure to postural load consisted of an observation of the workstation design and posture by a trained observer. A software program was used to record individual computer use.

Results: Comparing the answers for each item of postural load, six of eleven items showed low agreement (kappa <0.20). For six items the sensitivity was below 50%, while for eight items the specificity was 80% or higher. Computer workers were unable to identify risk factors in their workplace and work posture. On average, computer workers overestimated their total computer use by 1.6 hours. The agreement among employees who reported a maximum of three hours of computer use per day was higher than the agreement among employees with a high duration of computer use.

Conclusions: Self-report by means of this questionnaire is not a very reliable method to measure postural load and duration of computer use. This study emphasises that the challenge to develop quick and inexpensive techniques for assessing exposure to postural load and duration of computer use is still open.

Over the past few years, impressive developments have taken place regarding information and communication technology. In addition to the positive effects of these technologies, such as an increase in efficiency and communication velocity, potential adverse effects must not be overlooked. Increase of computer work coincided with a prevalence increase of work related musculoskeletal disorders of the upper extremities (WRMSDs).[1] Employees affected by WRMSDs often experience substantial pain and functional impairment, while employers are affected by loss of productivity and disability payment. The community could be affected by increased costs in the form of higher medical expenses.[2] As the number of WRMSDs and associated costs have increased, attention has turned to the need for preventive measures.

A nationwide occupational health service in the Netherlands has developed a multidisciplinary prevention programme, which offers individual employees one or more intervention(s) based on self-reported exposure to important risk factors. A basic requirement for individually based prevention of WRMSDs is a reliable method to measure exposure to risk factors. Questionnaires offer the possibility to investigate many subjects at a reasonable cost, but may be biased. However, objective measurement strategies will give the best description of exposure, but these methods are often time consuming and too expensive to investigate large groups of employees.[3–5] For the risk factors symptom history and psychosocial factors, reliable questionnaires already exist, namely the Nordic questionnaire[6] and the Job Content Questionnaire.[7] In office workers, postural load and duration of computer use are two important risk factors of WRMSDs for which it is not clear if exposure can be assessed by means of a questionnaire. No consensus has been reached about a fast, simple, and reliable measurement strategy of postural load and duration of computer use in a population of computer workers.[5 8–11] Therefore, the aim of this study is to compare two different methods to assess postural load and duration of computer use in a population of computer workers.

METHODS

All computer workers (n = 162) of a large administrative company were invited to participate in the study. The employees worked in their function for at least two months, worked at different divisions of the company, and had a large variation in the duration of computer use.

Firstly, data were collected by a questionnaire. Secondly, within two weeks after the questionnaire a trained observer also measured postural load. Duration of computer use was objectively measured for a period of three weeks after filling out the questionnaire. Data of WRMSDs during the past 12 months were collected using a modified version of the Nordic questionnaire.[6]

Postural load

The questionnaire contained 11 questions concerning postural factors that could be answered with yes or no (see table 1). For example, employees had to indicate whether their arms were supported during typing. The selected questions are based on extensive research of Punnett and Bergqvist.[1] No pictures were added to the questions.

An observation of the workstation design and work posture by a trained observer was regarded as a method capable of measuring true exposure. First, the trained observer asked if the observed workplace was the fixed workplace of the employee. Employees without a fixed workplace were excluded from analyses. A few subjects only worked with a laptop computer. Before the observation we asked these subjects if the circumstances during both measurements were the same. If not, these subjects were excluded from the analyses. Subsequently, the employee was informed to adopt his or her usual working posture and was asked to try to ignore the observer. During the 15 minutes observation period the employee was asked to perform a representative computer task with both keyboard and mouse. The trained observer used a checklist containing the same questions as in the questionnaire. For item 7 (about mouse reaction) we first had a look at the mouse movements during the 15 minutes observation period. After this period we asked the employee if

Main messages

- Employees were unable to assess risk factors in their workplace and work posture; the absence of risk factors could be assessed satisfactorily.
- Computer workers overestimated their total duration of computer use by 1.6 hours (or by 39%).
- Computer workers who reported a maximum of three hours of computer use per day gave a better estimation of total computer use than computer workers with a longer duration of computer use.

Policy implications

- Self-report by the questions in the current questionnaire is not a very reliable method to measure postural load and duration of computer use.
- The challenge to develop quick and inexpensive techniques for assessing exposure to postural load and duration of computer use is still open.

he or she experienced problems with the mouse. In addition, to simplify the question and to gather accurate information, we asked if the mouse slides well on the desk surface and whether someone often had to repeat mouse movements before reaching the desired position. At random observations we used the mouse ourselves to experience possible problems and to check the answer of the employee. The answer on item 9 (about series of the same actions without a pause) could not be collected during the 15 minutes observation period. Therefore, we asked the employee if he or she often performed series of the same actions without a pause, such as data entry or long lasting dragging and clicking with the mouse (for example, during drawing programs). Furthermore, items 2 (about readability) and 11 (about illumination problems) were difficult to examine in only one 15 minutes observation period, and the employee was therefore also asked about them. After the observation period we asked the employee if the readability of the programs he used most of the time was good. The answer of the employee was the final answer of the observation. To assess possible illumination problems the observer took the place of the employee at the workplace. The observer also asked if there was a sunblind and if this sunblind was used and worked correctly on sunny days.

Duration of computer use

In the questionnaire, duration of computer use was subdivided into use of keyboard and mouse. In both cases computer workers had to estimate the percentage of time they used the keyboard or mouse. Because there could be a large variation in tasks between days, employees were asked to estimate a mean duration of computer use per day.

In accordance with a study by Ketola and colleagues,[12] we used Workpace recorder (Niche Software Ltd, ErgoDirect) as an objective technique to measure duration of computer use. Workpace recorder is a software program which records total use of computer as well as use of keyboard and mouse separately. During 15 working days, information on computer use was gathered for each employee. This information was converted into a mean daily duration for comparison with the questionnaire data.

Statistical analysis

Postural load was compared question by question. The kappa coefficient with 95% confidence interval was calculated as measures of agreement corrected for chance.[13 14] Because the kappa coefficient is not a reliable method when there are only a few observations in one category, the results of some items must be interpreted carefully. Besides the kappa coefficient, sensitivity and specificity were calculated as measures of agreement and usefulness. Duration of computer use was compared on a continuous scale. We focused on total duration of computer use, but comparisons were also made between the duration of keyboard and mouse use separately. The Spearman rank order correlation coefficient was computed to determine correlation between the two methods. A paired *t* test was used to determine if the mean duration of self-reported computer use was different from the mean duration given by Workpace recorder. Subanalyses were made for computer workers with and without WRMSDs.[15]

RESULTS

From a total of 162 sent questionnaires, 98 were returned (response rate of 60%). The response was equally distributed over the divisions. Due to practical limitations (for example, working outside the main office or out of the office during the measurement period), 11 respondents could not be included in the objective measurements, leaving 87 employees for analyses of postural load. Due to technical problems with the installation of Workpace recorder, data from 17 employees could not be collected. As a result, 70 employees were included in the analyses of duration of computer use.

Table 1 Comparison of the answers from the questionnaire and the standardised measurement for each item of postural load

Question	Kappa (95% CI)	Sensitivity (%)	Specificity (%)
1. Do you have to look up, down, or aside to look at your screen during computer work?	−0.06 (−0.28 to 0.15)	13	81
2. Is the readability poor because of too small letters, bad colours, or too little contrast?*	0.12 (−0.18 to 0.43)†	18	92
3. Do you usually sit right in front of your keyboard?	0.21 (−0.16 to 0.59)†	43	87
4. Do you usually support your forearms during typing?	0.28 (0.07 to 0.49)	59	69
5. Is the angle of your elbow about 90° during typing?	0.23 (−0.03 to 0.50)†	64	73
6. Do you bend your hands backwards during typing?	0.07 (−0.15 to 0.29)	48	59
7. Does the mouse react well on your movements?*	0.36 (0.10 to 0.62)†	50	86
8. Do you usually use your mouse with a stretched arm?	0.13 (−0.09 to 0.36)	32	80
9. Do you often perform series of the same actions without a pause?*	0.58 (0.40 to 0.76)	78	80
10. Is your chair adjusted in order to put your feet right in front of you with your knees in an angle of 90°?	0.07 (−0.34 to 0.48)†	50	81
11. Do you have problems with the illumination or reflection on your workplace?*	0.08 (−0.23 to 0.40)†	27	82

*This question was also asked to the employees.
†These kappas must be carefully interpreted, because the answers were not equally distributed among the answer categories.

About half of the population were women (52%) and the mean age of the population was 36 years. In the 12 months preceding the questionnaire, 51% of the study population experienced regular or long lasting work related symptoms in the neck, upper back, or upper extremities.

Postural factors

According to the standardised measurements, 32% of all participating computer workers experienced at least four risk factors for postural load. Most frequent risk factors were mouse use with a stretched arm (45%), no support of forearms during typing (41%), hands bend backwards during typing (39%), and illumination problems (39%).

Comparing the answers from the questionnaire and the standardised method for each item of postural load, six of eleven items showed low agreement (kappa <0.20, see table 1). For six items the sensitivity was below 50%. For example, employees who looked up, down, or aside at their screen during computer work hardly ever indicated this themselves (sensitivity = 13%). On the other hand, for eight items the specificity was 80% or higher. For example, employees who did not use their mouse with a stretched arm, almost always indicated this themselves (specificity = 80%). In general, there was no difference in kappa, sensitivity, or specificity between computer workers with and without WRMSDs (results not presented). However, due to small numbers within some answer categories, this result must be interpreted carefully. Apparently, computer workers were unable to assess risk factors in their workplace and work posture; the absence of risk factors could be assessed satisfactorily.

Duration of computer use

According to the measurements by Workpace recorder, the mean total duration of computer use was 2.5 hours per day (standard deviation = 1.1). Mean duration of keyboard use was 0.6 hours per day (standard deviation = 0.3) and mean duration of mouse use was 1.1 hours per day (standard deviation = 0.5). On average, computer workers overestimated their total duration of computer use by 1.6 hours; in other words, 39% overestimation or a 1.6-fold overestimation (see table 2). Duration of keyboard use was overestimated by 1.9 hours (75%; 4.2-fold) and duration of mouse use by 0.5 hours (31%; 1.5-fold). All the overestimations were statistically significant. Figure 1 shows a scatter plot of mean total duration of computer use according to information from Workpace recorder and the questionnaire. The correlation between both methods was statistically significant ($r_s = 0.46$, $p < 0.01$). Although the majority of the employees overestimated their computer use, there were also employees who correctly estimated or underestimated their computer use.

We also performed analyses for certain groups of employees (see table 2). Employees who reported a maximum of three hours of computer use per day according to the questionnaire overestimated their total duration of computer use by 0.4 hours (19%; 1.2-fold); employees with more than three hours of computer use per day overestimated by 2.0 hours (43%; 1.7-fold). Employees with WRMSDs overestimated their total duration of computer use by 1.8 hours (41%; 1.7-fold); employees without WRMSDs overestimated their computer use by 1.5 hours (38%; 1.6-fold). The correlation between both methods was $r_s = 0.71$ ($p < 0.01$) for employees with a maximum of three hours of computer use per day, and $r_s = 0.16$ ($p > 0.05$) for employees with more than three hours of computer use per day. For employees with WRMSDs, this correlation was $r_s = 0.34$ ($p < 0.05$); for employees without WRMSDs this correlation was $r_s = 0.51$ ($p < 0.01$).

DISCUSSION

We compared two different methods for the assessment of postural load and duration of computer use in a population of computer workers. Postural load and duration of computer use are two important risk factors for WRMSDs in computer workers.

Half of the study population experienced regular or long lasting work related symptoms in the neck, upper back, or upper extremities during the past year. This percentage is considerably higher than the 24% in administrative occupations in the Netherlands, reported earlier by Blatter and colleagues.[16] This could partly be explained by the fact that the current study also included symptoms of the upper back. Selection bias could be another reason if computer users without symptoms were less likely to participate.

In cross-sectional studies the perception of symptoms can bias the self-assessment of risk factors because employees with pain might learn to do their jobs in a way that minimises postural load in order to alleviate symptoms or to avoid their aggravation. In addition, subjects with pain are more sensitive to tasks with high postural load.[17 18] Since outcome may have an influence on the agreement, prevalence of complaints has an influence on the overall agreement among the total study population.[15] We performed some subanalyses for computer workers with and without WRMSDs.

Postural factors

Li and Buckle[19] indicated that there is a wide variety of methods to assess physical workload. Each method has its own strengths and limitations that should be taken into consideration. Ultimately, the method or methods of choice should be selected based on the study objectives, resources, setting, and limitations. If questionnaires are reliable enough to assess postural load in computer workers, this measurement technique has a lot of advantages over standardised techniques.

Comparing the answers from the questionnaire and the trained observer for each item of postural load, six of eleven items showed low agreement. Employees were unable to assess risk factors in their workplace and work posture; the absence of risk factors could be assessed satisfactorily. There was no difference between employees with and without WRMSDs. As mentioned in the methods section, "true" levels for items 2, 7, 9, and 11 were obtained by a combination of direct observation and information from the employee. Because the opinion of the employee influenced the score, the sensitivity and specificity of these items could be higher because of this influence. This should be kept in mind when interpreting table 1. The inability to observe these items directly is a limitation of the 15 minutes observation period. We do not have qualitative information on how persons interpret the definitions of terms used in the 11 items; for example, how much movement of the head in relation to trunk is meant when one "looks up" (item 1). There is not enough evidence on exact angles for specific factors to become a risk factor. The questions we used are often used in comparable questionnaires. Karlqvist and colleagues[10] also reported poor reliability for self-reports of elbow height, while self-reports of the locations of keyboard and mouse showed high reliability. Jakobsson[14] and Wiktorin and colleagues[18] also concluded that employees were not able to rate their own physical load, while Dane and colleagues[9] and Viikari-Juntura and colleagues[4] reported the opposite. Apparently, there is still no consensus about the reliability of questionnaire data to assess postural load.

One might question the appropriateness of the observation technique as a reference. The observation consisted of one sample of 15 minutes for each employee, while postures may

Table 2 Duration of total computer use and difference between questionnaire data and information of Workpace recorder for different groups of employees

	Mean hours wp (1)	Mean hours quest (2)	Mean difference (h) (3)	Mean difference (%) (4)	Mean difference (ratio) (5)
Total population computer workers (n = 70)	2.5	4.1	1.6	39	1.6
Employees who reported maximum 3 hours of computer use per day according to the questionnaire (n = 16)	1.7	2.1	0.4	19	1.2
Employees who reported >3 hours of computer use per day according to the questionnaire (n = 54)	2.7	4.7	2.0	43	1.7
Employees with WRMSDs* (n = 35)	2.6	4.4	1.8	41	1.7
Employees without WRMSDs* (n = 32)	2.4	3.9	1.5	38	1.6

*Work related musculoskeletal disorders of upper extremities.
(1) Mean duration of total computer use in hours according to Workpace recorder.
(2) Mean duration of total computer use in hours according to the questionnaire.
(3) Mean difference in hours [(2)−(1)].
(4) Mean difference as percentage of total estimated time [(3)/(2) × 100%].
(5) Mean difference as ratio of questionnaire estimation/Workpace information [(2)/(1)].

vary over time. Longer or repeated observations could have enhanced the agreement between the observation and the subjective method on an individual level.[17] In general, recording procedures may be biased by the arrival of the observer at the workstation. It has been suggested that such bias may be reduced through the use of video cameras with later analysis. However, this is a very time consuming measurement strategy. Since longer or repeated observations are time consuming and expensive, many employees were involved, and the variability in postures was probably relatively small, we decided to perform one measurement of 15 minutes for each employee. Another discussion point is the possibility of intra- and inter-observer variability.[19] We tried to minimise this variability by training the two observers. As a test, the two observers observed the same 10 employees for a couple of days. Intra- and inter-observer variability was acceptable.

In conclusion, some studies have shown that the self-report approach has too low validity and reliability. Apparently, it is difficult to design questions that are easily understood, do not lead the subject to a specific response, and require clear responses. One possibility to improve the current questionnaire is to objectify the questions; for example, by adding pictures to the questions.

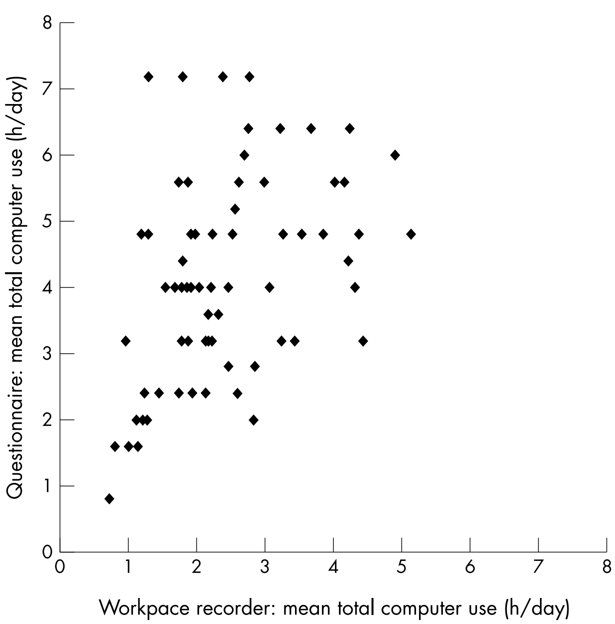

Figure 1 Scatter plot of mean total duration of computer use according to information from Workpace recorder and the questionnaire.

Duration of computer use

The questionnaire considered keyboard use and mouse use as separate risk factors. It should be kept in mind however, that total computer use is important for the occurrence of symptoms.[11] To be able to make a comparison between questionnaire data and data from Workpace recorder, the objective method firstly considered keyboard use and mouse use as separate risk factors. Subsequently, we analysed total computer use, by changing the algorithm of the questionnaire. Most employees seemed to overestimate their computer use, in accordance with other studies.[5 11 20 21] Previous studies have shown that employees are able to estimate their risk at a dichotomous level, but that estimations about duration and frequency are not reliable.[4 18]

One possibility to improve the current questionnaire is to ask for total computer use additional to keyboard and mouse use separately, because for employees it is probably easier to estimate total computer use. Besides, it is easier to estimate duration of computer use in real hours than as a percentage of working time as in the current questionnaire. Homan and Armstrong[5] performed a pilot test before the actual evaluation of measurement strategies. Based on this pilot, the wording of the questions was changed so that the worker estimated the number of hours (to the nearest half hour) rather than the percentage of time spent performing each task. To improve the current questionnaire we suggest asking for real hours instead of percentage of the working time.

Although Homan and Armstrong[5] found that computer workers with many hours of computer use per day (according to task definitions) gave a better estimation than computer workers with only a few hours of computer use per day, results from our study and from Douwes and colleagues[20] indicated the opposite. Homan and Armstrong[5] mentioned that their results are not surprising because it is theoretically impossible for employees with many hours of computer use to overestimate, because they work limited hours per day. As a result, employees with many hours of computer use per day have a smaller time period from which to overestimate. Our results showed that employees with only a few hours of computer use per day (according to the questionnaire) give a better estimation. Our explanation is that these employees are better aware of their actual computer use, because their computer tasks are limited and they know their time spent on other tasks. In our opinion, both explanations could be true and further research will probably give the final answer.

One might question the appropriateness of Workpace recorder as a reference technique. We additionally compared data from Workpace recorder with data from real time observations (registration of all activities) of five employees for half a day. The results of this ''quick scan'' are not presented but showed that Workpace recorder is reliable enough to be used as a objective method in this study. Our findings are confirmed by a study of Douwes and colleagues.[20] In this study the authors also compared data of Workpace recorder from 99 employees with data from real time observations. They concluded that Workpace recorder overestimates computer use only slightly, but within an acceptable range.

It is generally assumed that an increasing duration of computer use is associated with an increasing risk of WRMSDs.[1 8 22] However, because subjective methods are used to measure exposure and reliable data defining a dose-response relation are missing, until now no consensus has been reached about the maximum number of hours that an employee may use a computer on a daily basis.[5 11] For effective preventive measures, detailed information on quantitative dose-response relations is needed through further research.[4 5 21] Kryger and colleagues[23] indicated that preventive actions should include efforts to reduce weekly usage of mouse devise and keyboard to less than 20–25 hours.

Overall, a number of computer workers were unable to identify harmful factors in their workplace or work posture and as a consequence not all employees with a real high risk would be identified. On the other hand, the absence of risk factors could be assessed satisfactorily and due to this, unnecessary intervention and costs could be prevented. Most computer workers overestimated their total computer use. Considerable misclassification on both risk factors is inevitable when data from the current questionnaire are used to assign exposure categories for the determination of intervention. An improved questionnaire would identify more employees with harmful factors in their workplace or work posture and less employees with a high risk due to duration of total computer use. Effective individually based intervention will reduce the exposure to these risk factors and thereby minimise the risk for WRMSDs.

Further studies on reliability of questionnaire data and dose-response relations are necessary for implementation of effective preventive measures. This study underlines the statement made by several scientists that the challenge to develop quick and inexpensive techniques for assessing exposure to postural load and duration of computer use is still open.[5 21]

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