Test-retest reliability and intermethod agreement of a web-based questionnaire on work postures and workstation characteristics

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Abstract

Questionnaires are widely used to assess for non-neutral work postures in order to prevent upper extremity disorders among office workers. From previous research we know that the agreement between questionnaires and objective measurements for assessing work postures and workstation characteristics among office workers is low. One of the recommendations of previous research was to add pictures to increase clarity. Hence, we developed a web-based questionnaire in which pictures were added. Questionnaire items concerned both work postures and workstation characteristics.

We investigated test-retest reliability and agreement with observations and measurements with a manual goniometer. The study population consisted of 84 office workers of a research department.
Questionnaire items regarding workstation characteristics showed sufficient test-retest reliability and agreement with observation. Questions regarding work postures showed poor agreement with the observations. None of the questions showed good agreement with the manual goniometer measurements.

The conclusion of this study is that our questionnaire cannot validly measure work postures, despite the added pictures. Efforts should be directed to objective measurements if one wants to validly measure work postures among office workers.

Keywords: methods, epidemiology, questionnaire, work postures, validity

1. Introduction

Questionnaires are widely used to assess for non-neutral work postures in order to prevent arm, shoulder and neck symptoms among office workers. Items on work postures and workstation characteristics are frequently included. In the literature, it has been pointed out that observations or direct measurements should be used to assess work postures [1]. The main reason for this is that questionnaires often lack precision [i.e. large differences can be detected, whereas small differences cannot]. If the precision is low, it is difficult to identify the group of workers who could benefit from changes in work postures. The reasons that more sophisticated measurements, such as observation or direct measurements, are not used (in the workplace) include high costs and inapplicability in large groups of workers. Therefore, the search for useful questionnaires is still on.

Recently, Heinrich and co-workers [2] determined the agreement between a questionnaire and observation by a trained observer in a population of computer users. They concluded that the questionnaire was not valid to assess work postures. One of their recommendations was to add pictures to the questionnaire to increase validity.
Based on these recommendations, we constructed a new questionnaire with pictures added to the items. The objectives of this study were to evaluate the test-retest reliability of the questionnaire and its

agreement with observations and manual goniometer measurements.

2. Methods

2.1 Design

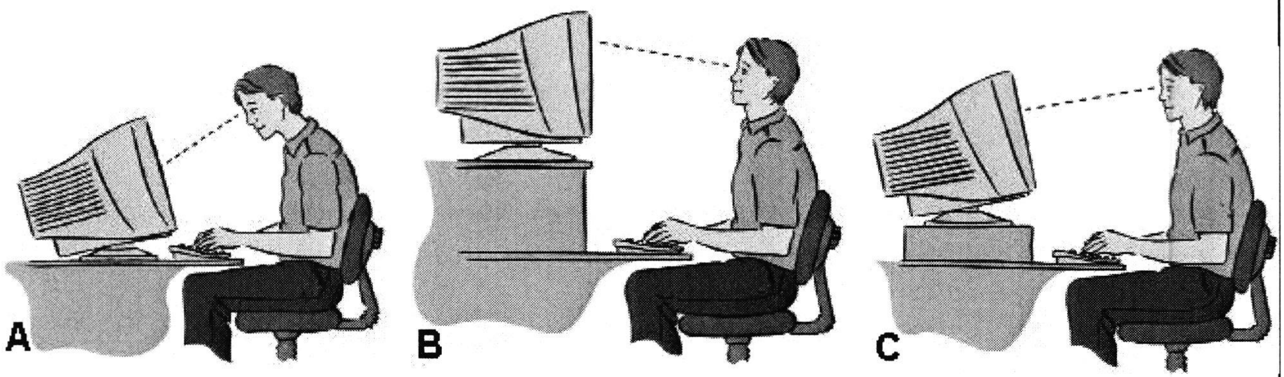
Employees of a research department of a university medical centre in the Netherlands filled out a web-based questionnaire on work postures and workstation characteristics twice with an intervening period of two weeks. After filling out the first questionnaire, the same items as in the questionnaire were observed by an observer. For a subgroup of workers, additional measurements of work postures with a manual goniometer were performed.

2.2 Questionnaire

The questionnaire contained 28 items on work postures during computer use and workstation characteristics. An example is presented in figure 1. Pictures were added where possible to provide visible guidance. In total, 16 items were supported with a picture. The participants were invited by e-mail to fill out a web-based questionnaire. The e-mail contained a link that guided participants to the webpage with the questionnaire.

2.3 Observation

The participants who approved additional observations were divided into two groups. Two observers performed the observations, one for each group. The observer used a checklist containing the same items and response categories as the questionnaire. The observer asked the employee to adopt his or her usual work posture and to try to ignore the observer. After the observation the observer measured the distance from table edge to the keyboard edge with a centimetre.



Please indicate your monitor height. Please remain seated as usual, do not sit upright if you usually do not sit upright.
- Lower than eye height (see picture a)
- Higher than eye height (see picture b)
- At eye height or a little lower (see picture c)

Figure 1. Questionnaire item with added picture

2.4 Manual goniometer measurements

Measurements of postural angles with the manual goniometer were used to assess seven postural angles on six occasions. Participants were measured twice on three different days, once in the morning and once in the afternoon. Both raters in this study were students who were trained to measure postural angles with a manual goniometer during four training sessions. Before, during and after the measurements, interrater reliability was evaluated.

Measurement methods were mainly based on those applied by Ortiz and co-workers [3]. Postural angles of the wrist (radial and ulnar deviation, extension and flexion), elbow (flexion), shoulder (abduction and flexion) and head (tilt) were measured.. Measurements were performed with inexpensive commercially available manual goniometers (Bodybow-Holland, The Netherlands). A 30-centimetre goniometer was used for measurements of elbow, shoulder and head tilt angle, and a 15-centimetre goniometer was used for measurements of wrist angles. In order to allow measurements relative to the true vertical, the 30-centimetre goniometer was modified by adding a carpenter's level to one of its arms.

Each employee was approached unexpectedly while he or she worked at his/her workstation. The rater asked the employee to freeze until all angles were measured. The rater registered the measured angles and the type of computer use the employee was performing (mouse use or keyboard use).

The angles were only measured at the side of the body where the mouse was placed. This choice was based on the results of Gerr and co-workers [4], who showed minor differences between measurement on the left and the right side of the body. Measurements took 5 minutes at maximum on each occasion.

2.5 Statistical analysis

For test-retest reliability and the agreement with observation, the original categories of the questionnaire items were used. For the agreement with manual goniometer measurements, the questionnaire items and the goniometer measurements were dichotomized. See for more details appendix A and B, and table 1.

3. Results

In total 84 employees participated in the study. All filled out the first questionnaire and 81 employees (96%) also filled out the second questionnaire. The average time between the questionnaires was 16 days (range 6-35 days). In total, 70% of the study population was female and the mean age was 36 years (range 24-61 years). In the 3 months preceding the questionnaire, 26% of the study population experienced regular or long-lasting arm, shoulder or neck symptoms.

In total 38 participants (45% of the study population) were observed and measured. This selection of participants was representative for the study population, regarding to the time between the questionnaires, gender, age, and symptoms.

All items concerning workstation characteristics showed sufficient test-retest reliability. In addition, only one item on work postures had sufficient test-retest reliability: mouse movement (i.e. moving the mouse by moving the wrist only compared to moving the whole arm). Six items showed sufficient agreement with observation. All these items concerned workstation characteristics. None of the questionnaire items showed a combination of sufficient test-retest reliability, sufficient agreement with observation and sufficient agreement with manual goniometer measurements.

4. Discussion

4.2 Comparison to previous studies

Karlqvist [6] showed sufficient test-retest reliability for mouse and monitor location and not for elbow height relative to keyboard height, which is consistent with our findings. However, Karlqvist [6] showed insufficient agreement (if our definition of sufficient agreement is applied) with objective measurements, whereas we found sufficient agreement for keyboard location. This difference can be explained by the fact that we only asked for the distance between table edge and keyboard and not for precise coordinates of keyboard placement on the desk, which Karlqvist [6] did.

Compared to the results of Heinrich and co-workers [2], we see that our items had overall higher agreement with observations. This suggests that questionnaire items with pictures seems more accurate than items without pictures. However, all our items still lacked sufficient agreement with measurement of postural angles, as has been shown previously by others [5].

Finally, the low agreement between workstation characteristics and work postures measured with a manual goniometer are in line with the results of a study by Gerr and co-workers [3].

4.3 Contributing factors to low agreement

There are several contributing factors to the observed low agreement between self-reported work postures and measured postural angles with a manual goniometer. First, office workers cannot self-observe their work postures, whereas someone else can. It follows that workers' estimates show poor validity. In contrast, workstation characteristics can be observed by the office workers themselves, resulting in sufficient validity. Second, it is possible that intra- and interrater reliability of the measurement with the manual goniometer were not sufficient. The raters we used in this study were inexperienced students who were trained in measuring postural angles for this study. For wrist ulnar deviation and wrist extension the percentage agreement was less than 80%.

Table 1. Overview of test-retest reliability, agreement with observation, and agreement with postural angles measured with the manual goniometer for each questionnaire item. In the last column the angle (measured with the manual goniometer) which was compared to the questionnaire item can be found.

Questionnaire item	*Test-retest*	*Observation*	*Measurements*	*Angle*
Workstation characteristics				
Distance keyboard to table edge	+	+	-	Shoulder flexion
Keyboard tilt	+	+	-	Wrist extension
Keyboard type	+	+	-	Ulnar deviation
Mouse type	+	+	-	Ulnar deviation
Mouse handedness	+	+	-	Shoulder abduction
Monitor location	+	+	a	
Chair height	+	+	a	
Characteristics of the mouse:				
- Ball	+	+	a	
- Light	+	+	a	
- Wireless	+	+	a	
- Scroll wheel	+	+	a	
Use of document holder	+	+	b	
Monitor height	+	-	-	Head tilt
Touch-typing	+	-	-	Head tilt
Number of fingers used for typing	+	-	-	Head tilt
Mouse location	+	-	-	Shoulder abduction
Work comfort	+	a	a	
Work postures				
Mouse movement	+	-	-	Ulnar deviation
Elbow height	-	a	-	Elbow flexion
Neck rotation	-	a	a	
Sitting posture	-	a	a	
Reason forward chin movement while looking at the monitor:				
- Concentration	-	a	a	
- Letters are too small	-	a	a	
- Usual posture	-	a	a	
Support of elbow during typing	-	a	a	
Support of wrist and forearm during typing	-	a	a	
Support of elbow during mouse use	-	a	a	
Support of wrist and forearm during mouse use	-	a	a	

+ = kappa > 0.6 or percentage agreement > 80%
- = kappa < 0.6 and percentage agreement < 80%
[a] no comparable measurement available
[b] situation not observed

This low interrater reliability could have influenced our results. However, the mean postural angles for wrist ulnar deviation and wrist extension were similar to the angles measured by Gerr et al. [3] and Ortiz et al. [2]. Another study reported similar mean angles for wrist extension, but larger mean angles for wrist ulnar deviation among office workers [7]. As a consequence, the agreement for the questionnaire items 'mouse movement' and 'mouse type' might have been underestimated.

Third, it is possible that the first questionnaire made participants aware of their work postures, leading to changes and different responses to the first questionnaire. However, exclusion of the participants who reported to have changed their work postures in the period between the first and second questionnaire, did not change our results. We cannot rule out this potential awareness effect, but we think it might at most explain a small part of the low agreement.

Finally, it is possible that the questionnaire items can be linked to differences in average work postures, but that these differences in average work postures are obscured due to the dichotomization of the measured angles.

4.5 Conclusion

A questionnaire with added pictures can validly assess workstation characteristics. However, the questionnaire cannot assess work postures validly.

If an ergonomist uses questionnaires to select office workers with high exposure to non-neutral work postures for a prevention program, the group of workers with actual high exposure to non-neutral work postures cannot be identified poperly. Based on questionnaire responses, a considerable group of workers without high exposure to non-neutral work postures will be included (false positive cases). At the same time, a considerable group of workers with high exposure to non-neutral postures will *not* be included (false negative cases). It should be noted that if questionnaires are used to select departments (within an organization) with the largest exposure non-neutral work postures (in order to efficiently distribute resources), self-reports might be valid. However, within the selected department a considerable group of workers without high exposure to non-neutral workers will be identified. Moreover, a considerable group of workers from other departments, who actually are exposed to non-neutral work postures will *not* receive the prevention program.

For research, using a questionnaire to measure work postures, will lead to considerable (nondifferential) misclassification, resulting in an underestimation of the true association between work postures and arm, shoulder and neck symptoms. Efforts should be directed to objective measurements if one wants to validly measure work postures among office workers.

Appendices

Appendix A. Definition of non-neutral angles. The opposite angles are neutral.

Postural angle	*Non-neutral category (degrees)*	*Reference*
Wrist ulnar deviation	>10	[8]
Wrist radial deviation	>5	[8,9]
Wrist extension	>15	[8]
Elbow flexion	<121	[9]
Shoulder flexion	>25	[4]
Shoulder abduction	>15	[4]
Head tilt	>3	[9]

Appendix B. Definition of risk categories based on questionnaire categories.

Questionnaire item	*No risk*	*Risk*
Monitor height	Lower or at eye height	Higher than eye height
Use of document holder	Use of a document holder	No use of a document holder
Elbow height	Keyboard lower or at same height as elbow	Keyboard higher than elbow
Distance keyboard to table edge	Less than 10 centimetres	More than 10 centimetres
Keyboard tilt	No tilt	Tilted (keyboard pins folded out)
Keyboard type	Split keyboard	All other keyboards
Touch-typing	Touch-typing (only looking at monitor while typing)	Not touch-typing
Number of fingers used for typing	Ten	One to nine
Mouse type	Track-ball	All other mouse types
Mouse handedness	Left	Right
Mouse movement	Arm movement	Wrist movement and arm movement or wrist movement
Mouse location	Right next to the keyboard	Not right next to the keyboard

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