DEVELOPING AN INSTRUMENT TO MEASURE KEYBOARDING STYLE: OBTAINING CONTENT VALIDITY

Nancy A. Baker
School of Health and Rehabilitation Sciences

Mark S. Redfern
Department of Bioengineering

University of Pittsburgh
Pittsburgh, PA

ABSTRACT

There is no observational instrument that can be used to document hand and finger use during computer keyboarding that may put a user at risk for musculoskeletal disorders of the upper extremity (MSD-UE). This paper describes a method used to obtain content validity for a new observational instrument, the PeCKS (Evaluation of Personal Computer Keyboarding Style), which can be used to document and assess these parameters of keyboarding style. Parameters of keyboarding style that might be risk factors for MSD-UE were developed through a review of the literature and interviews with MSD-UE experts. From these parameters a beta-1 version of the PeCKS was created and sent to seven experts to rate the content. Intraclass correlation coefficients were calculated to establish the agreement between raters concerning each parameter's importance as a risk factor for MSD-UE. There was good agreement among the raters about the importance of each parameter in the PeCKS (beta-1) and for the overall instrument. The instrument was subsequently modified and refined based on the experts' feedback.

INTRODUCTION

Computer keyboard use is considered to be a significant risk factor for musculoskeletal disorders of the upper extremity (MSD-UE). Approximately 18% of all work-related MSD in 2001 could be attributed to keyboard use (Bureau of Labor Statistics, 2003), and repetitive motion, including typing, resulted in the longest absences from work (Bureau of Labor Statistics, 2002). With the rising incidence of computer use both at home and work (U.S. Bureau of Labor Statistics, 2002; U.S. Census Bureau, 2001), understanding the association between computer use and MSD-UE is becoming increasingly important. Studies examining the relationship between MSD-UE and the kinematics of computer keyboard users have focused almost exclusively on the neck, arm, and wrist. There are few studies that describe typical hand and finger use during keyboarding (Sommerich, Marras, & Parnianpour, 1996), and only one study that attempts to identify which finger and hand postures may be associated with MSD-UE (Pascarelli & Kella, 1993).

Keyboarding style. Upper extremity postures and actions during keyboarding can be referred to as keyboarding style. Keyboarding style is defined based upon the definition of a workstyle from Feuerstein (1996) as an individualized and often stereotypical pattern of behaviors that occur while a worker is performing a specific job task. Keyboarding style is dictated both by the worker's individual strengths and limitations and the context of the computer workstation. Since the context of the computer workstation defines and constrains movement, and there are many commonalities between each computer workstation's context (e.g. the keyboard, monitor, chair, etc.), it is possible to identify aspects of keyboarding style that can be generalized between computer keyboarders.

Although the effect of workstyle on MSD-UE has rarely been examined in the literature, the few studies that have looked at workstyle have reported an association between "risky" workstyles and MSD-UE (Armstrong & Chaffin, 1979; Feuerstein & Fitzgerald, 1992; Kilbom & Persson, 1987; Pascarelli & Kella, 1993). Therefore, a valid instrument that can reliably measure the parameters of computer keyboarding workstyle could prove to be a useful tool.

While there are several observational methods presently available to evaluate the workstyles of the body and arm during a work task (Keyserling, Stetson, Silverstein, & Brouwer, 1993; Latko et al., 1997; McAtamney & Corlett, 1993; Moore & Garg, 1995), and several that focus on computer work specifically (James, Harburn, & Kramer, 1997; Lueder, 1996), there is no criterion based observational assessment tool available that can be used to document the workstyles of the hands and fingers during computer keyboarding. An instrument is needed that can be used to document and assess these parameters of keyboarding style for both clinical and research purposes.

Instrument validity. Instruments must be valid. Validity is "the extent to which an instrument measures what it is intended to measure." (Portney & Watkins, 2000). While there are several types of validity that can be determined depending upon what the instrument will be used for (Gandek & Ware, 1998; Portney & Watkins, 2000), one of the most basic types is content validity "the extent to which a measure or questionnaire represents the universe of concepts or domains" (Gandek & Ware, 1998, p. 953). Content validity is usually established by reviewing current literature, developing an extensive list of possible content, and then having experts in the field review the list and provide critical evaluation of that content.

The aim of this paper is to describe the method used to obtain content validity for a new instrument that is being developed to measure keyboarding style, namely the Evaluation of Personal Computer Keyboarding Style (PeCKS).

METHOD

The PeCKS is an observational instrument, that, when finished, can be used in the field by clinicians and researchers to quickly document and assess parameters of keyboarding style that could be risk factors for MSD-UE. The basic design of the PeCKS is similar to that of other observational work assessment tools such as the RULA or the Strain Index (McAtamney & Corlett, 1993; Moore & Garg, 1995): users observe a worker keyboarding and then select the option for each parameter that most closely describes what the worker is doing.

To identify and develop parameters that are potential risk factors for MSD-UE, we reviewed literature on the theories of the development of MSD-UE and risk factors associated with MSD-UE. In addition to searching the literature, we held discussions with experts in MSD-UE to identify what parameters might be appropriate for inclusion in the instrument.

Risk factors that could be related to keyboarding styles were identified both in clinical and lab research. There are many theories as to the pathomechanism of MSD-UE (Moore, 2002), however, the literature suggests three main areas into which the risk factors fall: posture, duration, and force or tension. We therefore focused on those areas while developing the parameters used on the PeCKS. The beta-1 version of the PeCKS described in this study included three types of parameters: a) parameters that described static body postures; b) parameters that described the frequency of wrist, hand, and finger postures; c) parameters that described tension and force. Table 1 lists the parameters included in the PeCKS (beta-1)

After possible parameters of the PeCKS were identified a beta-1 version of the PeCKS was created. This consisted of operationalizing each parameter and developing a criterion based rating scale for each parameter. The PeCKS (beta-1) version had 21 parameters.

Although the PeCKS (beta-1) had parameters that had been identified through literature review and expert discussion, the instrument required expert validation of the PeCKS (beta-1) parameters. To this end we used the Delphi Technique to develop expert consensus about each of the parameters. The Delphi technique was developed primarily as a method to obtain group consensus in political or emotional contexts, but it also works well when obtaining consensus of individuals who are not in close proximity, as in this case (Cline, 2000; Verhagen et al., 1998). In the Delphi technique, a criterion list of items is selected and disseminated to a panel of experts. A rating system is included with the criterion list, and each member of the panel is asked to rate each criteria using this system. The scores are tabulated, and the means and standard deviations for each criteria item are calculated. Items are kept or discarded based on these mean scores.

A copy of the PeCKS (beta-1), with a rationale and operationalization for each parameter, was sent to seven experts to rate the instrument for content validity. Experts fell into two categories; clinical and theoretical: clinical experts were certified hand therapists who had treated clients with MSD-UE related to computer use, and theoretical experts were bioengineers or researchers whose field of specialty was MSD-UE, and in all but one case, MSD-UE related to computer use. Three experts were hand therapists, and four, theoretical. Each expert was instructed to rate each PeCKS (beta-1) parameter on a scale of 0 to 3 in two areas: 1) the degree the parameter was a risk factor for MSD-UE and 2) the degree that the rationale for the parameter had a sound biomechanical or epidemiological basis. The raters were also asked to give any feedback about the parameters that they felt was pertinent to further improve the content of the PeCKS instrument.

Results

Means and standard deviations were calculated for the ratings of each parameter for each of the two areas. Intraclass correlation coefficients (ICC's) (Shrout & Fleiss, 1979) were calculated for the ratings of each separate parameter's risk factor and rationale combined to establish the agreement between raters concerning that parameter's importance as a risk factor for MSD-UE. One ICC for all the ratings for the parameters' risk factors and rationales combined was calculated to assess the overall content validity of the instrument. A Cronbach's alpha was calculated using the ratings of all the parameters' to determine the internal consistency of those ratings (Portney & Watkins, 2000).

Table 1: Parameters, means, standard deviations, and interclass correlation coefficients (ICC's) for experts' ratings of the risk factors and rationale for each parameter on the PeCKS (beta-1)

PeCKS (beta-1) parameter	risk factor Mean (SD)	rationale Mean (SD)	rationale/ risk factor ICC
Parameters of static body posture			
1. Shoulder tension	2.33 (0.82)	2.33 (0.45)	0.82
2. Shoulder angle	2.17 (0.41)	2.17 (0.41)	1.00
3. Elbow angle	2.17 (0.98)	2.33 (0.82)	0.95
4. **Hand position symmetry**	0.83 (0.75)	1.33 (0.52)	0.28
5. Wrist rest use	1.50 (0.84)	1.50 (0.84)	1.00
Parameters of frequency of wrist, hand, and finger postures			
6. Hand movement	1.60 (0.55)	1.40 (0.55)	0.80
7. **Continuity of typing**	0.20 (0.45)	0.20 (0.45)	-0.67
8. **# of fingers used to type**	0.50 (1.00)	0.50 (1.00)	1.00
9. **Space bar activation**	0.80 (0.45)	1.00 (0.00)	*
10. Wrist ulnar angle	2.83 (0.41)	2.67 (0.52)	0.76
11. Wrist extension angle	2.00 (0.89)	2.17 (0.98)	0.95
12. Changes in ulnar angle	2.17 (0.98)	2.50 (0.55)	0.88
13. **Changes in radial angle**	1.00 (0.63)	0.80 (0.45)	1.00
14. Changes in pronation	1.20 (0.84)	1.00 (1.00)	0.94
15. Finger postures	1.80 (0.84)	2.00 (1.00)	0.94
16. "Bouncing" wrist	1.80 (0.45)	1.80 (0.84)	0.62
Parameters of tension and force			
17. Key activation force	2.67 (0.52)	2.33 (0.52)	0.67
18. *Isolated 1st digit*	0.60 (0.55)	0.80 (1.00)	0.75
19. Isolated 5th digit	1.40 (0.55)	1.40 (0.55)	1.00
20. Hypermobile joints	1.20 (0.45)	1.00 (0.71)	0.83
21. Finger enslavement	1.00 (0.71)	1.20 (0.45)	0.83

* = no variance in scores, so ICC calculation was not possible.
p values are all greater than .05. Bolded parameters are ones that were eliminated. Italicized parameters are ones that met the criteria for elimination but were kept in on further discussion with experts.

Means and standard deviations and ICC coefficients are presented in Table 1. The overall content ICC was .80 (p = .00). The Cronbach's alpha was .80.

DISCUSSION

A priori we decided to eliminate any parameter in which the mean of the risk factor was less than one. In addition we decided to eliminate any parameter in which the risk factor was equal to one and the rationale score was less than or equal to one. This eliminated six parameters (# 4, 7, 8, 9, 13, and 18). In general, there was good agreement among the raters for individual parameters (ICC's greater than 0.75 are considered to have good agreement, those below 0.75 are considered to have poor to moderate agreement) (Portney & Watkins, 2000), with only four parameters falling below 0.75. The individual scores of these low ICC's were evaluated. The low agreement was caused by a single differing score from an expert for each parameter. We therefore eliminated the two parameters which met our elimination cut-off score (# 4 and 7), and kept the two parameters (# 16 and 17) in the instrument.

The overall content ICC of .80 suggests that the experts generally agreed as to which parameters were risk factors for MSD-UE. The Cronbach's alpha of .80 suggests that the reviewers were homogenous and measuring the parameters in a similar way and yet had enough variation that they were each providing a unique perspective on the instrument (Portney & Watkins, 2000). The generally high ICC's for each parameter kept in the PeCKS (beta-2) suggests that the experts agreed that these parameters were possible risk factors for MSD-UE and agreed with the rationale for the choices.

The results of these analyses were discussed with the experts who provided further feedback on the proposed changes. The parameter related to thumb isolation (#18) was reinstated after discussions with the experts about these results. In addition, two parameters suggested during the feedback process were added to the updated PeCKS (beta-2) instrument: one parameter related to neck posture and one parameter related to overall hand tension. Based on the content validity analysis, the PeCKS (beta-2) has 18 parameters.

Although the PeCKS (beta-2) now has content validity as to what parameters of keyboarding style should be measured to assess if a worker is at risk for MSD-UE, it must be refined further before it can be used in the field. We must develop concrete and reliable operationalizations of each parameter. These operationalizations must help trained raters who use the PeCKS (beta-2) to have good inter-rater (agreement between different raters) and intra-rater (agreement for one rater over several observation periods) reliability. In addition we must ascertain the predictive criterion-related validity of the PeCKS (beta-2), determining if the parameters of the PeCKS (beta-2) are valid predictors of those at risk for MSD-UE. We must also develop a weighting system to describe the magnitude of the risk each parameter has as a cause of MSD-UE.

The first step in developing any instrument is to identify what parameters must be measured to fully describe the construct of interest. This research demonstrates one method that was used to obtain content validity for an instrument that will be used to assess parameters of keyboarding style and their association with MSD-UE. Once the PeCKS (beta-2) demonstrates good reliability and validity it will contribute to both research and clinical interventions in the area of computer workstation set-up. It can be used to document the parameters of keyboarding style and how they interact, evaluate the effect of environmental constraints and personal anthropometry on keyboarding style, and design specific interventions to reduce risky keyboarding style. The PeCKS (beta-2) has the potential to become a useful tool for researchers and clinicians interested in preventing MSD-UE in computer users.

ACKNOWLEDGMENTS

We would like to acknowledge the support of the University of Pittsburgh Central Research Development Fund. We would also like to acknowledge Rakié Cham for all her help in developing this instrument.

REFERENCES

Armstrong, T., & Chaffin, D. B. (1979). Carpal tunnel syndrome and selected personal attributes. *Journal of Occupational Medicine, 21*(7), 481-486.

Bureau of Labor Statistics. (2002). *Lost worktime injuries and illnesses: Characteristics and resulting time away from work, 2000.* United States Department of Labor. Retrieved October 28, 2002, from the World Wide Web: http://stats.bls.gov/iif/home.htm

Bureau of Labor Statistics. (2003). *Number and percent of nonfatal occupational injuries and illnesses involving days away from work resulting from repetitive motion, occupations with one percent or more of total cases, 2001 (Table 4).* Department of Labor. Retrieved June 4, 2003, from the World Wide Web: http//: www.bls.gov/iif/oshwc/osh/case/ostb1147.pdf

Cline, A. (2000). *Prioritization process using Delphi technique.* Carolla Development. Retrieved December 22, 2002, from the World Wide Web: http://www.carolla.com/wp-delph.htm

Feuerstein, M. (1996). Workstyle: Definition, empirical support, and implications for prevention, evaluation, and rehabilitation of occupational upper-extremity disorders. In S. D. Moon & S. L. Sauter (Eds.), *Beyond biomechanics: Psychosocial aspects of musculoskeletal disorders in office work* (Vol. I, pp. 177-207). London: Taylor & Francis Ltd.

Feuerstein, M., & Fitzgerald, T. E. (1992). Biomechanical factors affecting upper extremity cumulative trauma disorders in sign language interpreters. *Journal of Occupational Medicine, 34,* 257-264.

Gandek, B., & Ware, J. E. (1998). Methods for validating and norming translations of health status questionnaires: The IQOLA Project approach. *Journal of Clinical Epidemiology, 51,* 953-959.

James, C. P., Harburn, K. L., & Kramer, J. F. (1997). Cumulative trauma disorders in the upper extremities: Reliability of the Postural and Repetitive Risk-Factors Index. *Archives of Physical Medicine and Rehabilitation, 78,* 860-866.

Keyserling, W. M., Stetson, D. S., Silverstein, B. A., & Brouwer, M. L. (1993). A checklist for evaluating ergonomic risk factors associated with upper extremity cumulative trauma disorders. *Ergonomics, 36,* 807-831.

Kilbom, A., & Persson, J. (1987). Work techniques and its consequences for the musculoskeletal disorders. *Ergonomics, 30,* 273-279.

Latko, W. A., Armstrong, T. J., Foulke, J. A., Herrin, G. D., Rabourn, R. A., & Ulin, S. S. (1997). Development and evaluation of an observational method for assessing repetition in hand tasks. *American Industrial Hygiene Association Journal, 58,* 278-285.

Lueder, R. (1996, August 8-9, 1996). *A proposed RULA for computer users.* Paper presented at the Proceedings of the Ergonomics Summer Workshop, San Francisco, CA.

McAtamney, L., & Corlett, E. N. (1993). RULA: A survey method for investigation of work-related upper limb disorders. *Applied Ergonomics, 24,* 91-99.

Moore, J. S. (2002). Biomechanical models for the pathogenesis of specific distal upper extremity disorders. *American Journal of Industrial Medicine, 41,* 353-369.

Moore, J. S., & Garg, A. (1995). The Strain Index: A proposed method to analyze jobs for risk of distal upper extremity disorders. *American Industrial Hygiene Association Journal, 56,* 443-458.

Pascarelli, E. F., & Kella, J. J. (1993). Soft-tissue injuries related to use of the computer keyboard. *Journal of Occupational Medicine, 35,* 522-532.

Portney, L. G., & Watkins, M. P. (2000). *Foundations of clinical research: Applications to practice* (2nd ed.). Upper Saddle River, NJ: Prentice Hall Health.

Shrout, P. E., & Fleiss, J. L. (1979). Intraclass correlations: Uses in assessing rater reliability. *Psychological Bulletin, 86*(2), 420-428.

Sommerich, C. M., Marras, W. S., & Parnianpour, M. (1996). A quantitative description of typing biomechanics. *Journal of Occupational Rehabilitation, 6,* 33-55.

U.S. Bureau of Labor Statistics. (2002). *Computer and internet use at work in 2001.* U. S. Bureau of Labor Statistics. Retrieved October 30, 2002, from the World Wide Web: www.bls.gov/news.release/ciuaw.nr0.htm

U.S. Census Bureau. (2001). *Workers using computers on the job: 1993 and 1997.* U.S. Census Bureau. Retrieved February 1, 2002, from the World Wide Web: http://www.census.gov/prod/www/statistical_abstract-01.html

Verhagen, A. P., de Vet, H. C. W., de Bie, R. A., Kessels, A. G. H., Boers, M., Bouter, L. M., & Knipschild, P. G. (1998). The Delphi List: A critical list for quality assessment of randomized clinical trials for conducting systematic reviews developed by Delphi consensus. *Journal of Clinical Epidemiology, 51,* 1235-1241.