

OBSERVATIONAL METHODS TO EVALUATE JOB STRESSORS OF THE UPPER LIMB

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BACKGROUND: Widely accepted guidelines, such as the revised NIOSH Lifting Equation (Waters, 1994) are available to evaluate physical stressors of the back, but similar guidelines for the upper extremities are unavailable. Although many exposure assessment methods have been used in studies to evaluate physical stressors to the upper extremities, they tend to be specific to one type of work or limited in the range of stressors that they assess. If researchers can agree on how to measure repetitiveness, force, awkward postures, and other physical stressors in a way that applies to all or most jobs, data could be pooled to advance our knowledge of relationships between these stressors and upper extremity MSDs. Better quantitative or at least semi-quantitative measures would improve our ability to assess dose-response relationships between specific stressors and health outcomes. This paper describes an effort by a group of NIOSH researchers to develop a standard method to evaluate physical stressors of the upper extremities in epidemiologic field studies.

Workplace physical stressors associated with musculoskeletal disorders (MSDs) include highly repetitive or static muscle exertion, work requiring high force, insufficient recovery time, awkward postures, localized contact pressure, vibration, and cold (Bernard, 1997). Direct reading instruments can provide objective, quantitative information about these stressors in laboratory studies, but are infrequently used in large field studies. Expense and interference with work limit the use of instrumentation in field studies that evaluate different stressors (e.g., force, posture and repetition) at multiple body locations

simultaneously. Workers' self-reported ratings of ergonomic stressors via questionnaires have been widely used in field studies, with varying reports on reliability and validity. Observational methods are most commonly used in field studies, with analysts counting, rating, or noting the presence of ergonomic stressors, either from direct observation of workers in the field or from videotapes. Observational methods are widely used in epidemiologic studies (Kilbom, 1994). Recent research has resulted in improvements in these methods, including improving reliability (Keyserling, 1986; Vander Beek, 1992; Burt and Punnett, 1999), and standardizing classifications for postures (Juul-Kristensen, 1997). Quantitative information such as weights of objects and production figures often are used to supplement observations. An ideal method would be reliable and valid, inexpensive and practical for use in large studies, and would apply to a wide variety of jobs.

Kilbom (1994) stressed that although several methods summarize exposure data into an index intended for priority setting for ergonomic interventions, they have not been fully validated, and should never be used in a way that obscures an analysis of the effects of single exposure variables.

METHODS: In 1996, a group of NIOSH investigators who have been involved in ergonomic evaluations addressing upper extremity musculoskeletal disorders organized to review and critique the available methods for use in field studies, with the goal of agreeing on uniform methods. This is a step in a continuing process to improve and standardize ergonomic exposure

assessment methods. Our agreement on a uniform method is not meant to preclude the use of additional, more detailed ergonomic job analyses focusing on a particular body part, stressor, task or type of work. This effort is also not meant to detract from the value of methods that use instrumentation or self-reports to evaluate ergonomic stressors. Each approach has important contributions to make, and using more than one approach should strengthen a study. Our goal is to agree to use a more universal observational method to evaluate basic ergonomic stressors to the upper extremities that can be applied across a wide spectrum of jobs and industries.

During early meetings, the group agreed that force, repetitiveness, awkward postures, static muscle exertion with insufficient rest time, and direct contact pressure were the most important physical ergonomic stressors to evaluate. A two-day workshop was held, in which participants discussed readily available, more commonly used, published methods. In a series of subsequent meetings, we further evaluated a subgroup of methods that we judged to be easy to use, that provide at least semi-quantitative data to evaluate dose-response relationships with MSDs, and address multiple stressors (repetition, force, awkward posture, etc.) at multiple upper extremity locations (hand/wrist, elbow/forearm, etc.). Since each method has strengths and limitations, we attempted to combine several methods to develop a hybrid or composite method.

Evaluation criteria: Data recording forms of the remaining methods were used to evaluate videotaped job tasks from NIOSH investigations. Factors considered in evaluating methods included: explicit criteria for selection of ratings (rather than requiring professional judgement); decision rules for situations such as rating observations at the boundary of two levels; appropriate level of detail for dose-response analysis (at least 3 levels, yet

observable and meaningful differences between levels); and the use of images to facilitate posture selection. Other considerations in applying methods included the ability to rate each stressor individually, provide a balanced evaluation of all stressors, and applicability to a wide range of jobs. Authors of three of these methods were invited to NIOSH to provide further information about their methods, and to participate in discussions about how the method might be modified or combined with another method to provide a core set of measures that could be used in any ergonomic investigation. Table 1 presents our evaluation of these methods according to criteria described above.

Proposed composite method: Our proposed composite method borrows largely from the hand activity level and other rating scales developed by Armstrong and Latko to rate repetition, force, contact stress, movement speed and exertion time. We borrowed the concept of using figures to represent postures from OWAS and RULA, but using different categories for degree of deviation from neutral and allowing each posture to be rated separately. The type of grasp is recorded similarly to Armstrong, and Rodgers' Ergonomic Job Analysis method (or an adaptation of it) is proposed to evaluate job tasks that cross a threshold for static muscle exertion. Recovery time data suggest that 6 seconds is an appropriate threshold to determine whether static muscle exertion may be a problem. Rather than attempt to assign weights to specific stressors or an overall score as some of the reviewed methods do, we propose to evaluate the strength of association between individual and combined stressors and musculoskeletal outcomes in epidemiologic studies, and to use this information in the future to determine weights and scores. A draft data recording instrument is proposed for the hand/wrist area. We plan to complete the data collection instrument for the other upper extremity locations.

Table 1

Method	at least 3 levels for upper limb	explicit criteria	rates stressors separately	balanced evaluation of all stressors	applies to a variety of jobs
OWAS ^{1,2,3}	No	Yes	Yes	No	Yes
VIRA ⁴	No	Yes	Yes	Yes	No
Postural Analysis in Simulated Real Time ³	No	Yes	Yes	Yes	No
Ergonomic Job Analysis ^{5,6,7}	Yes	No	No	Yes	Yes
Hand Exertion Classification System ¹²	No	Yes	Yes	No	Yes
RULA ^{8,9} , REBA ¹⁰	Yes	Yes	No	No	Yes
WOPALAS ¹¹	No	Yes	Yes	Yes	Yes
Strain Index ^{12,13,14}	Yes	Yes	No	Yes	No
Guidelines for rating work-related factors ^{15,16,17}	Yes	Yes	Yes	Yes	Yes

References

Bernard B (ed.) (1997) *Musculoskeletal Disorders and Workplace Factors: A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back*, 2nd printing, DHHS (NIOSH) Publication No. 97-141, Cincinnati, OH.

Burt S, Punnett L (1999) Interrater reliability of posture observations in a field study, *Applied Ergonomics* 30:121-135.

Juul-Kristensen B, Fallentin N, Ekdahl C (1997) Criteria for classification of posture in repetitive work by observation methods: A review, *International Journal of Industrial Ergonomics* 19:397-411.

Keyserling M (1986) Postural analysis of the trunk and shoulders in simulated real time, *Ergonomics* 29(4):569-583.

Kilbom, Å (1994) Assessment of physical exposure in relation to work-related musculoskeletal disorders - what information can be obtained from systematic observations? *Scandinavian Journal of Work Environment and Health* 20:30-45.

Van der Beek A, van Gaalen L, Frings-Dresen H (1992) Working postures and activities of lorry drivers: a reliability study of on-site observation and recording on a pocket computer, *Applied Ergonomics* 23:331-336.

Waters T, Putz-Anderson V, Garg A (1994) *Applications Manual for the Revised NIOSH Lifting Equation*, US Dept. of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 94-110.

Table citations

1. Karhu O, Kansi P, Kuorinka I (1977) Correcting working postures in industry: A practical method for analysis, *Applied Ergonomics* 8(4):199-201.
 2. Karhu O, Härkönen R, Sorvali P, Vepsäläinen P (1981) Observing working postures in industry: Examples of OWAS application, *Applied Ergonomics* 12(1):13-17.
 3. Kivi P, Mattila M (1991) Analysis and improvement of work postures in the building industry: Application of the computerised OWAS method, *Applied Ergonomics* 22 (1):43-48.
 4. Kilbom Å, Persson J, Jonsson B (1986) Chapter 5, Risk factors for work-related disorders of the neck and shoulder - with special emphasis on working postures and movements, *The Ergonomics of Working Postures*, Taylor & Francis, Philadelphia.
 5. Rodgers S (1988) Chapter 5, Job evaluation in worker fitness determination, *Occupational Medicine: State of the Art Reviews* 3(2):219-239.
 6. Rodgers S (1992) A functional job analysis technique, *Occupational Medicine: State of the Art Reviews* 7(4):679-711.
 7. Rodgers S (1997) Chapter 10, Work physiology - fatigue and recovery, *Handbook of Human Factors and Ergonomics*, John Wiley & Sons, Inc., New York.
 8. McAtamney L, Corlett E (1993) RULA: A survey method for the investigation of work-related upper limb disorders, *Applied Ergonomics* 24(2):91-99.
 9. McAtamney L, Corlett E (1996) *Reducing the Risks of Work-related Upper Limb Disorders: A Guide and Methods*, Institute for Occupational Ergonomics, University of Nottingham, Nottingham, U.K.
 10. Hignett S, McAtamney L (1997) Rapid entire body assessment (REBA) in the health care industry, *IEA '97 (Proceedings of the 1997 International Ergonomics Association Conference)* 4:162-164.
1. Pinzke S (1994) A computerised system for analysing working postures in agriculture, *Industrial Ergonomics* 13:307-315.
 2. Moore J, Garg A (1994) Upper extremity disorders in a pork processing plant: Relationships between job risk factors and morbidity, *American Industrial Hygiene Association Journal* 55(8):703-715.
 3. Moore J, Garg A (1994) A comparison of different approaches for ergonomic job evaluation for predicting risk of upper extremity disorders, *IEA '94, (Proceedings of the International Ergonomics Association Conference)*, 2:176-178.
 4. Moore J, Garg A (1995) The strain index: A proposed method to analyze jobs for risk of distal upper extremity disorders, *American Industrial Hygiene Association* 56:443-458.
 5. Armstrong T, Foulke J, Latko W, Rabourn R, Ulin S (1996) Work related musculoskeletal disorders of the upper limb: Exposure evaluation, *International Ergonomics and Safety Conference (Proceedings)* Zurich, Switzerland.
 6. Latko W, Armstrong T, Foulke J, Herrin G, Rabourn R, Ulin S (1997) Development and evaluation of an observational method for assessing repetition in hand tasks, *American Industrial Association Journal* 58:278-285.
 7. Latko W (1997) Development and evaluation of an observational method for quantifying exposure to hand activity and other physical stressors in manual work, University of Michigan (doctoral dissertation).



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