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Effect of rater background on objectivity of the rapid upper limb assessment

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EFFECT OF RATER BACKGROUND ON
OBJECTIVITY OF THE RAPID UPPER LIMB ASSESSMENT

A Thesis

Presented to

The Faculty of the Human Factors/Ergonomics Program

San Jose State University

In Partial Fulfillment

Of the Requirements for the Degree

Master of Science

by

Virginia J. Hixson

December 2005

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ABSTRACT

EFFECT OF RATER BACKGROUND ON OBJECTIVITY OF THE RAPID UPPER LIMB ASSESSMENT

by Virginia J. Hixson

Insufficient evidence of reliability testing of work-related assessments is a major concern in the field of ergonomics. Objectivity, the ability of a scale or test to be used by any rater to measure the same when examining the same thing, is one type of reliability. This paper presents a detailed exploration of the objectivity of such a scale, the RULA, or Rapid Upper Limb Assessment (McAtamney & Corlett, 1993). Four video tasks were presented to 3 groups of raters. Variables examined were rater years of experience in movement observation, rater experience using the RULA, and rater training in use of the RULA. Objectivity was not identified in any variable. Main effects were present for all variables. Based on the rater sample and the data collected, the RULA cannot be considered an objective tool for communicating or comparing information between raters.

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CHAPTER 1

Introduction

In 1986, with only small increases shown in most workplace illness categories as defined by Occupational Health and Safety Administration, those related to repeated trauma showed a strong increase (Department of Labor, 2000). Repeated trauma disorders remain the highest component of nonfatal illnesses (241,800 or 67% of cases in the year 2000). Currently, work-related musculoskeletal disorders account for approximately one-third of workers' compensation costs for private industry in the United States (Barr & Barbe, 2002).

The Rapid Upper Limb Assessment (RULA) was developed as part of a comprehensive approach to ergonomics in the United Kingdom, filling the role of a screening tool designed for office and other employment classifications where a majority of the task was accomplished using primarily the upper extremities (McAtamney & Corlett, 1993). McAtamney and Corlett developed the RULA as a screening tool to identify job tasks that might result in repetitive strain, i.e. injuries related to repeated trauma. In their 1993 article discussing the development of the RULA, McAtamney and Corlett selected safety, therapy, and engineering professionals as raters. McAtamney and Corlett, in their article of 1993, briefly mentioned that where ergonomic issues were indicated by the RULA, a second battery of assessments would be employed. Dr.A. Hedge of Cornell University, who presented the RULA in the United States (Hedge, 1997), stressed that when high risk was indicated in a job task as identified by

the RULA (McAtamney & Corlett, 2003), the screening would be followed by more focused ergonomic study (Dr. A. Hedge, personal communication, August 20, 2003).

Raters can use the RULA to identify and quantify risks in work tasks that are introduced by an employees' general posture, specific limb and joint postures, movement repetition, static muscle load (isometric contraction), and force (McAtamney & Corlett, 1993). The RULA is essentially an observational rating scale of work technique, job demands, and stress.

Following the RULA format, the raters' observation is guided through samples of different potential work postures. The rater then chooses which category he or she feels best estimates the posture observed (see figure 1). The posture estimation results in a

Figure 1: Diagrams of Left Wrist Posture from Modified Cornell RULA

score that is used to assign risk status. Heavily reliant on observation, proper use of the RULA requires that the rater have a basic ability to estimate upper extremity joint position of a worker and estimate the amount of effort being put forth while job activity is performed. Further, it requires that the rate be able to judge which aspects of the task

present the most ergonomic risk. The RULA instructions guide raters to make a judgment in choosing which posture in the task is most hazardous, or which is most typical. Raters should then focus on that portion of the job in determining a score (McAtamney & Corlett, 1997).

The RULA can be completed while observing actual job performance, or by viewing videotape of the job process (Wynn & Ip, 2002). Although most items in the RULA are directed to the upper limbs and back, some items for the neck, trunk, and leg exist. Scores range from (a) acceptable, (b) needs further investigation, (c) investigate further and change soon, or (d) investigate and change immediately. Each major joint posture is scored separately and then totaled for a limb score (McAtamney & Corlett, 1997). Limb scores are totaled with the trunk, neck, and leg scores for a total score for each side of the body (Appendix A). The RULA is a tool one can carry on a clipboard to a job site. It is lightweight and quick to administer requiring no instruments other than a form and a pen or pencil. The RULA is highly reliant on human observation, and this presents another question: How reliable is human observation?

The ability of humans to accurately observe and report what is seen has been an object of study for some time. In a comparison of the reliability among self-report, video observation (such as the RULA), and direct measurement as methods for evaluating risk factors for upper extremity work related musculoskeletal disorders, Spielholz (2001) found that self-report was the least reliable in quantifying exposure. Participants consistently over-estimated exposures for each risk factor. In wrist deviation, duration and frequency, electrogoniometric measures and EMG were less precise than video

analysis. Forearm rotation, duration, and repetition, as well as grip force and velocity were best measured by the electronic tools (automated measurement).

In a personal communication with Dr. Alan Hedge, Director of the Human Factors and Ergonomics teaching and research programs at Cornell University, he stated that the RULA can only be appropriately used by those who are properly trained in biomechanics, ergonomics, and in use of the instrument (RULA). The most potential for accuracy using the RULA is by a trained professional in direct observation of job tasks. The next most accurate scoring is obtained when a professional rates from videotape of the job. Still photographs are less accurate, mainly because judgment in choice of which posture to rate is in the hands of the photographer. This, in itself, takes away a valuable aspect of professional judgment (Dr.A. Hedge, personal communication, August 20, 2003). Hedge did not consider it appropriate for those without a background in ergonomics or biomechanics to use the RULA.

One of the primary approaches to improvement in rater consistency is to guide the development of expertise. In his discussion of how to train physicians in the practice of diagnosis, Heeger (2003) considered the set of different possible symptoms related to a diagnosis. He was also aware of other diagnoses these combinations of symptoms might suggest. Choosing the correct symptoms to focus on as important would lead to a correct diagnosis (unspecified in the article). Unrelated symptomatology presented by the patient increased the difficulty of determining diagnosis correctly. Wrong decisions would be either incorrect diagnosis (caused by missing important symptoms or focusing on the wrong symptoms) or the decision that nothing is wrong when something actually is

wrong. Also, the physician could determine that the patient is ill when no illness is present. By increasing expertise, novice doctors improved their ability to identify the correct symptoms to focus on for diagnosis.

Rikers, Winkel, Loyens, and Schmidt (2003) examined medical diagnostic expertise in student physicians and physicians. They found that experts were faster than novices and had fewer errors. They stated that experts had a more complete mental schema of the medical problem, showing deeper understanding. Rikers, Winkel, Loyens, and Schmidt further stated that schemas serve as a physician's guide for what is important and what is not.

In the RULA, rating of postures that approach but are not at the point where scoring category actually changes (see Figure 2), or postures that are

Figure 2: RULA Depiction of Elbow Posture Scoring Categories

past the point of change but are fleeting or not relevant in the job task may increase the probability of a higher score than is appropriate. Additionally, movement of contiguous joints may affect spatial orientation and rater's perception of the joint being rated (Figure 3). The visual image of what is occurring in the target joint changes through foreshortening (Figure 3 and 4), obscuring of the actual target joint during part of the task

(Figure 4), or the rater being guided by final position of the limb rather than focusing on the joint motion (Lortie & Bruxelles, (2002).

Figure 3: Perceptual Foreshortening Effects and Effect of Dual Joint Posture.

Directions to all versions of the RULA that were reviewed state that raters should focus only on the posture deemed by the rater to be most extreme, or one that most typifies the task (McAtamney and Corlett, 1993, 2000, and 2004). These directions may be contradictory. The most extreme posture may be crucial to the job and may be repeated, but it may not most typify the task. A rater must identify which posture he or she will rate among the many shown by the worker in completing his or her work task.

Observing joint position in the chosen posture, the rater using the RULA determines whether to rate a joint in one position range or in an adjacent position range (see Figures 1 and 2). The final joint position rating may be guided by the rater's visual

accuracy, mental schema of the human body, schema of ergonomic risk, and understanding of the job task.

Figure 4: Perceptual Foreshortening and Occlusion Effects

Weiss and Shanteau (2003) stated that there are two criteria to establish expertise. The first is the ability to discriminate among relevant stimuli including the ability to differentiate small but relevant increments of difference between non-identical stimuli. The second quality they require is consistency of judgment. Both are required for reliable RULA use.

Li and Buckle (1999) addressed the problem of evaluation and assessment in applied work (other than laboratory based research). They stated that because this work is done in the field, there are more variables than encountered in the laboratory. First, the

work must be interpreted by the practitioner. A practitioner finds his or her own meaning in an observation and context. This meaning is based upon his or her view of the theories on which the assessment is based. Without intending to modify the evaluation, a practitioner uses his or her training, background, and skill set to view the work and the assessment from an individual vantage point (Jentsch, Bowers, & Salas, 2001). The expert may look for one thing, while the novice may look for another. Rating depends, in large part, on what is being perceived.

In using the RULA, this tendency of the practitioner to add meaning to observation creates an obstacle to good objectivity. Field ergonomists are of varied backgrounds. In May 2002, John Schwartz, a student in ergonomics from the University of Waterloo in Ontario, Canada, submitted a list of people that he knew were serving as field ergonomists to the ErgoWeb online discussion group. The list included registered nurses, chiropractors, physical therapists, occupational therapists, safety professionals, engineers, semitrained ergonomics team members, and certified ergonomists. Each of these groups practicing ergonomics comes from a different educational and practice background. These differences may affect what is observed, as well as the way observations are interpreted and rated. Depending on past experience and training, there may also be a difference in what is perceived as a postural risk, and, in using the RULA, this might affect the target posture chosen for task assessment.

Musculoskeletal Disorders

Although certain postures are generally accepted as being more of a risk than others, disagreement on what specific exposure poses ergonomic risk and how to weigh

such risks for their impact on employee health is endemic among ergonomists. This was shown in the hearings held to review the Occupational Safety and Health Association's (OSHA) proposal for an Ergonomics Regulation in 2000. No consensus existed among the accepted and certified ergonomics professionals who presented to the hearing about answers to any of the basic questions asked by U.S. Labor Secretary Chao (Moffitt Reporting Associates, 2000).

Secretary Chao's first question concerned the definition of an ergonomics injury. Injuries related to poor ergonomics are often described by the term musculoskeletal disorders (MSDs). This refers to injuries and illnesses that affect the musculoskeletal system. There is no single diagnosis for musculoskeletal disorders (OSHA, 2002). Taken widely, it can include traumatic injury as well as injuries that occur over time, or cumulative trauma. In the United States, musculoskeletal disorders are usually equated with ergonomic injury and refer to cumulative trauma. This was not contested in the hearings. What was contested was the type of diagnoses to be included in cumulative trauma.

Different branches of the United States Department of Labor define musculoskeletal disorders in different ways. The Occupational Safety and Health Administration (OSHA) includes injuries or disorders to muscles, tendons, ligaments, joints, cartilage, and spinal discs (2002). The Bureau of Labor Statistics excludes herniated spinal discs and certain other injuries, including tarsal tunnel syndrome (2000). The Bureau of Labor Statistics includes injuries caused by task-related environmental and process exposure, but disallows (into the musculoskeletal injury category) injuries related

to causes such as slips and trips, falls, and other direct trauma. OSHA records cumulative trauma as an illness rather than an injury, because it develops over time.

Industries that report statistics to OSHA and the Bureau of Labor may have their own definitions for the terms they are given by the agencies. Thus, one company records cumulative trauma as a set of injuries that occur throughout the body over the course of a worker's tenure, while another may record only those injuries that have a doctor's diagnosis of cumulative trauma.

The second question dealt with determination of cause. How can OSHA and individual employers determine whether an ergonomics injury was caused by work-related activities or by non-work-related activities? Since the same muscles and joints are used both in work and off the job, musculoskeletal disorders may well be related to both. In this case, Secretary Chao further asked how OSHA and employers should respond to such injuries. In the various forums, this question was either acknowledged as a problem or ignored. This leads to the last question: Secretary Chao asked for advice on the approach OSHA should take to cost-effectively assist employers in controlling musculoskeletal disorders (Moffitt Reporting Associates, 2000).

Stanton and Young (2003) addressed the issue of musculoskeletal disorders control from a manufacturer's viewpoint. Following their identification of the most reliable and valid ergonomic measures for novices to use, Stanton and Young did a cost-benefit analysis. They found that some of the most important aspects of ergonomic analysis in product design were not included in the usual measures accepted for and applied to this issue. Thus, based on the results of the available measures, a company

may redesign the product and retool the factory, only to find that the benefits projected in reduced cost have not been achieved and that musculoskeletal disorders among employees have not decreased. This points to the importance of ensuring that the chosen evaluation tool is properly applied to the correct issue and that there is proper interpretation of results.

In 1998, Stanton and Young reported on a survey of ergonomic professionals in *Applied Ergonomics*. They stated that those who employed ergonomic methods were generally unaware of any evidence in published studies of reliability or validity for the methods they used. Stanton and Young did not provide detail about the background of the people they surveyed.

Indeed, one need not have any special training or awareness of research or theory to be an ergonomist. The term ergonomist is not protected by law as are some other occupational terms such as medical doctor, physical therapist, or psychologist. There is no single, consistent base of knowledge required. Although there are several certifying agencies for ergonomists, qualifications are inconsistent, and certification is not required to be an ergonomist. The three main qualifying agencies in the United States are the Board of Certified Professional Ergonomists, the Oxford Research Institute, and Roy Matheson Systems.

The Board of Certified Professional Ergonomists (BCPE) certifies applicants through adhering to the criteria and policies for competency assessment as set by the National Organization for Competency Assurance and has been endorsed by the International Ergonomics Association as an accredited ergonomics certifying body. At

the professional level, it requires a master's degree in ergonomics or human factors, or an equivalent educational background in the life sciences, engineering sciences, and behavioral sciences from an approved university level program; four years of full-time professional practice as an ergonomics practitioner. This should have an emphasis on design involvement derived from ergonomic analysis and/or ergonomic testing and evaluation. A passing score on the BCPE Certified Professional Ergonomist/Certified Human Factors Professional written examination (Board of Certification in Professional Ergonomics, 2003) is also required. The application for examination includes a request for work samples indicating competence.

The Oxford Research Institute confers the Certified Industrial Ergonomist title, requiring five or more years of experience plus a masters degree or three years experience and a doctorate in a closely related field of employment such as human factors, engineering, engineering psychology, or ergonomic technical services. Evidence of specialized training or formal education in fields directly or closely related with ergonomics or human factors engineering or both must be provided. The Oxford Research Institute also requires submission of at least two work samples or technical reports that show the experience and competence of the petitioner and two letters of reference from certified members of the profession. The petitioner must also achieve a satisfactory score on a certification exam (Oxford Research Institute, 2003).

The Matheson system provides a certification in ergonomic evaluation to individuals from the fields of safety, allied health, and human resources. Applicants must have demonstrated competency in ergonomic evaluation by completing the five-day

Ergonomic Evaluation Certification Program and submitting several acceptable work samples over one year following the course (Roy Matheson System, 2003).

The professional organizations, the Occupational Health and Safety Association, the National Safety Council, and producers of evaluations have not made a basic qualification statement or professional rule about who is qualified to use what assessment procedures (Occupational Health and Safety Association, 2003; National Safety Council, 2003; Human Factors and Ergonomics Society, 2003). Without provision of guidance in these matters, and with ergonomic measurement tools freely available over the Internet, anyone is able to administer and interpret these assessments.

Relevance of This Study

The National Research Council Institute of Health (2001) reported that musculoskeletal disorders resulted in approximately one million people losing time from work each year. They identified these musculoskeletal disorders as a significant national health problem and made reference to the large negative effect these conditions had on the national economy, including lost wages, and productivity, upwards of \$50 billion annually.

Across the nation, musculoskeletal disorders produced a large drain on the workforce as well as great expense to business and society that continues into the present. The National Research Council Institute of Medicine (2001) estimated that direct workers' compensation costs for musculoskeletal injuries were close to \$20 billion across the nation. This figure did not include indirect costs to companies and did not take into account the effect these injuries have on the lives of injured employees and their families.

The Occupational Safety and Health Administration considered these costs a significant problem, and they have attempted to enact specific legislation to address ergonomics (Occupational Safety and Health Administration [OSHA], 2000a). When that legislation was retracted by President George W. Bush upon his taking office in 2001, OSHA pursued other routes to manage the business approach to work-related musculoskeletal dysfunction, primarily through a series of voluntary programs. Currently, enforcement is accomplished through invocation of the general safety rule (OSHA, 2002).

OSHA's approach is based on the control of identified risks, so that workers' compensation claim frequency and the severity of the claims will decrease and costs to the employer and the economy will be minimized. OSHA considers that current evaluations for ergonomic risk, as they are being used, address significant ergonomic hazards. This is indicated by the continued posting of these evaluations on its Web site (OSHA, 2000b). OSHA indicates that the significant financial outlays by employers in an attempt to follow ergonomists' recommendations and lessen hazards are actually successful (OSHA, 2003). This was supported by the United States General Accounting Office in their report to Congress (1997). Success stories in five companies from across the United States were reviewed in this report. Staffing levels ranged from 300 to 5,300 employees. Each company had instituted successful ergonomics programs that resulted in decreased costs and increased productivity among employees.

Different types of guided observation scales and task hazard assignment systems have been developed. These assessment tools were initially developed for use by the

individual professionals, seeking to make their work more consistent. A few were designed for broader use. Most are observational. Except for rare instances where force, oxygen consumption, or other physiological variables can be measured, scoring relies on the observation skills and judgment of the rater (Lisle, 2001).

Addressing the issue of human factors specialists (professional ergonomists) as expert witnesses, Haber and Haber (1999) presented a format to assist in development of consistency in testimony. Their goal was that with the same evidence and the same information structure, human factors specialists looking at the same evidence would reach consistent conclusions. Haber and Haber aimed for a science-based reasoning chain toward identification of the contributing factors of accident causation.

In their article on novice application of ergonomic methods, Stanton and Young (2003) stated that there is little substantive empirical evidence that ergonomic methods work. Lack of knowledge about reliability lessens the potential for the science-based reasoning chain desired by Haber and Haber.

Several articles searching for evidence of successful application of ergonomic methods have been published. In their study looking at the effects of training in ergonomics on risk exposure, worker beliefs and symptoms among computer users, Greene, DeJoy and Olejnik (2005), used the RULA as their measurement for risk exposure in a baseline and post study test with four groups. One participant group received training and intervention, (including ergonomic problem solving as well as workstation redesign if needed, work organization change, exercise change, and equipment, if requested). The second group did not receive intervention until after the

study was complete. They found a statistical significance between the baseline and the post test for those that received intervention. This was particularly true of those who initially scored a right $\times$ left average of 4.62 or higher on the RULA. The control group showed no significant change.

In their study of neck, shoulder, and arm symptoms among newspaper employees who used visual display units in their work, Nevala-Puranen, Pakarinen, and Louhevaara (2002) used electromyography as a measure of muscle tension. Neck flexion was measured with a Cervical Range of Motion Instrument (CHROM). Shoulder flexion and abduction, elbow flexion and ulnar deviation at the wrist were measured with a manual goniometer. Viewing distance was measured with a tape measure and viewing angle with a manual goniometer. An attempt was made to standardize the measurement descriptions specifically enough to avoid confounds often found in manual measurement. For example, elbow flexion was defined as the angle defined by the acromion, lateral epicondyle of the humerus, and styloid process of the ulna. The authors indicate that they would have preferred to use electrogoniometers as there would be less chance of error. The authors also spoke to potential of error in electromyography. Slight misplacement of leads can affect reliability with this technique.

Feuerstein et al., in 2004, looked at ergonomic intervention as a job stress management tool. The recruited participants reported symptoms (pain, aching, burning, stiffness, tingling and/or numbness) in the fingers, hands, wrists, forearms, elbows, shoulders, or neck. Only office workers from the World Bank who worked on a computer 3 to 4 hours per day and were employed at least 32 hours per week were

recruited. Two groups were randomly populated with one receiving ergonomic intervention only and the other both ergonomic intervention and stress reduction. Following intervention at 3 and 12 months follow-up, both groups showed significantly decreased ergonomic risk (determined by workstation evaluation) and decrease in symptoms. Difference between the groups was not significant at either 3 or 12 months. Stress reduction intervention did not show significant effect, but decreased ergonomic risk was recorded. The measure employed was a work site analysis checklist based on the State of Washington Department of Labor and Industry's *Ergonomic Work Site Analysis Form* (1997). This had been modified by the authors with the aim of increasing inter-rater reliability and to make the scoring more numerical than qualitative. The results of this attempt were not reported.

Few standardized and reliable work evaluation tools are available for the ergonomist in his or her fieldwork other than push-pull meters, grip strength indicators, or counting of repetitions. Instructions and guidelines to the conventional ergonomic measuring tools do not present or suggest qualifications that a user should acquire prior to applying them in the field. The Osmond version of the RULA online, (McAtamney & Corlett, 2000) suggests that users read the 1997 article by McAtamney and Corlett and also use the RULA several times on a trial basis prior to using it in a real application.

There are essentially two issues related to measurement and the RULA. The first issue is the reliability of the evaluation tool. The second is the knowledge and skill of the evaluator so that the tool is used and interpreted in a reliable manner.

With greater instrument reliability and appropriate training, an ergonomist can have greater confidence in the accuracy of his or her evaluation of work technique and risk. Additionally, the derived information will be accepted as more trustworthy in business and legal societies. With greater consistency in the methods and application of ergonomists who use assessment tools, evaluation results will have greater value in identifying and addressing hazards and in measuring change. This paper is aimed at establishing objectivity of the RULA and at determining the impact of rater background and specific RULA training and on rater consistency.

Statement of Purpose

The purposes of this study were to:

1. Determine objectivity of the RULA.
2. Examine the impact of rater background and training on RULA objectivity.

Limitations

This study only examined the objectivity of a specific field measure. Generalization to other observational scales is not appropriate. In order to allow attendance at training sessions, the trainee group members (selected to receive training in use of the RULA) were limited to those within an hour's drive of San José. Although initially randomly selected from those within that area, raters were allowed to opt out of that research phase. Three raters opted out of the training phase. This may have introduced a component of self-selective bias.

One of the first concerns identified by this investigator was the difference in visual and reactive effect of the various RULA versions. Particularly, visual images used

in the Cornell version (McAtamney & Corlett, 2003, see Appendix C) and the Osmond Group Web-based version (McAtamney & Corlett, 2000, see Appendix A) looked different. The Osmond Scientific version used a stylized model while the Cornell version uses diagrams that are more anthropomorphic than the Osmond version.

Copyright was a major concern; Osmond Scientific, a British company, holds copyright of the proposed Web page and its artwork. Following several contacts, a release was received for use of the Web page and its PDF version as long as no changes were made to the material (see Appendix D). The PDF did not allow input on the form, but would have required not only a copy of the PDF but a separate answer sheet, either printed or on screen. This would introduce more chance of error and required visual targeting of three separate items for each response.

Dr.A. Hedge at Cornell University gave complete release for any use of his forms (personal communication, August 20, 2004, Appendix E). Therefore, a version of his form that showed pictures in approximately the same size as shown on the Osmond RULA Web page was developed in Word format (see Appendix B). In this manner, answers could be entered directly onto the form showing on the monitor in Word format side by side with the task video. Even if technology limitations (small monitor or lack of dual window capability) required the rater to use a hard copy, only one set would be necessary.

Limitations in the Osmond Web page made it inaccessible to raters unless they used the Internet Explorer browser and were not using a Macintosh or Linux operating system. Final results were that 64 respondents of 77 used the modified Cornell version

(Appendix B) with 13 using the Web site (Osmond version, Appendix A). This may have affected the scores.

Although the Cornell version was supplied to raters in an electronic format viewable on computer monitors, 5 raters chose to print it out and use it as a paper-based method. This changed the visual task. While the electronic versions allowed side-by-side viewing of the rating sheet and the video task, the paper-based version required moving the eyes up and down frequently, from screen to paper, while making judgments about rating.

Delimitations

Only those over the age of 20 years were accepted as raters. Most of the novice raters and the trainee group were recruited from a small geographic area. Although their backgrounds varied, these participants may not have represented a true cross section of the three populations considered (those who worked in ergonomics, those who had some work connection with ergonomics, and those who had no knowledge of ergonomics). Additionally, to complete the study, raters were required to access the Internet and have an email address. To control for learning under therapy conditions, 17 persons who reported that they had received treatment for a repetitive motion injury were eliminated from the study.

Assumptions

Certain assumptions were made about the quality of the participating raters. They were assumed to be unbiased. Physical therapists, chiropractors, and occupational therapists were assumed to spend an average of at least one hour daily in activities that

involved joint measurement, joint manipulation, or other close involvement with human anthropometrics and movement. They were selected as a target population in rater recruitment because of this commonality.

It was assumed that McAtamney and Corlett produced a well-designed study in 1993 when they presented the design of the RULA. It was further assumed that the RULA measures what it intends to measure.

Hypotheses

This thesis investigated the following hypotheses: H_o^1 : rater background and anthropometric experience would have no effect on RULA objectivity; H_o^2 : specific training in the RULA would have no effect on RULA objectivity; H_o^3 : objectivity would not change with experience in using the RULA, i.e., there would be no increase in rater objectivity across the four task ratings, and there would be no difference between the different RULA experience levels identified in this study.

Operational Definitions

Anthropometric. In this study, anthropometric refers to the type of work experience possessed by the professional group. It includes close observation and manipulation of human limb movement.

Awkward posture. Study participants used the RULA guidelines of awkward posture. To determine whether this was present in the job task they observed, they compared what was done in the task to diagrams of postures on the RULA scoring form. Anything outside the safe limits as indicated on the scoring form is considered awkward.

Background. Background was defined as general education, work experience with anthropometrics or movement observation, experience using the RULA, and specific training in RULA use.

Education level. This indicated the rater education level as was determined by awarded degrees from educational institutions.

Ergonomic risk factors. For the purposes of this study, ergonomic risk factors are repetitive, forceful, or prolonged exertions of the hands; frequent or heavy lifting, pushing, pulling, or carrying of heavy objects; and prolonged awkward postures, vibration, and cold. Participants in the study used the RULA to identify the presence of risk factors and to calculate level of risk in the areas of repetition, force, and posture.

Evaluation. Evaluation is the considered analysis of a situation or job task. Often this is the result of several assessments. Raters who complete the RULA using the Osmond Web page were asked to make a general evaluation statement about job task

hazard level. They were asked to compare the RULA hazard assignment and the subjective impression gained while viewing the video task.

Force. In this study, force was estimated by raters through visual observation of subject effort as seen in the presented video tasks. The RULA indicates that the estimation should be in kilograms. As this is not the usual measurement system in the United States, a translation to the U.S. system of weights and measures was provided to raters.

Group assignment. Raters were assigned to one of 3 groups based on their work experience in dealing with or observing movement and anthropometrics. This experience was self-evaluated and communicated to the researcher through the registration questionnaire (See Appendix E).

Neutral posture. Neutral posture is a description of the posture into which the body falls naturally when standing or seated with shoulders and upper extremities relaxed. It differs from the anatomical position by taking into account individual differences and by working from a relaxed basis. Theoretically, this is the position of least stress. Ratings on the RULA are based on deviation from neutral posture.

Objectivity. Objectivity is the reliability of a test or measurement to measure the same, regardless of rater characteristics. A scale is objective when two random people measuring the same thing with the same scale under the same circumstances, dependably find the same result.

Range of motion. A joint's range of motion is the extent of joint movement from full extension to full flexion. The RULA depicts the range of motion used in job tasks in

order to identify and rate task risk for involvement in the development of musculoskeletal disorders. The rater must judge the job task requirements for risk using range of motion criteria.

Rater. A study participant charged with rating a person's task performance from video Compact Disk (video CD), using the RULA.

Repetitive motion. In this study, a motion (muscle use) was considered repetitive if it occurred more than four times in a minute, as indicated on the RULA form (McAtamney & Corlett, 1993). It is one of the risks that the raters assessed when using the RULA.

RULA experience. RULA experience indicated the amount of experience or acquaintance a rater had with the RULA. This experience was self-evaluated and communicated to the researcher through the registration questionnaire (see Appendix E).

Sustained posture. As indicated on the RULA scoring form, raters were instructed to rate a posture as sustained or static if it was held for longer than 1 minute.

Training. Training indicates specific training and practice in using the RULA as outlined in the methods section.

Upper extremity. A person's upper limb, including shoulder, arm, elbow, forearm, wrist, hand, and digits. The RULA focuses on job tasks that involve primarily the upper extremity. One part of the RULA is designed for scoring results for the right or left upper extremity.

Video CD. Video CD indicates the compact disk upon which the video task is recorded.

Video participant. A video participant is a study participant whose role in this study was to appear in the video tasks provided to the raters.

Video task. Video task indicates the saved video clips of the job tasks recorded for evaluation on the CD distributed to all raters.

Work experience. Work experience indicates the amount of experience a rater has in working with movement or anthropometrics. This experience was self-evaluated and communicated to the researcher through the registration questionnaire (see Appendix E). Work experience was used to determine group assignment of raters.

Summary

Ergonomics is a field that is currently practiced by professionals from numerous professional and training backgrounds. This can be both a strength and a weakness. In terms of strength, it affords a breadth of experience and knowledge that is generally unattainable. These differences, however, mean that different users may apply the RULA differently. Rater background may affect not only the knowledge that is held, but also understanding and interpretation of ergonomic theory.

What is observed is guided by experience and to some degree by expectation. Observation, as well as the way observations are interpreted and rated on a scale such as the RULA, may change with learning. Depending on past experience and training, there may also be a difference in what is perceived as a postural risk, and in using the RULA, this might affect the target posture chosen for task assessment.

This study was designed to study the effect of rater background on application of a postural observation scale, the RULA. It examined objectivity among raters and the

possible significance of rater background on the scoring outcomes of the RULA across four office tasks.

CHAPTER 2

Review of Literature

OSHA put forth its proposed Ergonomics Regulation in 2000, following years of study by the National Institute for Occupational Safety and Health (NIOSH, 1997a). At that time, business and labor, as well as the professional ergonomic communities, were strongly divided in opinion. This led Secretary of Labor Chao to conduct public inquiries into the three questions regarding the nature of ergonomic injury mentioned above (Moffitt Reporting Associates, 2000). No consensus on any of the questions was achieved in any of the three venues where they were presented.

OSHA (2000a) defined a work-related musculoskeletal disorder as a disorder of the muscles, nerves, tendons, ligaments, joints, cartilage, blood vessels, or spinal disks in the neck, shoulder, elbow, forearm, wrist, hand, abdomen (hernia only), back, knee, ankle, and foot associated with exposure to risk factors. In recent years, several theories behind the cause of ergonomic (or musculoskeletal) injury have been explored. None have been discarded, and none has been wholly accepted. In part, this is because there are many work-related musculoskeletal disorder diagnoses. Each work-related musculoskeletal disorder is defined by a collection of symptoms (or syndrome) and may present in different ways, making diagnosis difficult. Many symptoms are shared by many syndrome diagnoses. Additionally, many of the tests considered definitive for specific syndromes have low sensitivity and may only identify cases that are highly advanced (Agency for Healthcare Research and Quality, 2005; Bernard, 1997).

In his article of December 2000, Westgaard observed that although tasks with evident risk, or high exposure levels (e.g., lifting 100 pounds repeatedly while in an awkward posture) are often addressed by ergonomists and employers, a task that has low exposure levels over longer time periods is often missed. The type of risk created by low exposure over time is harder to identify and measurement of risk is not easy. As the risk potential of the task is unclear, the cause is less likely to be addressed. The RULA was developed to assist the ergonomist in focusing on small force, frequent repetition tasks, and rate their risk.

In 1997 the National Institute for Occupational Safety and Health produced a landmark document examining in detail the epidemiological evidence for causation of work-related musculoskeletal disorders. The leading factors they identified were repetition, force, and awkward posture. These are the primary factors addressed by the RULA. Pertinent research is discussed below.

Risk Factors

Byl et al., (1997) related a situation where two owl monkeys are set to a repetitive task against force using different types of grasp. Repetitive finger squeezing (modified pinch) resulted in degradation of the hand representation in the somatosensory cortex and resulted in decreased motor control (some symptoms of work-related musculoskeletal disorders seen in humans). The monkeys that were able to do a more variable and proximal grasp showed less sensory degradation and did preserve motor control. Although this second group of monkeys was required to do motion that was essentially repetitive, it was not always exactly the same motion.

Kumar (2001) proposed that work-related musculoskeletal disorders resulted from a gradual mechanical degradation of the tissue due to repeated and often forceful overuse,. Silverstein, Fine, and Armstrong (1987) found that simultaneous exposure to high repetitiveness and high forcefulness in job activities was most hazardous followed, in order, by high repetitiveness and low forcefulness, low repetitiveness and high forcefulness, and low repetitiveness and low forcefulness. Although the RULA is particularly designed for tasks with high repetitiveness, it also includes a weighting factor for force. There is no suggestion of how one would arrive at this measurement of force or weight in using the RULA. The article McAtamney and Corlett (1993) published after first developing the RULA makes no mention of how force measurement was done in their study.

Hedge, in discussing his early involvement with the RULA, stated that the force factor was included to allow application of an extra increment of risk when force was a significant component of the task and should be applied at the judgment of the rater. As the RULA is a screening tool, it was not intended that specific forces be measured (personal communication, August 20, 2003).

Lin and Radwin (1998) found that with forceful movement they could create a mathematical formulation predictive of subjective discomfort (symptoms of work-related musculoskeletal disorder). Snook, Vaillancourt, Ciriello, and Webster (1997) found that in forceful activity, maximum acceptable torque decreased with increasing work hours in the day and with the days of exposure in the week. There was a concomitant increase in symptoms of work-related musculoskeletal disorders, tactile sensitivity, and task error

rate. Kumar (2001) stated that residual strain, accumulated over time, may create the conditions for injury even if stress levels do not rise excessively.

In attempting to explain work-related musculoskeletal disorders where the cause is not clearly evident, Haag (1991) proposed the Cinderella hypothesis, stating that selective overexertion of low-threshold motor units may explain complaints when risk potential is not clear. He used his hypothesis to explain the presence of injury risk when only a small percentage of maximum voluntary contraction is being used.

Normally, it is expected that following an exertion, the involved muscle fibers will relax, and another fiber take over the work. This alternation of work by the fibers allows a sustained contraction without overworking any one fiber. When the work is no longer required, all fibers should return to a more relaxed state. According to the Cinderella hypothesis, when it is expected that muscle fibers will relax, a small number of fibers may remain in sustained activity.

Haag's hypothesis was examined by Forsman, Taoda, Thorn, and Shang (2002) who were unable to reject the Cinderella hypothesis but did not state they accepted it as a basis for musculoskeletal injury. They found that, although it was more common for motor units to fire once and then be substituted by others, some motor units were continuously active for at least 25 minutes in a low-level static contraction. In the RULA, a rater attempts to account for the physiological stress this type of contractive force creates through giving a higher rating for a position held longer than one minute. In developing the RULA, McAtamney and Corlett (1993) attempted to assign risk, based

on posture as measured by observation of movement while taking into account repetition, force, and static hold, in the realm of the Cinderella hypothesis.

Following an extensive review of epidemiological literature relating to risk factors for upper extremity work-related musculoskeletal disorders, Bongers, Kremer, and der Laak (2002) found that high-perceived job stress was positive in more than 85% of the studies where musculoskeletal disorders were present. In 60% of the studies, high job demands were associated with the report of symptoms. Low job satisfaction was determined not related to incidence of musculoskeletal disorders while lack of control over work was marginally associated. More relevant were risk factors such as worry, tension, and general distress (75%).

It has been proposed that most of the psychosocial component of risk for work-related musculoskeletal disorders is the result of low level muscle activity caused by stress. This has been difficult to examine, but in 1987 Westgaard and Bjørklund found that they could elicit sustained low level muscle activity by manipulating stress in conditions of minimal voluntary movement. They postulated a relationship to local lowered blood flow. The RULA does not guide the user to assess either psychosocial factors or blood flow, but does request a rating for low level muscle activity. Again, the ability of the scale to record muscle activity depends on the skill of the rater. If the rater can observe it, it is recorded. If the rater does not see it, the rater does not record it.

In 2003, Drinkaus et al. studied the RULA in comparison to the Strain Index (Moore, Steven, and Garg, 1995). Raters used both scales to separately determine the hazard level of specific job tasks in an automotive assembly plant. They found that

although there was a similar directional component in scores, the actual hazard ratings were not related. The authors indicated this was because the assessments had a different focus: Whereas the RULA was focused on posture and only rated force at an added 1 point, the Stress Index focused on force and used a multiplier of 3.6 for a task of average intensity.

In its 1997 metaanalysis of work-related musculoskeletal disorders, the National Institute for Occupational Safety and Health found awkward posture strongly related to back, shoulder, wrist, and neck injuries (NIOSH, 1997a). Remple (1994) studied pressure inside the carpal tunnel and found that hand and finger motions are linked to increases in carpal tunnel pressure. He also found that working with the wrist in non-neutral positions increased the internal pressure. Remple related this to risk for carpal tunnel syndrome. Remple has recently stated that he considers awkward posture the strongest risk factor for work-related musculoskeletal illness or injury (personal communication, summer 2004).

In 2002, Choudhary and Sapur reported their investigation of the development of repetitive strain injury in relation to posture. In studying 15 male computer professionals with a focus on mousing, they found the major impact of awkward mousing position was on trapezius and triceps muscles. They postulated that this proximal tension and spasm made the entire upper extremity more sensitive to repetitive motion injury.

Data from epidemiological studies suggest that there is a relationship between the onset of workplace musculoskeletal disorders and forceful, repetitive work, particularly if it is coupled with awkward positions, vibration, or harsh environments (NIOSH, 1997a;

Hildebrant, et al., 2001). The generally accepted risk factors for work-related musculoskeletal disorders are force, repetition, awkward postures, static contraction, vibration, and extreme temperatures (NIOSH, 1997a). The RULA is based on this empirical information. The RULA defines awkward posture by diagram, using neutral joint postures as the best positions and delineating acceptable movement variation ranges. It is the rater's role to choose which diagram most closely approximates the postures assumed by the employee during the work task and apply that rating.

The National Research Council (2001) found that there was no way to separate workplace disorders and individual risk. Risk depends on both the individual's physical and mental makeup and on the workplace. Risk is not body part specific but should be approached in the context of the whole person (National Research Council, 2001).

Westgaard et al., (1996) found that there is a large inter-individual variation in muscle activity level and patterns of contraction among different workers doing the same work tasks. This variation complicates the search for a dose/response relationship between a particular posture or type of repetition and an injury. Although the externally appearing exposure was the same, the internal (or actual) exposure was very different between individuals. This may explain, in part, why one person develops an injury while another individual doing the same activity does not.

If risk varies by the person, perhaps solutions need to be individually designed. The RULA directs the user to look at a specific person performing a specific task. Although individual physiological differences are not addressed by the rater, he or she examines the person and his or her individual technique for task completion. The RULA

focuses specifically on the upper body and does not address other work attributes such as stress or freedom to make decisions. The RULA developers do not claim that the method is sufficient by itself as a work evaluation tool, but suggest that other, non-specified instruments be included in the total evaluation (McAtamney & Corlett, 1993).

Evaluating Ergonomic Risk

Lisle (2001) stated that work done in the field presents more variables than work in the laboratory. Ergonomists working in the field have many of the same problems clinicians encounter and more. Whereas a clinician looks at a person in a relatively stable environment, the field ergonomist studies the real world, where few if any controls can be applied. These raters often rely on observation as the major basis for evaluation and recommendations for controlling injury (Clayton Environmental, 2001; Rogers, 2002; MikeWhite Consulting, 2002).

Portney and Watkins (1993) considered that in evaluations that relied on observation, objectivity was the most important type of reliability. Objectivity looks at how the test and the rater interact. It looks at how a test measures, regardless of the rater. For the evaluation to be used as a communication tool with management or other ergonomists, objectivity is required. This type of reliability shows that there is a consistency across the field, that what one person using the tool identifies as a risk is also identified by others using the same tool. Thus, it approaches Haber and Haber's (1999) ideal of the science-based reasoning chain.

Assessments are used by ergonomics professionals to examine job tasks, the way that people carry out those tasks, and any other factors that may affect the human being in

job performance. In research settings, complex systems have been developed in an attempt to find accurate ways to measure movement and force.

Looking at effect (or what the risk factors have produced in terms of physical damage) and its cause leads to a reliance on highly technical devices that can measure fine differences in muscle tension, force or angle of action, circulation, or even microscopic examination of tissue. The technical approaches include electrode placement on muscles (external), electrode implantation, computer simulation, analysis of videotapes including frame by frame measurement of motion, electromagnetic sensors, microscopic examination of tissues, and others (Byl, et al.; Huang, Feuerstein and Sauter, 2002; Larsson, Oberg and Adams, 2002; NIOSH, 1997, 2001).

Due to the high cost and high time involvement required and lack of portability, work assessments such as these are generally not appropriate for use in the field but serve to help in developing theory and basis for practice. These techniques are essentially “after-the-fact” or experimental processes and do not, without extrapolation to other evaluation techniques, facilitate prevention of injury or illness. For day to day application, it is more appropriate to use the longitudinal studies and the few prospective studies available as a theoretical basis for estimating risk and to look for visible cause.

Huang, Feuerstein and Sauter (2002) particularly mentioned that in the ideal instance, neurobiological research findings would be directly applied at the workplace, identifying risk through direct measurement of physical toll on the individual. That is currently not possible. They further state that enough is known regarding identified risks

that action needs to be taken aimed at reduction of biomechanical and work organization stressors.

Although the type of damage that results in symptoms of work-related musculoskeletal disorders cannot yet definitively be identified, common risk factors have been found. The RULA addresses these risk factors.

Reliability in Ergonomic Assessment

In order for an instrument to be useful to ergonomists for general use in the field, it must be trusted regardless of where it is applied (indoor, outdoor), regardless of weather, temperature, and regardless of the person, task, and tools that are being evaluated. As mentioned by several researchers above, ergonomics must be concerned with the individual.

Because ergonomics deals with the relationship between the person and his or her work, a true picture of what is happening on the job must be obtained. This means that most value will be obtained by assessing the task at the work site where the work is normally done and by observing those who normally do it. The assessment instrument must be portable, easy to apply and not require a great deal of setup. It must be flexible enough to show consistency with several types of tasks and with all types of people. The RULA fits these criteria for tasks that primarily involve upper extremities.

In their survey of tools and methods used by certified professional ergonomists (2005), Dempsey, McGorry and Maynard found that 51.6% had used the RULA in their work. Of that group 28.4% used it once a month or more, while 50.3% used it once per

year or less. The RULA was the most often used posture scale with 159 users. The next most used was the Ovako working posture analysis system with 66 users.

Reliability refers to the consistency of a test across dimensions and raters. Most psychological measurement (such as intelligence tests, motor skills tests, etc.) only claim reliability if the raters are trained and certified in administration of the specific instrument. Ergonomic assessments have not reached for such stringent guidelines. For some, there is little evidence that reliability testing has been attempted. The OSHA office ergonomic checklist from the 2000 recommended evaluations list, for example, was presented without any reliability information and remains on their list of recommended assessment tools (OSHA, 2000b).

In their RULA study, McAtamney and Corlett (1993) found significant correlation between reported pain or discomfort and the presence of identified risk factors in the neck and lower arm. They reported that the RULA was less precise (undefined) but still significant in the wrist and trunk. This does not mean that the risk was not as prevalent in the wrist and trunk, but that pain was not present to such an intense degree or that the RULA was more effective in identifying hazard. The hazard may have been identified before symptoms developed for many people.

In the same article, an attempt was made to establish objectivity by presenting the RULA during training (unspecified) for physiotherapists, industrial engineers, and safety and production engineers. The participants viewed and rated a videotape (4 jobs). Time required for training and any instructions were not indicated. Scores were reported as showing high consistency, but no details were reported either of the process or how high

consistency was determined. It is unclear, but implied, that “high consistency” refers to objectivity. The planned objectivity study will detail the training and experimental process as well as detail the statistical operations used to determine significance.

The RULA is one of the set of evaluations chosen by OSHA for inclusion in its proposal for ergonomic regulation in 2000. It was presented to the human factors and ergonomics community at the Human Factors and Ergonomics Society conference in 1997 and has been used in research projects and by companies for tool design research. It is available on the Internet and is widely used by professional ergonomists. RULA is essentially a checklist for identifying ergonomic risk factors for the upper extremity and back. Essentially, it attempts to take a snapshot of a job task and pinpoint the hazardous components that relate to posture, force, and repetition. It addresses many issues of concern to the ergonomist.

In an informal study, Wynn and Ip (2002) assessed 10 different jobs with both the Rapid Entire Body Assessment (Hignett & McAtamney, 2000) and the RULA. The Rapid Entire Body Assessment is similar to the RULA but has a more involved rating system and addresses both sitting and standing tasks in detail. Hignett and McAtamney found that the RULA scored more conservatively in general (e.g., rated risks as higher than the Rapid Entire Body Assessment). Thus, the RULA indicates intervention at a higher rate than the Rapid Entire Body Assessment. If it errs, it is on the side of safety.

In 1998, the National Safety Council (1999) as part of the ASC Z365, produced a draft document including a scale very similar to the RULA. The rater was required to judge posture by observation and comparison to postural diagrams similar to the Cornell

graphics (Appendix D) but also to answer a wider range of information including the type of position or action (static, slow, moderate rate, or rapid), task duration, and some psychosocially based variables. All of these have been determined by longitudinal studies to be related to development of repetitive strain injury. The document was withdrawn in 2000 without comment and no new version of the scale has been put forth.

Fagarasanu and Kumar (2002), in their review of measurement instruments related to ergonomics, stated that there is a general lack of importance placed on reporting instrument properties in the majority of articles they reviewed. Innes and Straker (1999) reviewed a number of work evaluations in great detail looking for evidence of reliability. They came to the same conclusion. Few assessments demonstrated reliability that they considered strong enough for clinical and legal use. Nonetheless, these are well-trusted tests, often reported in literature.

Innes and Straker further stated that the reliability of an instrument and its testing procedure are crucial to clinicians when performing a client assessment, in monitoring treatment for its efficacy for improving performance, and in treatment planning. If a measurement is reliable, then the changes noted between one evaluation and the next are likely to be indicative of a real improvement or deterioration in the client's abilities, and not due to measurement error.

For the ergonomist, a reliable measure would make it possible to develop better work models, to better determine task risk, and to predict and monitor the effects of changes to the workplace in terms of decreased risk to employees for development of repetitive strain injury.

Methods to Minimize Variance Among Raters

Reviewing the literature on selection of panels, raters and juries, there appear to be two major approaches to obtaining agreement in responses, sometimes used in tandem. They both deal with decreasing the amount of difference between the individuals involved. The first type of control has to do with selecting for specific background or personal experiences.

Cohen (2001) stated that the strongest influence on a jury member is previous experience and previous exposure to the issues being considered in the trial. The closer the juror's experiences match the details of the case being heard, the more likely they are to have an opinion or even a conviction about the issue. This experience can be from direct involvement, from reported experiences of family members or friends, or it can be exposure through television or the press.

Ensuring that all raters have at least a common baseline of understanding and experience limits variability. Among professions, this commonality is assumed to be established through professional training. Sometimes, specific training in the assessment concerned is provided, and at times this includes hands-on practice as a precursor to a research study (American Psychological Association [APA], 2003).

With experience, the ability to know what you are looking for and to recognize it quickly, increases. Signal-detection theory states that this ability is also involved in and affected by the salience of the sensory target. In their article dealing with observation of modeled behavior, Jentsch, Bowers and Salas (2001) began by stating that there is a critical assumption in such rating; that the rater can and does recognize what he or she is

to be looking for. They found that those they termed intermediate and advanced observers (based on exposure to similar tasks in work experience) showed significantly more ability to recognize the target behaviors than the novices.

A second related factor identified by Jentsch, Bowers, and Salas (2001) was the raters' mental model for classification and organization of observation. They hypothesized that this model guides the attention process. Thus, for novices, they recommend detailed instructions for observation that may not be needed by experts. The RULA does not differentiate between novices and experts.

Psychologists have attempted to decrease the amount of variation related to experience in interpretation of evaluation instruments by requiring extensive training in testing and interpreting specific tests, followed by certification. Thus, they ensure a fairly consistent mental model, at least for the beginning evaluator. Ideally, in both paper and pencil and in performance tests, validity and reliability have been established, norms have been developed and practice guidelines clearly outlined (APA, 2003).

Rater Training Techniques

Latimer, Lee, and Adams developed a study in 1996 to identify the best way to teach manual judgments of lumbar posteroanterior stiffness (postural) to physical therapy students. They used immediate quantitative feedback from a reliable mechanical device. During the training, the novice raters were provided with this immediate and accurate feedback for each postural judgment. The instructors were attempting to develop strong mental models by supplying good examples of the target behavior. No significant improvement in observational learning was identified. Ottenbacher, et al. (2002) used 6

hours of direct instruction and supervised, guided practice in manual muscle testing (using the Nichols Manual Muscle Tester) to develop 75–96% consistency with layperson raters (percentage varied depending on the specific test).

In looking at facial expression used to judge pain levels, Solomon, Kenneth, and Farewell (1991) tested raters who attended a 30 - minute training session that focused on four facial movements postulated to be related to pain. They found a significant improvement in the raters' ability to identify patients in pain. In this case, provision of the exemplary model was successful.

In 1998, Müller et al. reported a study of standardized rater training for a psychiatric scale. All raters were trained in basic psychiatry previous to the study. The authors found that three weekly sessions were required to reach 80% general agreement among raters of a schizophrenia syndrome rating scale. They did not report how long the sessions were. Heneman (1988) studied rating accuracy in a laboratory, using 87 supervisors. He was surprised to find that they were better at rating traits than behaviors. Rater training did not appear to have an impact.

Bernardin (1998) felt that the important thing to stress in training raters was the type of errors that might occur. The raters would be made aware of specific types of errors that often occur (leniency error, halo effect, central tendency, and range restriction) and could then avoid them. His study showed greater consistency among the raters after training.

Dr. A. Hedge of Cornell University (personal communication November 2002, August 20, 2003) instructs students in use of the RULA in his applied ergonomics

methods class. Prior to this, they have completed biomechanics and basic ergonomics classes, creating a more consistent mental model. Following the training session, the students complete assigned fieldwork using the RULA.

Hedge bases his lesson plan on the phenomenon of consensus effect studied by Meyer, Gilat, and Erev in 2003. Meyer, Gilat, and Erev described how, among raters, the desire to reach a consensus can affect how observations are scored. The outcomes of scoring decisions depended not only on how the rater assessed the task based on his or her own judgment, but also on the reinforcement this judgment received from others. With repetition of the rating task, variation among raters was minimized.

Dr. Hedge stated that in teaching the RULA he does not use a formal lesson plan. Following introduction of the scale items by PowerPoint, his primary role is moderator of group discussion (April 26, 2004, personal communication). Ratings for each task are discussed with identification of any primary areas of discrepancy. Then the students state why they rated as they did. The next task is shown for rating, and another discussion ensues. He reported improved consistency within the group after using such a process for 3 to 4 different job tasks. Thus, Dr. Hedge closely follows the consensus method. At the time of our discussion, Dr. Hedge had no specific data to report on comparison between the different groups he has worked with.

In 2002, Denis, Lortie, and Bruxelles studied observational reliability among a group of experienced ergonomists and a group of untrained participants viewing videotapes and photographs of a manual materials handling task. Each group was trained separately receiving an initial training session, a practice session, and a post-practice

training. They found that practical experience in ergonomic observation procedures was not a significant factor on reliability. They also found that the experienced participants took longer to complete the rating than the inexperienced group.

These examples of the varied effects of rater training and the amount of training required to produce consistency indicate that there may be no rule of thumb for creating a training session that will produce good control of rater variability, and thereby improve objectivity. The amount of training given in different studies, the type of training, and the success in obtained consistency varies greatly. It is not clear what factors impact success when success is defined as a training plan that produces decreased variability in raters. As there is no clear method indicated, this study will follow the guidance of Dr. Hedge (November 2002, and August 20, 2003, personal communication) and will use the consensus method for specific RULA training in a randomly selected group to be compared with those who do not receive training (see training plan, Appendix F).

CHAPTER 3

Method

The purpose of this study was to determine objectivity of the RULA and to identify any impact that rater background or training in the RULA may have on the manner in which raters apply this assessment. Objectivity is essentially inter-rater reliability, or the trustworthiness of the assessment tool across users. It should be kept in mind that objectivity measures how alike the raters score using the measurement tool. A good level of objectivity does not necessarily indicate that the raters have arrived at a correct assessment of the task.

Presented in this chapter are the methods that were used to determine objectivity of the RULA. Also presented are the methods employed in testing the null hypotheses. The design included four independent variables (see Table 1) and three dependent variables (scores obtained from raters using the RULA). Due to the anticipation of significant email use in this study, one of the first steps taken was to establish a separate email address for the study. All email communication to and from raters and video participants occurred through this address.

Dependent Variables

Three RULA scores were identified as dependent variables. These were the weighted total, the total raw score, and the total for muscle use (sustained posture) and force (together, termed Total Ex).

Raw Score. The raw score is a simple total of all scores for one video task before the weighting criteria are applied. The raw score was chosen for a measure because it

represented the largest score and could be expected to show more variation among the groups. Additionally, this score reflects more clearly the actual choices of raters in using the RULA. Raw Score is also less sensitive to ceiling effects (lack of variation due to many responses at the top of the possible range). The ceiling for this measurement would not be reached unless every item was scored at the highest potential rating.

Weighted Total. RULA scores are indicated by body part (i.e., right wrist, right lower arm, and right upper arm) compiled into a right upper extremity subtotal, with a similar one for the left body side. A rating for neck, trunk, and legs becomes another subtotal. Sub-totals are added to produce two totals, one for each side of the body. Next, a weighting criterion is applied to produce a grand total for each side of the body. The calculation of these totals can be found in Appendix A.

The right and left weighted scores were used by McAtamny and Corlett (1997) to assign their risk rating. A grand right or left total of one or two indicates that a posture is acceptable if it is not maintained or repeated for long periods. Long periods were not defined. McAtamney and Corlett (1993) considered that a grand right or left total of three or four indicates that the job task requires further ergonomic investigation and that changes to the task, tools, or technique may be required. With a grand total of five or six, urgency is placed on the investigation and potential change. A score of seven or more indicates that further ergonomic investigation and changes are required immediately. Subtotals are useful in determining which part of the task is most problematic. For this study, the right and left final scores were added to produce one final weighted total. The maximum possible weighted score was 14.

RULA Experience. RULA experience was defined by the number of times a rater had used the RULA to rate a job task prior to participation in this study. It did not count the experience gained by trainees during the training sessions.

Training. At the end of the recruitment period, 5 raters from each group were randomly selected to attend RULA training sessions (Appendix F). To encourage participation, trainees were selected only from those within an hour drive of San José. Two selected raters declined to participate in the training phase of the study. Replacement raters were randomly selected from the relevant group.

Trainees received a one hour RULA training session based on the consensus effect method as described by Dr. Hedge (personal communication, August 20, 2003) and as presented at the Human Factors and Ergonomics Conference in Houston (Human Factors and Ergonomics Society, 1997). As a group, trainees viewed a PowerPoint introduction to the RULA and participated in several practice rating trials. A video task depicting a job segment was shown while trainees completed individual RULA scoring. Trainees then participated in a group discussion reviewing scoring choices. This was repeated three to five times, until a general consensus on most scores was reached.

Work Practice. Work practice level was determined by the length of time the participant had worked at least half time as an ergonomist. Intern time spent applying ergonomic experience in the field was counted as work experience.

Participants

Two types of participants were involved in this study. The first were employees of the City of San José, who were filmed in their ongoing job processes. These are called

video participants. The second group consisted of people from a wide population range, with ages from 20 through 85 and representative of 15 occupational groups (see Table 2). These were recruited to serve as raters.

Video Participants. Following permission and approval from the Human Subjects Institutional Review Board of San José State University (see Appendix G), a letter of agreement was crafted with the City of San José (see Appendix H) to allow filming of employees in the course of their normal work. Video participants were recruited by members of the City of San José ergonomics team. These participants volunteered to be filmed performing their normal job tasks. Each video participant signed a consent form and photo release form (see Appendix I). Filming was scheduled to coincide with normal job operations and occurred in the normal work setting. Each video participant was filmed using a digital camcorder, performing 2 tasks they normally do in the practice of their job. Film was edited using Pinnacle Studio, version 8 software. Each film ran for 3 minutes and was saved in RealPlayer format.

Raters. Recruited raters were designated into three experimental groups. The novice group had 2.9 years or less experience in ergonomics or any other field that included the measurement of joints postures or observation of movement. The intermediate group had from 3 to 4.9 years of related work. The experienced group had 5 years or more experience with measurement of joint postures and movement observation. From this point, they will be referred to as raters or by their group name of novice, intermediate, and experienced. These levels were self-reported in the rater registration form as work experience (see Table 1).

There is a discrepancy between the work experience requirements of the Board of Certification in Professional Ergonomics (2003) and the Oxford Research Institute (2003) for professional designation. With a master's degree, the former requires 4 years, while the latter requires 5 years. Studies regarding the development of expertise generally state that the time required for its development is approximately 10 years (Ericksson & Charness, 1994; Crowley, Naus, Steward & Friedman, 2003; Barreto & D'Eredita, 2004). With this in mind, the 5 year level was chosen for the experienced designation. Some experienced raters achieved their 5 years of anthropometric observation in fields other than ergonomics (see Table 2).

Procedure

Following permission and approval from the Human Subjects Institutional Review Board of San José State University, (see Appendix G) raters were recruited by letter (Appendix J) and through an open communication to Web based ergonomics discussion groups and roundtables. Recruitment also occurred through the use of posters in the community (Appendix K) and through networking by relatives and friends of the investigator. It was thought that the intermediate group of raters would be hardest to identify and recruit. Raters placed in the experienced group were contacted and asked to assist in recruitment of this group. A total of 104 potential raters responded to recruitment efforts. Following rejection of those diagnosed with repetitive strain injuries and those that dropped out of the study due to technical or time constraints, a total of 75 remained (see Table 2).

Table 2

Participants by Occupation and Work Experience			
	Novice	Intermediate	Experienced
Occupation	<i>N</i> = 30*	<i>n</i> = 18*	<i>N</i> = 27*
Analyst	3	3	0
Artist / Architect	2	0	0
Clerical / Administration	0	2	0
Ergonomist (self-defined)	1	2	10
Human Factors Scientist	1	0	1
Librarian / Library Assistant	2	0	0
Manager	5	3	1
Occupational Therapist	1	0	2
Painting Contractor	1	0	0
Physical Therapist	0	0	4
Physician	2	0	0
Retired	3	0	0
Safety Professional	3	4	7
Student	1	1	1
University Instructor / Teacher	5	3	1

*Numbers from each category that completed the study

Upon receiving notification of a potential rater's interest, a rater registration packet (Appendix E) was sent by U.S. Postal Service or through email. The packet included a letter of welcome, a registration form, and an informed consent for signature. If no response was received within two weeks, attempts were made to contact the

participant. Unless a response was received, the process was initiated again in another two weeks. Eight persons did not respond.

Recruitment continued for two months. As each registration form was received, it was entered into a Microsoft Access TM database, which automatically assigned individual participant code numbers. To insure confidentiality, the participant code was used in handling all data. One database was developed for contact and demographic information. A second database was designed to hold RULA ratings. Review of the registration questionnaires resulted in 17 respondents being disqualified due to previously diagnosed repetitive strain injury. They were mailed a thank you for their offer of participation and one small recognition gift (penlight) but informed that they would not participate (Appendix L).

Raters were asked their occupation. This was used in compiling descriptive information about each group. The use of self-selected occupational designations created some ambiguities. An example of this is one respondent who considered him or herself an ergonomist but had less than a year of work experience. In the same way, one rater who considered him or herself a student had more than 5 years of experience. The first of these was included in the novice group. The second was included in the experienced group.

As soon as the raters were divided into work practice levels, five from each of these levels who was local to San José were selected for training. Training sessions were initiated as described above.

Raters not from the geographic area for trainee selection were immediately sent a rater welcome package (see Appendix m) containing a welcome letter, a set of RULA instructions, a compact disk containing 4 video tasks (see Table 2), and a printed copy of the modified Cornell's RULA (see Appendix D) for reference. Raters within the geographic area for trainee selection, but not selected for training were sent their rater packets as soon as the training group was selected. Trainees received their package following the training session. Those not in the training group did not receive the Microsoft Powerpoint™ presentation.

Each compact disk (CD) was numbered with the rater's participant code number. The compact disk included four video task clips described in Table 1. Video tasks were identified by a number, 1-4. Participants were instructed to view and score the tasks in numerical order, completing one rating before going on to the next. They were also instructed to do this in the first week after receiving the welcome package, within one sitting if possible. Each video task could be reviewed as often as necessary to complete the rating, but once the next video task was started should not be seen again. One rater reported a defective disk and was given a replacement.

A more frequent technical problem was difficulty with CD formatting (12 instances). Although RealPlayer is available without charge on the Internet and is reported to work on Windows, Macintosh, and Linux, it was blocked by some security systems and virus protectors. This was an unexpected problem. The identified solution was to ask the rater to contact their information technology professional to request installation of the program or turn off their virus protection temporarily. In one instance

this did not work and the video tasks were reformatted into Windows Media Player and sent again. Four raters dropped out at this point due to personal time constraints. At the suggestion of one rater, the video tasks were sent by email. When this was found to be successful, the method was suggested to and adopted by other raters to decrease time involvement.

Raters were instructed that the preferred method for scoring the RULA was through use of the Osmond Web page (McAtamney & Corlett, 2000). This Web page prevented missed items and provided automatic calculation of the weighted right and left scores. For submission of study results, the final Web pictorial contained all results and could be copied and emailed or printed and sent in by mail (Osmond Ergonomics Workplace Solutions, 1996).

Early in the data collection process, several raters indicated there were difficulties with the Web page. The Web page functioned only with Internet Explorer as a browser and worked only sporadically with non Microsoft™ systems even when Internet Explorer was the browser. It was decided to send all raters a copy of the modified Cornell's RULA (see Appendix D) by email for use as an option to the Web site. Directions were included for setting up the windows. This would allow side-by-side viewing with the video task. The result was a visual task very similar to that demanded by the Osmond Scientific Web page.

The raters that used the Web page were requested to complete the RULA Addendum. Those that used the modified Cornell version of the RULA would not receive the final weighted score calculations available on the Web page, and therefore

could not complete the RULA Addendum (see Appendix M). Participants emailed the final RULA score sheets and the completed addendum to the research study where the results were entered into the results database. Five participants opted to use the printed paper version of the modified Hedge RULA and sent their results by mail.

Instructions to raters were included in the welcome package as a Word document. These were provided both on paper and as an email attachment (see Appendix M). These directed the rater in accessing the RULA Web page and alternatives. Instructions also indicated basic rating instructions and the circumstances when rater judgment was the primary rating criteria, including selection of the actual posture to rate. These were taken directly from RULA instructions on the Osmond Scientific Web site.

When a participant submitted his or her scores, a letter of thanks (see Appendix N), a penlight, and staple remover with the silk-screened slogan *Ergo on the Go* were sent. Participants also received a booklet outlining the California Occupational Safety and Health Administration required ergonomics training information. In cases where scores were not returned within two weeks, a follow-up contact was made by phone or email. Initial plans were that participants who had not returned their forms within one month of initial mailing date would be disqualified. Exceptions to disqualification from participation were granted when follow-up contact revealed that the participant remained interested in participating and data collection had not closed. Data collection ended four months after the initial mailings.

Study Design

This study was designed to determine objectivity of the RULA and to identify any impact that rater background or training in the RULA may have on this assessment. The null hypothesis was that rater background, work practice in observing anthropometrics, experience with using the RULA, and specific RULA training have no effect on objectivity.

Objectivity. Objectivity is a form of reliability which measures the ability of a scale to accurately reflect the same picture of an item regardless of the rater using it. Cronbach's alpha is the most common test for this purpose and was chosen as the test to determine objectivity. It has been widely accepted for this function and was suggested for this study in confirmation by the Statistics Consultation Service at Sanford University (personal communication, May 16, 2005).

Cronbach's alpha is a correlation that examines the likeness of responses to items on scales or tests. The higher the alpha score, the more reliable the scale is among the raters or test takers. If the alpha statistic is used to test internal scale consistency, a value of .90 to .95 is desirable. For comparing groups, a lower value of .70 to .80 is satisfactory (Bland and Altman, 1997; Santos, 1999; European Commission Directorate General Joint Research Centre, 2004). Scores are expected to fall between 0 and 1. Objectivity was tested for all dependent variables and for all independent variables with acceptable Cronbach's alpha set at .70. Calculations were completed with the use of *Statistical Package for Social Sciences*, version 12.0 for Windows™ (SPSS).

Analysis of Variance (ANCOVA). The analysis of variance (ANCOVA) was used to examine differences between rater responses, to determine the factors that may significantly differentiate raters, and to contribute to objectivity or lack of objectivity. The ANCOVA also compared all variables and potential interactions. This study included both categorical and numerical variables, with raters categorized into one level of each independent variable except in the case of the video tasks. All raters rated all videos. Dependent variables were numerical. Because of this, the type of ANOVA chosen was an ANCOVA, or analysis of covariance. Additional examination of these variables was made through analysis of Tukey HSD tests for multiple comparisons. Another form of ANOVA, the Tukey HSD, tested the relationship between levels in each independent variable. Significance level for all ANOVAs was set at $p \leq 0.05$. Variance attribution and power estimates for ANCOVA and Tukey HSD were estimated within the calculations completed with SPSS software.

RULA Addendum. The RULA Addendum (see Appendix M) was a questionnaire designed to get rater feedback on their opinion of the RULA ratings. When the weighted scores were returned from the Web page, the rater was asked to indicate on a five point scale how much agreement they had with the risk assessment for each task video. Then raters were asked for any other comments about the experience. These results are reported in Chapter 5, Discussion and Conclusions. Only raters who used the Web page were able to complete this form because only they had access to the risk assessment results.

CHAPTER 4

Results

This chapter explores the objectivity of the RULA across all variables and examines variable significance. It includes results from Cronbach's alpha as well as individual ANCOVAs for independent variables, between subject effects, and results from multiple comparisons (Tukey HSD).

Overall Analysis

Objectivity. Cronbach's alpha for independent variables showed a range of -.395 to .68. None of these scores reaches the critical level for objectivity (.07). Negative alphas indicate that rather than the scores trending in a similar direction, they are related by a negative correlation.

Table 3

Cronbach's Alpha for Independent Variables

	Raw Score	Weighted Score	EXtra Score
Work practice	-.22	.07	15
RULA experience	.37	.29	.17
Training	-.395	.68	.57
Video Task	.53	.56	.53

The weighting effect on RULA score moves most raw scores into a more objective direction. This ranges from a -.8 to a + 1.075. Nonetheless, no alphas reach the objective criterion.

Table 4

Analysis of Variance for Independent Variables (ANCOVA, Significant items only)

Source	<i>df</i>	F	η_p^2	<i>p</i>
Video Task (V)	9	9.375**	.105	.000
Work Practice (W)	6	5.634**	.067	.000
Training (T)	3	5.338**	.064	.001
RULA Experience (R)	9	2.216*	.027	.020
W × R	12	3.504**	.056	.000
T × R	3	5.903**	.070	.000
T × W × R	3	3.952**	.048	.009
V × T × W × R	9	1.994*	.025	.035

p* < .05. *p* < .01

Variance. Main effects were identified in all independent variables studied. Results ranged from $p \leq .001$ to $p \leq .05$ (see Table 4). Thus, all identified independent variables affected RULA scoring by the recruited raters.

With this in mind, each of these variables was examined in detail. In particular, the relationship between variable levels and the attribution of variance was considered. Interactions are also discussed below.

Effect of Work Practice

Work practice is defined as number of years spent in an occupation where observation of joint movement or position is a large component of the job. This was to address the skill of matching a picture to a specific joint posture observed during a job task. The RULA was not objective when looking at this variable. An ANCOVA for effect of work practice indicated that this variable had a strong effect on scoring of the RULA. In comparing group levels using the Tukey HSD, significance was found between the novice and the experienced raters, with no significant difference

Table 5
Tukey HSD Comparison of Work Practice Levels

Level Comparison		Raw Total		Weighted Total		Extra Score	
		Mean Difference	Sig	Mean Difference	Sig	Mean Difference	Sig
Novice	Intermediate	.18	.982	.05	.993	.56	.466
Novice	Experienced	2.16*	.755	.86*	.333	1.50*	.364
Experienced	Intermediate	-1.98	.138	-.81	.181	-.95	.143

* $p < .05$.

found for the intermediate level (see Table 5). The Board of Certified Professional Ergonomists and the Oxford Research Institute judged that approximately 5 years was required for development of a professional judgment level, and because there was no significance found at the intermediate level, it is probable that 5 years, or near 5 years, is the actual amount of time required for development of this skill.

Acceptable power is generally estimated at .80 (Keppel, Saufley & Tokunaga, 1992). Power on this ANCOVA was .28, indicating that a real difference between groups would be recognized by this test less than 50% of the time. Approximately 7% of rater variance was attributed to work practice. Increasing sample size would assist in improving power.

Work practice was instrumental in several significant interactions. Essentially, these can be viewed as one variable affecting the effect of another. There is an interaction between work practice and RULA experience. This was expected, as many of those with the most work practice also had the most RULA experience. There is also an interaction between training and RULA experience. Those with more RULA experience who also had training scored differently than those with more RULA experience and no training. Also significant for work practice was an interaction with training and RULA experience and the interaction of all variables.

With current data, the RULA cannot be considered objective among the different work practice levels. This variable does affect the way raters score the RULA.

Effect of Training

Cronbach's alpha results for training showed a mixed relationship in the trained and untrained raters, ranging from near acceptable at .681 to -.395 (see Table 3). Negative scores are not a standard finding from Cronbach's alpha and were caused by a negative correlation. Instead of rating items in generally the same way, the trained and untrained groups tended to rate in opposing ways. (Nichols, 1999).

This difference in trained and untrained raters resulted in an ANCOVA score of $p \leq .001$, or a probability of less than one in a thousand that the differences are due to chance. Training showed most effect on raw total, with weighting factors applied in the RULA providing good control (for weighted score $p \geq .05$). For Training, Tukey's HSD could not be implemented, as there were only 2 levels, trained or not trained.

There was not a significant interaction of training and work experience; however, there was such an interaction with RULA experience. Since this is the case, it is possible that this was a result of the way work experience was defined for this study. If it had only included ergonomists or those with specific types of training, it is possible that the interaction would have been significant. This combination of interactive effects might also result purely from practice effects with the RULA.

Power was a concern for both the weighted score (.136) and the EXtra score (.095) in training. This is far from the set criterion for power of .80. The RULA cannot be considered objective between trained and untrained raters (see Table 3). Training raters using the consensus method does produce a significant effect.

Effect of RULA Experience

Cronbach's alpha results for RULA experience between the different variable levels showed $\alpha = .365$. The ANCOVA for RULA experience was significant. Power on the ANOVA was strong (.84). Multiple comparisons (Tukey HSD) did not identify significant differences among the variable levels. The exception to this was in comparing those who never heard of the RULA and those who have used the RULA 5 times or more. This was shown to be significant both in EXtra score and in weighted score.

Multiple comparisons (Tukey HSD) indicated that a significant difference was present between the novice and the professional groups. Power on the ANCOVA for RULA experience weighted scores was .903. The RULA cannot be considered objective among the different RULA experience levels for raw score. The raw scores were sufficiently different to indicate that the raters who have never heard of the RULA and those who have used the RULA more than 5 times are different.

Significant interactions for RULA experience included work practice and training as discussed above. Additionally, significant interactions were identified in a triune of training, work practice, and RULA experience, although work experience and training were not interactive.

Effect of Video Task

As the purpose of the RULA is to differentiate among tasks to identify which tasks hold more ergonomic risk than others, it was not expected that Cronbach's alpha would show strong correlations. Objectivity on video task was examined in all three dependent variables: raw score, weighted score, and EXtra score. Cronbach's alpha for video task objectivity are reported in Table 3 at $\alpha = .53$. Video task was identified by ANCOVA as a significant variable with $p \leq .01$.

Scores applied to the scanning task by raters were significant compared to all other video tasks for raw and weighted scores. In EXtra score, no difference was identified with the data entry task. These tasks require similar arm postures, and both include primarily small scale movement.

The data entry video task was also significant compared to all other video tasks for raw and weighted scores (Tukey HSD). As above, EXtra score was not significant in comparison to scanning.

Filing was significant against all other video tasks except collating in raw score and weighted score. In EXtra score, this task was significant against all other tasks.

Collating, as mentioned above, was not different from filing except in EXtra score where it was significant against all other tasks. Collating and filing have similar arm postures required. Both have a large component of finger and hand activity in paper handling.

The Task variable was involved in significant interaction with RULA experience. Thus, it appears that people with experience in using the RULA either approached the assessment of task differently or had a different focus on movement.

Further interactions with work practice and RULA experience and in a significant interaction of all identified variables indicate that the Task has a large effect on the scores produced by the raters. The tasks chosen for filming were sufficiently different to provide a good variety for this study.

Summary of Findings

Objectivity. Of the many variables examined, no overall objectivity was identified. A comparison of objectivity in variable levels showed that negative correlations occurred across all dependent variables. Additionally, some correlations between levels reached a negative amount below -1.0. Nichols (1999) states that this type of negative result is an indication that the raters involved are not evaluating the same

thing. It is likely that different levels of the variable chose primarily different parts of the task to evaluate.

For an evaluation scale or an assessment to be used by many different evaluators, this is not what is desired. Unless different people using the same scale to examine the same thing come up with essentially the same result, the measurement tool is not useful.

Variable Significance. This study included both categorical and numerical variables, with raters categorized into one level of each independent variable except in the case of the video tasks. There, the raters participated in all levels. Dependent variables were numerical. Because of this, the type of ANOVA chosen was an ANCOVA, or analysis of co-variance. This decreases degree of freedom but at times will increase significant findings because of the added weight of the covariance. Significance was identified in video task, RULA experience, and in training. Significant interactions were found in work practice $\times$ RULA experience, in video task $\times$ RULA Experience, in training $\times$ work practice $\times$ RULA experience, and in training $\times$ work practice $\times$ RULA experience $\times$ video task (see Table 4).

Some of the interactions not indicated as significant showed test power lower than .50. This indicates that with a true effect present, it would be identified less than 50% of the time. An example of this is task $\times$ training $\times$ work practice, where the power was only .285. The chance of a type 2 error is large due to lack of power.

Variance Attribution. Attribution of variance showed that a large proportion of the variance observed in responses from raters was due to error. In raw score, error accounted for 37.5% of the identified variation. In weighted score, 7.3% of variance was attributed to error. In Ex score, 8.32% of the variance was related to error. Another large proportion of variance was unattributed, that is, it was due to an unidentified source. This amount fluctuated, depending on the variables being addressed. Raw score for training showed no unattributed variance. In fact, raw score for Group showed only .09% unattributed and RULA experience raw score had no unattributed variance. Education raw score showed 23.97% unattributed, while Video Task showed 20.77%.

Table 6

Unattributed Variance (MINQUE)

Source	Raw Score	Weighted Score	Ex Score
Training	0%	82.15%	72.74%
Group	9.33%	77.55%	75.302%
RULA Experience	0%	75.81%	58.86
Education	23.97%	84.46%	72.78%
Video Task	0%	85.77%	54.84%

Other scores tended to show much higher levels of unattributed variance. For training weighted score, unattributed variance was 82.15%, while Ex score was 72.74%. The pattern of more complete attribution of variance or Raw score than the other dependant

variables was consistent. This may be an artifact of the manner in which weighted scores and Ex scores are calculated.

CHAPTER 5

Discussion and Conclusions

Discussion

The genesis of this study came from a desire to identify a good, reliable postural assessment for use in the field, in particular, screening office personnel in local government for ergonomic risk. It was hoped that, although some training might be required, there would be no objectivity concerns in allowing ergonomics team members of various backgrounds to use the RULA as a tool for identifying areas of high concern. It was also hoped that this tool would allow comparison of jobs and work techniques across more than 200 physical locations. To address the variety of employees who might use this assessment and the number of tasks to which it might be applied, several variables and levels were needed.

Power. Acceptable power is generally estimated at .80 (Keppel, Saufley & Tokunaga, 1992). The large number of variables and levels in this study made some computations problematic by decreasing statistical power. This made it difficult to form true judgments about the effect of some variables and interactions. Power ranged from .08 to 1.00, depending on the variable combination and the specific test being used. In addition, the small size of some variable combinations made it possible for outliers to have an inordinately strong effect on statistical results. Observed power in overall variable categories for main effects were good with RULA experience, .807; training, .93; work practice, .997; and video task, 1.0. Power in tests of interaction was often lower, as was power for Tukey's HSD.

Directly related to power and the number of variables were the number of raters.

In order to increase power, more raters would be needed. Although recruiting went on for several months, the number of participant numbers could have been improved, perhaps by targeting several rater characteristics while recruiting instead of focusing only on work practice. This would provide a more even distribution for variables and might have improved the power in statistical tests by increasing power.

Having a trainee group matching the size of the untrained participant pool at each level would have assisted in statistical operations involving training as a variable. Although training was carefully allocated across work practice levels, no other variables were considered in participant selection for training. Having more trained raters would result in a better balance across all variable levels.

The lack of adequate sample size of various occupations may have affected results (see Table 1). It was hoped that sufficient representation from groups such as occupational and physical therapists would be recruited that comparison across occupational categories would be possible. This would allow some acceptance or rejections of the thought that a background strong in biomechanics and actual observation of joint movement would improve objectivity. In actuality, 9 raters were in the targeted categories (see Table 1). Two potential raters declined to participate because their background was purely related to biomechanics, which they felt was inappropriate. Perhaps a clearer statement of purpose could have been written so that these individuals would feel their input would be valuable.

Using larger groups in all levels of RULA experience and developing a study in cooperation with researchers who have occupations in targeted areas might result in stronger results. With a wider geographical representation from investigators, training could also occur in more places, increasing the number and representation of trained raters in different categories.

RULA Format. The visual and presentation differences in the RULA form may have affected results. Many versions of the RULA are available, and each is visually and interactively different. They are used interchangeably throughout the ergonomics community. Paper, Internet, laptop, and PDA (Personal Data Assistant) versions are used interchangeably. Although this was not brought forth as a concern by any of the participants, a valid concern is the different visual images that are used and the possibility that they produce a different scoring pattern.

Some of the concerns brought up by the 6 respondents to the RULA addendum related to a feeling that the RULA overestimated some risks, and that other items of ergonomic concern were not addressed, such as grip or pinch. Another concern was the numerical ceiling of the weighted scores, or the narrow range that was possible only 1 through 7. The ceiling effect did appear in this study in weighted score. It is depicted in Figure 5.

Although the weighted score does hit a ceiling, this is not a true problem. The purpose of the RULA is to detect risk in work tasks. The weighting criteria built into the RULA is designed to provide limits that can quantify risk within bounds. Any task that scores the maximum weighted score requires immediate further investigation and

intervention, whether it is just barely at that level, or whether a particular task would score much higher if the scale allowed. As a measure of risk, if two tasks need immediate intervention (the highest risk level of the RULA), whether one task is much worse than another is not important. They both need the immediate intervention.

Figure 5. Ceiling Effect of the RULA using Ordered Weighted Scores: Total Potential

Score = 14

Another concern brought forth in the RULA addendum was lack of attention to small joint movements and positions. This omission can affect the RULA's usefulness in jobs that are largely finger or manipulation tasks. This speaks to some of the skills and knowledge required of the RULA user. The user is required to know appropriate evaluations for different job tasks and to choose the appropriate assessment for the task being assessed. If the RULA does not measure what you wish to measure, use a different evaluation.

The RULA is not a complete task or risk assessment. It does not pretend to be one. Again, the judgment of the rater is required to bring in other assessments as needed to adequately address the qualities of the task being investigated. This is true, even in task screening. Before choosing the RULA as the assessment of choice, or as part of a screening battery, the essential elements of the job task need to be known and considered.

Task Differentiation. In this study, the RULA was able to differentiate between most tasks. As no true measure of task risk was available, it is possible that the two tasks that were not identified as different actually have the same risk level. Alternately, it is possible that the commonalities of these tasks produced a postural score that does not reflect true risk.

The two nondifferentiated tasks, filing and collating, both require shoulder flexion to more than 90° alternating with shoulder extension to near neutral. Both tasks require some shoulder elevation. Both require lifting and moving of paper. The primary difference was in speed and force, and hand and finger use. RULA addendum responses indicated that raters felt the RULA was able to rate equally well with all tasks.

Rater Differentiation

The work practice variable in this study addressed the length of time the rater had spent in an occupation that dealt closely with anthropometrics or assessment of posture. Work practice was significant at $p \leq .001$. It was only after 5 years of work practice that a difference appeared. In multiple comparisons (Tukey HSD), the experienced group was significantly different from the novice group across all dependent variables (see Table 5).

Other rater characteristics that impacted significance were specific training on the RULA and experience in using the RULA.

Raters were not clearly differentiated by Cronbach α scores. No scores were identified as objective. It may be that different postures were being assessed by different group levels. In the RULA, being able to identify and focus on the correct posture to evaluate may be an important element of expertise with bearing on the objectivity of the assessment and on its utility. This is an element of the RULA that requires further investigation.

Training. In comparing the effect of training between groups, no combination approached acceptable objectivity. Indeed, training appeared to make objectivity worse in the intermediate group (see Table 9). As training was provided in an attempt to decrease variance between raters, this was unexpected. Perhaps other training methods need to be examined for their ability to decrease variability and increase objectivity in RULA use. Following the advice of Dr. Hedge of Cornell University and the protocol used in McAtamney and Corlett's study of 1993, this study used the consensus training method.

The theory behind this method is that people like to agree. In face, they will unconsciously alter the way they score a test so that they develop more agreement with other raters. This is achieved through group discussion of the scoring process. It should produce more rater consensus among trained than untrained raters. In this study, training was a significant variable (see Table 4), but objectivity was inconsistently affected by training (see Table 7). At some variable levels, objectivity improved with training. At

some levels, it appeared to decrease. The consensus training method does not require any particular understanding of the reasons for RULA items, or any theoretical base that might assist the rater in choosing one posture over another in a task for focused rating.

Table 7

Cronbach's α for Group Weighted Score, Effect of Training.

Group	Novice		Intermediate		Experienced	
	Untrained	Trained	Untrained	Trained	Untrained	Trained
Novice	1.0	1.0	.350	.181	.018	.498
Intermediate	.350	.181	1.0	1.0	.594	-.736
Experienced	.018	.498	.594	-.736	1.0	1.0

It is possible that objectivity in the RULA could be improved through application of a different training method. If raters are guided only by their desire to agree with each other, objectivity might decrease once the feedback of the other raters is no longer there. A more didactic method would supply raters with a framework to base their ratings on.

A study design comparing three training methods would allow a comparison of the consensus method, a didactic method, and a combination method, where practice of RULA use along the consensus model combined with some training in the actual risk factors and postures employed in developing the RULA might provide some useful information.

Objectivity. There were few instances when Cronbach's alpha approached objectivity (.70). Frequently, Cronbach's alpha was in the negative range. With any assessment or evaluation, this is not desired. It indicates that the raters are not reacting the same way to the question. In some cases, where the negative value is less than -1, it indicates probability that raters are actually not evaluating the same thing. In the RULA, this is very possible. Most job segments require several postures from the worker. The RULA requires the rater to make a judgment about which posture to choose for evaluation. The video tasks mimicked work in the field by requiring the rater to make this judgment. It is very possible that different postures were chosen for evaluation by the different groups.

Video Task Design. The videos in this study were developed to mimic actual job situations. The rater approaches a job and views it in progress. Few jobs except assembly line tasks consist of only one action. The RULA rater is instructed to choose the posture most representative of the job task for evaluation. This choice may require expertise or background.

The videos used in this study presented a beginning, middle, and end to the job task. They also presented the job task from several angles, so that joint postures could be assessed without strong foreshortening or occlusion effects. This resulted in increasing the rater difficulty level. Preparing videos from one point of view and comparing rater scores with videos with a more complex design across rater experience and training might yield useful information for future standardization of RULA training.

Recommendations for Future Study

As was shown in this study, several versions of the RULA are available for use. Many have very different perceptual and physical characteristics. Each one has a different body and joint depiction. Some are Web based, and some are paper based. One useful study for the future would be to compare scoring results of several of RULA versions using standardized tasks.

Does the RULA identify risk? Tasks with known risks, such as a history of injuries related to specific postures and actions, would be examined with the RULA to see if those particular job actions are identified as “risky.” In the same way, two tasks with similar postural requirements and known risks that are at different levels may be studied to discover if the RULA does show a differentiation in risk level.

Training in the RULA has generally followed the consensus model. Comparison of the effects of different training approaches may yield a method that is more effective at improving objectivity.

What is the agreement between trained observer RULA ratings and user's self-ratings of posture using RULA? In some companies, and indeed some ergonomists recommend this, users are encouraged to self-apply RULA. This is not how the method is supposed to be used, and it might yield quite inaccurate results (Dr.A. Hedge, personal communication, August 20, 2004).

What is the agreement between RULA observations made by actual observation at a job site and RULA ratings that are made based on a video of the same job, viewed from the same angle or a different angle? Some ergonomists record videos and then make

RULA assessments using the video as a base, as was done in this study. How are judgments of angular deviations different when viewing the actual job?

RULA is like a snapshot; it's a "photograph" of potential postural risk. Which tasks and positions are analyzed? Most jobs comprise a variety of tasks and positions. Selecting the one that may present the greatest injury risk and is salient requires trained judgment and skill. How similarly do different observers make this selection?

Because RULA is a snapshot, it is designed to be used repeatedly to characterize a job. This is generally not done. If the RULA was used to measure the way work was done over a day, would there be a difference between morning and evening performance? What would happen to RULA scores if measurement occurred several times a day over a work week?

Perhaps Hedge (2002) was correct in his estimation that a background in biomechanics and ergonomics is necessary to use the RULA with objectivity, and perhaps that is sufficient. This could be the basis of another study.

Summary

At first glance, the RULA, especially the Osmond online version, appears an easy evaluation to do. Because this is true, it will be and is being used by a large number of raters who are untrained and do not have appropriate background. An anonymous source has reported that employees in some companies have been instructed to do the RULA on themselves. The availability and seductive simplicity of the RULA invites inappropriate use. Guidelines and perhaps a formal certification structure need to be developed for this assessment so that, once a method of training and experience criteria are developed for

the RULA that produces raters who have consistent and objective results, the RULA can be widely used with trusted results. This will prevent unneeded expenditure by employers to address misidentified risks in job tasks and direct costs to real job risks. It will prevent degradation of the RULA's reputation and thereby the reputation of ergonomists who appropriately employ the RULA.

Stanton and Young's 1998 article in *Applied Ergonomics* stated that those who employed ergonomic methods were generally unaware of any evidence in published studies of reliability or validity for the methods they used. The article may be pointing to an endemic problem in the field that should be addressed at some point. Ergonomists do not have a consistent background and theory base. Identification of problems and suggestion of different solutions depend on what the practitioner is familiar with. Concern with reliability and validity is a start towards unification.

In his discussion of how to train physicians in the practice of diagnosis, Heeger (2003) considered the set of different possible symptoms related to a diagnosis. He was also aware of other diagnoses these combinations of symptoms might suggest. Choosing the correct symptoms to focus on as important would lead to a correct diagnosis (unspecified in the article). Unrelated symptomatology presented by the patient increased the difficulty of determining diagnosis correctly. In ergonomics, dealing with jobs in the field and the multitude of variables found there, identification of the problem, or diagnosis, can be a complex issue. How can we become experts?

Identifying the true knowledge base required to appropriately and consistently apply the RULA to job tasks remains an issue. Perhaps a background in biomechanics

and ergonomics is sufficient. No group in this study completely met those criteria. Ideally, Haber and Haber's science-based reasoning chain (1999) should be the goal, where two ergonomists looking at the same information with the same tools will reach the same conclusion.

The first null hypotheses, H_o^1 , is rejected. Rater background and anthropometric experience have an effect on RULA objectivity. The second hypothesis, H_o^2 , is rejected. With the training method used, specific training in the RULA did have an effect on RULA objectivity. The third hypothesis, H_o^3 , is accepted. Objectivity did not change with experience in using the RULA, i.e. there was no increase in rater objectivity across the 4 task ratings or the 4 levels of RULA experience as identified for this study.

In the provision of reliable information regarding task analysis, there are essentially two issues. The first issue is the reliability of the evaluation tool. The second is the knowledge and skill of the evaluator, so that the tool is used and interpreted in a reliable manner. As things stand, the RULA cannot be considered objective. It is possible that working with the variables that have been identified as having an effect on the manner in which the RULA is scored by raters, a curriculum or practice protocol can be established that will result in acceptable objectivity.

Based on the data collected the sample measured and the variables studied, the RULA cannot be considered an objective measure. Until these issues are addressed, it is not recommended that the RULA be used.

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APPENDIX A

Original Cornell RULA with Calculation Matrix

RULA Employee Assessment Worksheet

Complete this worksheet following the step-by-step procedure below. Keep a copy in the employee's personnel folder for future reference.

A. Arm & Wrist Analysis

Step 1: Locate Upper Arm Position

Step 1a: Adjust...
If posture is neutral, score = 1.
If posture is slightly abducted, score = 2.
If posture is abducted, score = 3.

Step 2: Locate Lower Arm Position

Step 2a: Adjust...
If posture is neutral, score = 1.
If posture is slightly flexed, score = 2.
If posture is flexed, score = 3.

Step 3: Locate Wrist Position

Step 3a: Adjust...
If posture is neutral, score = 1.
If posture is slightly twisted, score = 2.
If posture is twisted, score = 3.

Step 4: Wrist Twist:
If wrist is twisted mainly in one range = 1.
If wrist is at or near end of working range = 2.

Step 5: Look-up Posture Score in Table A

Step 6: Add Muscle Use Score

Step 7: Add Force/load Score

Step 8: Find Row in Table C

SCORES

Table A

Upper Arm	Lower Arm	Wrist	Wrist Twist	Muscle Use	Force/load
1	1	1	1	1	1
1	1	2	1	1	1
1	1	3	1	1	1
1	2	1	1	1	1
1	2	2	1	1	1
1	2	3	1	1	1
1	3	1	1	1	1
1	3	2	1	1	1
1	3	3	1	1	1
2	1	1	1	1	1
2	1	2	1	1	1
2	1	3	1	1	1
2	2	1	1	1	1
2	2	2	1	1	1
2	2	3	1	1	1
2	3	1	1	1	1
2	3	2	1	1	1
2	3	3	1	1	1
3	1	1	1	1	1
3	1	2	1	1	1
3	1	3	1	1	1
3	2	1	1	1	1
3	2	2	1	1	1
3	2	3	1	1	1
3	3	1	1	1	1
3	3	2	1	1	1
3	3	3	1	1	1

Table B

Neck	Trunk	Legs	Posture Score
1	1	1	1
1	1	2	2
1	1	3	3
1	2	1	2
1	2	2	3
1	2	3	4
1	3	1	3
1	3	2	4
1	3	3	5
2	1	1	2
2	1	2	3
2	1	3	4
2	2	1	3
2	2	2	4
2	2	3	5
2	3	1	4
2	3	2	5
2	3	3	6
3	1	1	3
3	1	2	4
3	1	3	5
3	2	1	4
3	2	2	5
3	2	3	6
3	3	1	5
3	3	2	6
3	3	3	7

Table C

Upper Arm	Lower Arm	Wrist	Wrist Twist	Muscle Use	Force/load	Posture Score
1	1	1	1	1	1	1
1	1	2	1	1	1	2
1	1	3	1	1	1	3
1	2	1	1	1	1	2
1	2	2	1	1	1	3
1	2	3	1	1	1	4
1	3	1	1	1	1	3
1	3	2	1	1	1	4
1	3	3	1	1	1	5
2	1	1	1	1	1	2
2	1	2	1	1	1	3
2	1	3	1	1	1	4
2	2	1	1	1	1	3
2	2	2	1	1	1	4
2	2	3	1	1	1	5
2	3	1	1	1	1	4
2	3	2	1	1	1	5
2	3	3	1	1	1	6
3	1	1	1	1	1	3
3	1	2	1	1	1	4
3	1	3	1	1	1	5
3	2	1	1	1	1	4
3	2	2	1	1	1	5
3	2	3	1	1	1	6
3	3	1	1	1	1	5
3	3	2	1	1	1	6
3	3	3	1	1	1	7

B. Neck, Trunk & Leg Analysis

Step 9: Locate Neck Position

Step 9a: Adjust...
If posture is neutral, score = 1.
If posture is slightly flexed, score = 2.
If posture is flexed, score = 3.

Step 10: Locate Trunk Position

Step 10a: Adjust...
If posture is neutral, score = 1.
If posture is slightly flexed, score = 2.
If posture is flexed, score = 3.

Step 11: Legs

Step 11a: Adjust...
If posture is neutral, score = 1.
If posture is slightly flexed, score = 2.
If posture is flexed, score = 3.

Step 12: Look-up Posture Score in Table B

Step 13: Add Muscle Use Score

Step 14: Add Force/load Score

Step 15: Find Column in Table C

Final Score =

Subject: _____

Company: _____

Department: _____

Date: _____

Scorer: _____

FINAL SCORE: 1 or 2 = Acceptable; 3 or 4 investigate further; 5 or 6 investigate further and change soon; 7 investigate and change immediately
 Source: *McAtamney, L. & Corlett, E.N. (1993). RULA: a survey method for the investigation of work-related upper limb disorders. Applied Ergonomics, 24(2), 91-99.*
 © Professor Alan Hedge, Cornell University, Feb. 2001.

APPENDIX B

Copyright Release from Osmond Group, Ltd.

Thank you for your email. We did send a response to your original enquiry - I am not sure why you would not have received it. We do allow people to use the resources and our websites so long as they are not altered in any way.

Best Regards

Andrew Kennedy

Customer Service Manager

T:0845 3450898

E: andrew.kennedy@ergonomics.co.uk

Osmond Group Limited

21 Johnson Road, Ferndown Industrial Estate, WIMBORNE BH21 7SE, UK

T: +44 (0)1202 850550 F: +44 (0)1202 850560 W: <http://www.ergonomics.co.uk>

Please visit our free online Posture Guidance at <http://www.ergoergo.info>

This e-mail:

- is not contractual nor shall it be taken to create any legal relations, contractual or otherwise
- represents the personal views of the author/sender. The author/sender has no authority or delegation to bind Osmond Group by this e-mail and Osmond Group accepts no responsibility whatsoever for its contents
- is communicated in confidence. It is intended for the recipient only and may not be disclosed further without the express consent of the sender.

From: vjh [<mailto:vjhixson@comcast.net>]

Sent: 27 October 2004 02:55

To: Andrew Kennedy

Subject: RULA and Thesis[Scanned]

I wrote to you a couple of days ago requesting permission to use your website and PDF files in my Master's thesis research project. I have had some difficulty finding out how to direct my request. I have contacted Lynne Mills who told me to contact Dr. Hedge at Cornell University. He gave me total permission to use what I wanted, but I remain unsure if this includes your graphics and website, or only his information from Cornell.

At this point, due to time pressures, and a lack of response from your offices, I have decided to use the Cornell information, although I would prefer to use yours.

Please get in touch with me regarding your policies for any future endeavors.

Virginia J. Hixson

Human Factors Analyst

(408)277-3038

APPENDIX C

Copyright Release from Alan Hedge

--

Professor Alan Hedge, PhD, CPE
 Director, Human Factors and Ergonomics Laboratory
 Co-Director, Design Concepts Laboratory
 Cornell University
 Dept. Design and Environmental Analysis
 MVR Hall, Forest Home Drive
 Ithaca, NY 14853-4401, USA

Phone: 607-255-1957

Fax: 607-255-0305

URL: <http://ergo.human.cornell.edu> Virginia:

I'm glad to allow this - you have my permission.

Alan

>

> Good morning,

>

> Some time ago I wrote to you to request release of copyright for use of
 > the RULA in my masters thesis. You were kind enough to oblige. Now,
 > having just received the booklet for publication submission, I find that
 > the requirements are more detailed than previously stated to me. The
 > publisher requires that the permission letter state that ProQuest
 > Information and Learning needs permission to supply copies on demand (as
 > the Word document is included in my appendix). Will you allow this?

>

> Please reply ASAP. I received the booklet just before Christmas, and have
 > submission date of January 6th.

>

> Virginia J. Hixson
 > Human Factors Analyst
 > (408) 975-2552
 > (408) 400-0406
 > Virginia J. Hixson
 > Human Factors Analyst
 > (408) 773-1404

> -----Original Message-----

From: Alan Hedge [mailto:ah29@cornell.edu]

Sent: Monday, June 20, 2005 9:38 AM

To: Hixson, Virginia

Subject: RE: RULA: finishing, finally. One last request.

Hi Virginia:

Good luck - I'm sure you'll do a fine job. I'd like to hear about your thesis findings when the dust has settled.

Best
Alan

At 12:24 PM 6/20/2005, you wrote:

Thank you Dr. Hedge.

My Orals are July 13th.

This e-mail message, including any attachments, is for the sole use of intended recipient(s) and may contain confidential and protected information. Any unauthorized review, use, disclosure or distribution, without the express permission of the originator is prohibited. If you are not the intended recipient or an employee or agent responsible for delivering the communication to the intended recipient, please contact the sender by reply e-mail and destroy all copies of the original message

Virginia Hixson, O.T (L), C.A.E.
Ergonomics Program Manager
Employee Services / Safety and Health Division
City of San Jose
801 North First Street, Room 207
San Jose, 95110
phone: (408) 277-3038
fax: (408) 288-7894

-----Original Message-----

From: Alan Hedge [mailto:ah29@cornell.edu]

Sent: Monday, June 20, 2005 9:17 AM

To: Hixson, Virginia

Subject: Re: RULA: finishing, finally. One last request.

Dear Virginia:

Congratulations on getting to submitting your thesis. I am pleased to give your permission to use the RULA from the CUErgo web site. Keep me posted on your thesis progress.

Best

Alan

At 11:52 AM 6/20/2005, you wrote:

Good Morning, Dr. Hedge,

I spoke with you several times in the past about my thesis. Your input has been invaluable. At this time, I am formally submitting my thesis, and have discovered that I cannot find the e-mail with your approval to use your version of the RULA. You stated that if needed, I could enlarge the pictures and change the format. I did that in my study, but now require some written documentation.

Please respond with your approval and copyright release. (I'll send you a copy of the final paper, if you wish)

This e-mail message, including any attachments, is for the sole use of intended recipient(s) and may contain confidential and protected information. Any unauthorized review, use, disclosure or distribution, without the express permission of the originator is prohibited. If you are not the intended recipient or an employee or agent responsible for delivering the communication to the intended recipient, please contact the sender by reply e-mail and destroy all copies of the original message

Virginia Hixson, O.T (L), C.A.E.
Ergonomics Program Manager
Employee Services / Safety and Health Division
City of San Jose
801 North First Street, Room 207
San Jose, 95110
phone: (408) 277-3038
fax: (408) 288-7894

-----Original Message-----

From: Virginia Hixson [mailto:vjhixson@attbi.com]
Sent: Sunday, September 08, 2002 10:04 AM
To: Hixson, Virginia
Subject: Fw: rula

----- Original Message -----

From: Alan Hedge
To: Virginia Hixson
Sent: Sunday, September 08, 2002 5:55 AM
Subject: Re: rula

Dear Virginia:

RULA was developed as a rapid screening tool for use by ergonomists in the EC. In the original article (McAtamney, L. & Corlett, E.N. (1993) RULA: a survey method for the investigation of work-related upper limb disorders, Applied Ergonomics, 24, 91-99) as I recall I think there's some validation data and maybe some inter-rater reliability data. One issue is that when used correctly RULA is taught until raters attain a satisfactory level of inter-rater agreement (e.g. when I teach it in my classes at Cornell, typically on the first use there's variation in scores between students, but as this is repeatedly practiced so scores fall into agreement. I find RULA to be quite a trustworthy tool when used correctly.

I hope that some of these suggestions are of use. Let me know if you have any questions.

Good luck with your graduate work.

APPENDIX D

Research Version, Cornell RULA

Rapid Upper Limb Assessment

Assigned Number of Assessor¹: _____

What is the Task Video Number²: _____

Date of viewing _____

Complete the worksheet, placing an 'X' in the box below the picture that most represents what you see in the task video. Be sure to choose at least one answer in each category. If you are unsure of your answer, take your best guess. There is no real 'right' answer. Your Assessor number is the number on your CD. Save the four forms first, named 'Task 1, Task 2, etc.

Then, as you open the CD video file, open the related form, and fill it out. When finished, save your answers.

Right Side:

Right Upper Arm (choose one of the pictures below)

				<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;">Yes</th> <th style="width: 50%;">No</th> </tr> <tr> <td style="text-align: center;">Is Shoulder raised?</td> <td></td> </tr> <tr> <td style="text-align: center;">Is upper arm abducted (held away from the body)?</td> <td></td> </tr> <tr> <td style="text-align: center;">Is the worker leaning or supporting weight on the arm?</td> <td></td> </tr> </table>	Yes	No	Is Shoulder raised?		Is upper arm abducted (held away from the body)?		Is the worker leaning or supporting weight on the arm?	
Yes	No											
Is Shoulder raised?												
Is upper arm abducted (held away from the body)?												
Is the worker leaning or supporting weight on the arm?												

Move on to Right Lower Arm

Right Lower Arm (Choose one of Diagram 1 – 3)

60 to 100° flexion	0 to 60° Flexion	More than 100°	Answer questions below

Yes	No
-----	----

Is arm rotated outward?

Do arms cross the midline of the body?

Right Wrist (Choose one of diagrams 1-3)

Wrist is straight, up and down	0 – 15° Extension	0 – 15° Flexion

Is wrist bent away from midline?
ANSWER BELOW

Yes	No
-----	----

Is wrist bent sideways?

Is wrist extended or flexed more than 15°?

Is wrist twisted?

Is twist near the end of twisting range?

Yes	No

Muscle Use, Force and Load for Right

Is posture mainly static (held for longer than 1 minute)?

Is action done repeatedly, 4 times a minute or more?

LOAD

Is load less than 5 lbs (and intermittent)?

Is load 5 to 20 lbs (intermittent)?

Is load 5 to 20 lbs. (static or repeated)?

Is load more than 20 lbs. or repeated, or shocks?

Yes	No
-----	----

--	--

Yes	No
-----	----

--	--

--	--

--	--

--	--

Move on to Left Side

Left Side:

Left Upper Arm (Choose One)

-20° to +20°	More than 20°	+20° to 45°	+45° to 90°	More than +90°

Is Shoulder raised (hunched up)? Is upper arm abducted (held away from the body)? Is the worker leaning or supporting weight on the arm?	Yes	No

Left Lower Arm (Choose one of 1st three pictures)

60° - 100°	0° - 60°	More than 100°	More than 100°

Answer questions below	
Yes	No

Is arm rotated outward? Do arms cross the midline of the body?	

Move on to Left Wrist

Left Wrist

0° (straight up and down)	0° - 15° extension	0° to 15° flexion	Is Wrist Bent away from midline?	
			Answer below	
			Yes	No
Is wrist bent sideways, away from midline?				
Is wrist Flexed or Extended more than 15°?				
Is wrist twisted?				
Is twist near the end of twisting range?				
Muscle Use, Force and Load for Left				
			Yes	No
Is posture mainly static (held for longer than 1 minute)?				
Is action done repeatedly, 4 times a minute or more?				
LOAD				
Is load less than 2 kg (and intermittent)?				
Is load 2kg to 10 kg (intermittent)?				
Is load 2kg to 10kg (static or repeated)?				
Is load more than 10kg or repeated, or shocks?				

Move on to Neck, Trunk and Legs.

Neck, Trunk and Legs

Neck

In Extension

	Yes	No
Is neck Twisted?		
Is neck Side-bending?		

Trunk

0° - 20°

20° - 60°

More than 60°

	Yes	No
Is Trunk Twisted?		
Is Trunk Side-bending?		
If seated, is back well supported?		
Are Legs and Feet well supported and balanced?		

Muscle Use, Force and Load for Left

	Yes	No
Is posture mainly static (held for longer than 1 minute)?		
Is action done repeatedly, 4 times a minute or more?		
LOAD		
Is load less than 2 kg (and intermittent)?		
Is load 2kg to 10 kg (intermittent)?		
Is load 2kg to 10kg (static or repeated)?		
Is load more than 10kg or repeated, or shocks?		

You've finished this task evaluation. Congratulations!

APPENDIX E

Registration Package

RULA Research Study Summer / Fall 2004

Registration Packet

San José State University
Graduate Studies and Research
Systems Engineering and Human Performance Departments

Primary Researcher:	Virginia Hixson
Phone	408- 277-3038
e-Mail	rularesearch@comcast.net

San José State UNIVERSITY

Human Performance Department

Spartan Complex, SPX 56
One Washington Square
San Jose, CA 95192-0085
Voice: (408) 924-3018
E-mail: hup@sjsu.edu
E-mail: afreitag@hup.sjsu.edu
<http://www2.sjsu.edu/depts/casa/hup>

The California State
University:
Chancellor's Office
Bakersfield, Channel Islands,
Chico, Dominguez Hills,
Fresno, Fullerton, Hayward,
Humboldt, Long Beach,
Los Angeles, Maritime
Academy, Monterey Bay,
Northridge,
Pomona, Sacramento, San
Bernardino, San Diego, San
Francisco,
San Jose, San Luis Obispo,
San Marcos, Sonoma,
Stanislaus

RULA Study
801 North First Street, Rm. 207
San Jose, Ca. 95110
Phone: (408)277-3038
Fax: (408)288-7894

Dear Participant:

Thank you for your help in this study. You are assisting in the development of knowledge about ergonomics that will be useful for many years to come.

Assessments are used by ergonomics professionals to examine job tasks, the way that people carry out those tasks, and any other factors that may affect the human being in job performance. All are aimed at identification of risk, most toward Work Related Musculoskeletal Disorders (Work Related Musculoskeletal Disorders). Few are well researched. Although they may be theoretically sound, their reliability in settings other than where they were developed has not been confirmed.

The purpose of this study is to identify and test the objectivity of a work assessment that is portable, easy to apply and does not require a great deal of set-up. The main tools generally needed are a pencil, the recording form and good observational skills. For this study, you will need a computer with a CD drive and access to the internet.

We are looking for a group of raters representing many different backgrounds and training levels. As a first step in this process we are collecting information about potential raters and their backgrounds.

Please complete the enclosed forms and return them as soon as possible in the enclosed pre-addressed and stamped envelope or by e-mail.

After your registration as a rater, you will receive a video showing four job scenarios. You will be asked to review the video and rate each job for ergonomic risk factors using the Rapid Upper Limb Assessment.

Your participation in this study will help in taking an important step in establishing a valid approach to work hazard identification. In turn, this supports the development of ergonomic science.

As a thank you for your time and effort, you will receive a small gift at the completion of this study and, if you wish, a copy of the completed work.

From this point on, material you return will be identified only by number. Except for the information on the Informed Consent, please do not include your name or other identifying marks on any papers. When you return information by e-mail, the attachment or information will be saved prior to opening under your rater number.

Again, thank you for your participation.

Virginia J. Hixson
Graduate Student, HFE
San Jose State University
rularesearch@comcst.net

RATER REGISTRATION

Date: _____

Age	20-29 yrs ☐	30-39yrs ☐	40-49yrs ☐	50-59yrs ☐	60-69yrs ☐	Over 69 yrs ☐
Gender	(optional)	Female ☐	Male ☐			

Primary Occupation _____

If contact is necessary, would you like to be contacted by:

Phone: _____

e-mail: _____

Mailing address for the

CD: _____

Have you ever experienced a Repetitive Strain Injury?

Education / Training (This information is required)

High School graduate ☐

AA degree _____ Major _____

BA degree _____ Major _____

MA degree _____ Major _____

Additional Licenses, Certifications, Registrations, etc. _____

Specific training in Ergonomics:

Number of Hours (approximately)

Provider:

Subjects Covered (Main Focus):

Number _____

Is your job or consultation related to employee Safety
 Is there a component of Work or Movement Observation in your work?
 If yes, approximately how many hours per week?

Yes	No

EXPERIENCE: How long have you worked in ergonomics or a field that involves close observation of human movement?

0-2.9 Years _____ 3-4.9 Years _____ More than 5 Years _____

Rapid Upper Limb Assessment

I have never heard of it

 I have heard of it or read about it

 I have used it once or twice but not in my work ..
 I have used it in my work less than 10 times
 ...
 I have used it in my work more than 10 times

 I have had training in using the RULA

Please return these forms using e-mail or snail mail to the primary researcher as soon as possible so that the study can begin. Your typed name and the e-signature of your computer is acceptable.

Initial at the bottom of page 4

Signature at the bottom of page 5

Initial at the bottom of page 6

Thank you for your assistance.

Virginia Hixson
 801 North First Street, Rm. 207
 San José, CA 95110
 USA
 rularesearch@comcast.ne

Agreement to Participate in Research

San José State UNIVERSITY

Human Performance Department

Spartan Complex, SPX 56
One Washington Square
San Jose, CA 95192-0055
Voice: (408) 924-3018
E-mail: hup@sjsu.edu
E-mail: afreitag@hup.sjsu.edu
<http://www2.sjsu.edu/depts/casa/hup>

Responsible Investigator(s): Virginia J. Hixson

Title of Protocol: Effect of Rater Background on Objectivity of the Rapid Upper Limb Assessment

1. You have been asked to participate in a research study investigating the objectivity of an observational scale designed to identify postures that increase risk for work related musculoskeletal injury.
2. You will be filmed while doing a work task. The resulting video will be presented on a CD including work task videos of other office workers, to raters who will rate the postures you use while on the job using a scale they will be provided with. The focus of this research is on how the scale is used, not how the job is done.
3. You may experience some mild anxiety or uncertainty about your task performance, but there is no reason to be concerned. There is no reason to expect that any harm might befall you.
4. For your participation you will receive some increased knowledge of ergonomics as well as some small tokens of appreciation. These will include a pen light, a staple remover, and a booklet detailing some basic ergonomic information and the California repetitive strain regulation. You will also have the satisfaction of having contributed to the development of increased knowledge about ergonomics.
5. Although the results of this study may be published, no information that could identify you will be included. Any pictures will have the face occluded for publication.
6. No compensation will be provided except the items as mentioned above.
7. Questions about this research may be addressed to:
Virginia Hixson
Employee Services
801 North First Street, Room 207, San José
Phone: 408-277-3038
8. Complaints about the research may be presented to

**The California State
University:**
Chancellor's Office
Bakersfield, Channel Islands,
Chico, Dominguez Hills,
Fresno, Fullerton, Hayward,
Humboldt, Long Beach,
Los Angeles, Maritime
Academy, Monterey Bay,
Northridge,
Pomona, Sacramento, San
Bernardino, San Diego, San
Francisco,
San Jose, San Luis Obispo,
San Marcos, Sonoma,
Stanislaus

Dr. Greg Payne, Department Chair
Human Performance
San José State University
1 Washington Square, SPXC 56
San José, 95054
Phone: 408-924-3028

Participant Initials	
Researcher Initials	

9. Questions about research subjects' rights, or research-related injury may be presented to

Pamela Stacks, Interim Associate Vice President,
Graduate Studies and Research, at
(408) 924-7029

10. No service of any kind, to which you are otherwise entitled, will be lost or jeopardized if you choose to "not participate" in the study.

11. Your consent is being given voluntarily. You may refuse to participate in the entire study or in any part of the study. If you decide to participate in the study, you are free to withdraw at any time without any negative effect on your relations with San Jose State University or with any other participating institutions or agencies.

12. Upon receipt of the signed consent form, the investigator will send you a copy for your records, signed and dated by the investigator.

- **The signature of a subject on this document indicates agreement to participate in the study.**
- **The signature of a researcher on this document indicates agreement to include the above named subject in the research and attestation that the subject has been fully informed of his or her rights.**

_____ Date _____
Signature

Virginia J. Hixson Sept. 20, 2004
Investigator's Signature Date

Individuals Being Asked to Participate in Research Have the Following Rights

- To be asked to participate, as a subject, in a study involving human subjects in an open, honest, and non-coercive manner.
- To be told the project is research.
- To be told what the study is investigating.
- To be told exactly what will be required, including where and when the study will occur and what materials and/or devices will be employed.
- To be clearly informed of any possible risks or inconveniences, including psychological stress, physical stress, or harm.
- To be told about any possible benefits that might reasonably be expected from participation in the study.
- To be encouraged to ask questions concerning the study before and during the course of the study.
- To be assured that no service to which a person is otherwise entitled will be lost or jeopardized if a person chooses not to participate in the study.
- To be informed that subjects have the right to choose not to participate in the study or in any part of the study.
- Additionally, if subjects choose to participate in the study, they may withdraw at any time without prejudice to their relations with San Jose State University.
- To receive a copy of the signed and dated Consent Form. Or, if a consent form is not used, to be given a list of appropriate contact numbers to be used in the event of harm or complaints.

Basics of Informed Consent

- No investigator may involve a human being as a subject in research unless the investigator has obtained the legally
- effective informed consent of the subject or the subject's legally authorized representative as specified by the SJSU
- policy for the Protection of Human Research Subjects.
- Unless waived by the HS-IRB, informed consent shall be documented by the use of a written "Consent Form" signed by the subject or the subject's legal representative and the principal investigator. Under appropriate circumstances, a "cover letter" addressing all issues pertinent to a consent form, and signed by the principal investigator, may serve as evidence of informed consent.
- If any potential subject is less than eighteen years old, a parental consent form is normally required.
 - Informed consent must be secured in the native language of the subject or from the subject's legally authorized representative unless English is readily understood. If translation to another language is necessary, the Verification of Translation Accuracy form must be completed. Initial _____

APPENDIX F
Training Plan

Lesson Plan

RULA Instruction for Training Group

1. Welcome
 - Introduction of instructor and general welcome
2. Introduction of RULA
 - Introduction to purpose of the RULA
 - Pass out sample forms - PowerPoint presentation of RULA items
 - Questions
3. Presentation of job task 1 by video
 - Participants rate job task
 - Each reports their total rating
 - Examine areas of discrepancy
 - Questions
4. Presentation of following tasks (7 prepared*)
 - Follow procedures as in number 3 until 2/3 or more consistency in rating achieved.
5. Conclusion and Thank you
6. Dispense Welcome Packets
 - Each trained rater presented with welcome packet as they leave training session.

APPENDIX G

Approval from the Institutional Review Board

**San José State
UNIVERSITY**

**Office of the Academic
Vice President
Academic Vice President
Graduate Studies and Research**

One Washington Square
San José, CA 95192-0025
Voice: 408-293-7500
Fax: 408-924-2477
E-mail: gradstudies@sjsu.edu
<http://www.sjsu.edu>

To: Virginia J. Hixson
1480 Samedra Street
Sunnyvale, CA 94087

From: Pam Stacks,
Interim AVP, Graduate Studies & Research

Date: August 26, 2004

The Human Subjects-Institutional Review Board has approved your request to use human subjects in the study entitled:

**"Effect of Rater Background on Objectivity of the Rapid Upper
Extremity Assessment."**

This approval is contingent upon the subjects participating in your research project being appropriately protected from risk. This includes the protection of the anonymity of the subjects' identity when they participate in your research project, and with regard to all data that may be collected from the subjects. The approval includes continued monitoring of your research by the Board to assure that the subjects are being adequately and properly protected from such risks. If at any time a subject becomes injured or complains of injury, you must notify Pam Stacks, Ph.D. immediately. Injury includes but is not limited to bodily harm, psychological trauma, and release of potentially damaging personal information. This approval for the human subjects portion of your project is in effect for one year, and data collection beyond June 28, 2005 requires an extension request.

Please also be advised that all subjects need to be fully informed and aware that their participation in your research project is voluntary, and that he or she may withdraw from the project at any time. Further, a subject's participation, refusal to participate, or withdrawal will not affect any services that the subject is receiving or will receive at the institution in which the research is being conducted.

If you have any questions, please contact me at (408) 924-2480.

cc: Emily Wughalter, Ph.D.

The California State University:
Chancellor's Office
Bakersfield, Channel Islands, Chico,
Dominguez Hills, Fresno, Fullerton,
Hayward, Humboldt, Long Beach,
Los Angeles, Maritime Academy,
Merced, Monterey Bay, Northridge, Pomona,
Sacramento, San Bernardino, San Diego,
San Francisco, San Jose, San Luis Obispo,
San Marcos, Sonoma, Stanislaus

APPENDIX H

Agreement with the City of San José

Employee Services Department

July 12, 2004

Pamela Stacks, Interim Associate Vice President San Jose State
University
Graduate Studies and Research
Bldg/Room/Zip: SSC 427 - 0025 San Jose

Re: RULA study

Dear Ms. Stacks:

It is my understanding that in the completion of her master's thesis, Virginia Hixson, an employee of the City of San Jose', will be required to film people who are doing office work tasks.

I further understand that she will be asking City of San Jose employees to volunteer, allowing their film to be used in the research project she is completing. They will be fully informed and sign an informed consent form as well as a photo release prior to the filming.

I have reviewed the thesis proposal and protocol. I fully support Ms. Hixson in her pursuit of this degree and agree to cooperate with San Jose' State University in these procedures..

Mark Danaj
Director, Employee Services, 801 North First Street, Rm. 207 San Jose,
CA. 95110

APPENDIX I

Video Participant Registration Packet

San José State UNIVERSITY

Human Performance Department

Spartan Complex, SPX 56
One Washington Square
San Jose, CA 95192-0085
Voice: (408) 924-3018
E-mail: hup@sjsu.edu
E-mail: afreitag@hup.sjsu.edu
<http://www2.sjsu.edu/depts/ca/sa/hup>

**The California State
University:**
Chancellor's Office
Bakersfield, Channel Islands,
Chico, Dominguez Hills, Fresno,
Fullerton, Hayward, Humboldt,
Long Beach,
Los Angeles, Maritime
Academy, Monterey Bay,
Northridge,
Pomona, Sacramento, San
Bernardino, San Diego, San
Francisco,
San Jose, San Luis Obispo,
San Marcos, Sonoma,
Stanislaus

Release Form

Project Title: Effect of Rater Background on Objectivity of
the Rapid Upper Limb Assessment

I understand the photograph(s) or video taken of me by
Virginia J. Hixson, representing San José State University,
are to be used for research and / or training purposes.

I hereby irrevocably authorize to copy, exhibit, publish or
distribute any and all such images and audio of me or
wherein I appear, including composite or artistic forms and
media, for purposes of research, training, or publicizing
training programs or for any other lawful purpose. In
addition, I waive any right to inspect or approve the finished
product, including written copy, wherein my likeness
appears.

I hereby hold harmless and release and forever discharge
Virginia J. Hixson, my employer (the City of San José) and
San José State University their directors, officers, successors
and assigns from all claims, demands and causes of action
which I, my heirs, representatives, executors, administrators
or any other persons acting on my behalf or on behalf of my
estate have or may have by reason of this authorization.

(Signature)

(Date)

(Printed Name)

(Street Address)

(City, State, Zip Code)

San José State UNIVERSITY

Human Performance Department

Spartan Complex, SPX 56
One Washington Square
San Jose, CA 95192-0085
Voice: (408) 924-3018
E-mail: hup@sjsu.edu
E-mail: afreitag@hup.sjsu.edu
<http://www2.sjsu.edu/depts/cas/a/hup>

The California State University:
Chancellor's Office
Bakersfield, Channel Islands,
Chico, Dominguez Hills, Fresno,
Fullerton, Hayward, Humboldt,
Long Beach,
Los Angeles, Maritime Academy,
Monterey Bay, Northridge,
Pomona, Sacramento, San
Bernardino, San Diego, San
Francisco,
San Jose, San Luis Obispo,
San Marcos, Sonoma, Stanislaus

Agreement to Participate in Research

Responsible Investigator(s): Virginia J. Hixson

Title of Protocol: Effect of Rater Background on Objectivity of the Rapid Upper Limb Assessment .

1. You have been asked to participate in a research study investigating the objectivity of an observational scale designed to identify postures that increase risk for work related musculoskeletal injury.
2. You will be filmed while doing a work task. The resulting video will be presented on a CD including work task videos of other office workers, to raters who will rate the postures you use while on the job using a scale they will be provided with. The focus of this research is on how the scale is used, not how the job is done.
3. You may experience some mild anxiety or uncertainty about your task performance, but there is no reason to be concerned. There is no reason to expect that any harm might befall you.
4. For your participation you will receive some increased knowledge of ergonomics as well as some small tokens of appreciation. These will include a pen light, a staple remover, and a booklet detailing some basic ergonomic information and the California repetitive strain regulation. You will also have the satisfaction of having contributed to the development of increased knowledge about ergonomics.
5. Although the results of this study may be published, no information that could identify you will be included. Any pictures will have the face occluded for publication.
6. No compensation will be provided except the items as mentioned above.
7. Questions about this research may be addressed to:
Virginia Hixson
Employee Services
801 North First Street, Room 207, San José
Phone: 408-277-3038

Participant Initials	
Researcher Initials	

8. Complaints about the research may be presented to

Dr. Greg Payne, Department Chair
Human Performance
San José State University
1 Washington Square, SPXC 56
San José, 95054
Phone: 408-924-30289.

9. Questions about research subjects' rights, or research-related injury may be presented to

Pamela Stacks, Ph.D., Interim Associate Vice President,
Graduate Studies and Research, at (408) 924-7029

10. No service of any kind, to which you are otherwise entitled, will be lost or jeopardized if you choose to "not participate" in the study.
11. Your consent is being given voluntarily. You may refuse to participate in the entire study or in any part of the study. If you decide to participate in the study, you are free to withdraw at any time without any negative effect on your relations with San Jose State University or with any other participating institutions or agencies.
12. Upon receipt of the signed consent form, the investigator will send you a copy for your records, signed and dated by the investigator.
- **The signature of a subject on this document indicates agreement to participate in the study.**
 - **The signature of a researcher on this document indicates agreement to include the above named subject in the research and attestation that the subject has been fully informed of his or her rights.**

Signature

Date

Investigator's Signature

Date

APPENDIX J

Recruitment Letter

RULA Study
801 North First Street, Rm. 207
San Jose, Ca. 95110
Phone: (408)277-3038
Fax: (408)288-7894

Dear _____,

I am presently working on my Master's thesis in Human Factors / Ergonomics at San Jose State University, titled *Objectivity of the Rapid Upper Limb Assessment (RULA)*.

I am inviting you to participate as a rater(s) of job scenarios. You would be asked to complete a short 'general information' form, and then to view a video of four different jobs, using the supplied forms to rate them to identify ergonomic risk factors. Your total involvement should take about one hour.

The Purposes of the study are:

1. To determine objectivity of the RULA.
2. To examine comparative rater agreement based on rater background and training.

Your participation in this study will help in taking an important step forward in establishing a valid approach to work hazard identification. In turn, this supports the development of ergonomic science.

Following the study, you will be presented with a small 'thank you' gift for your efforts and time.

Please contact me by phone, fax or e-mail with your response as soon as possible so that I can begin preparing your packet.

Thank you for your attention and consideration,

Virginia J. Hixson,
Graduate Student
San Jose State University
Phone (408) 277-3038
Fax (408) 288-7894

virginia.hixson@sanjoseca.gov

APPENDIX K

Recruitment Poster

Interested in Ergonomics?

*Your chance to learn a little
and save yourself a lot of pain.*

Learn the basic risk factors for injury!

Get a free booklet of ergonomic facts and other
gifts!

Help develop Ergonomic Science!

We are looking for a group of raters from many different
backgrounds to participate in research into ergonomic
evaluation.

Spend an hour

Get 2 thank you gifts

*Learn facts that can make your life easier
and safer*

For more information, call (408)277-3038
e-mail: rulastudy@comcast.net

APPENDIX L

Rejection Letter

San José State UNIVERSITY

Human Performance Department

Spartan Complex, SPX 56
One Washington Square
San Jose, CA 95192-0085
Voice: (408) 924-3018
E-mail: hup@sjsu.edu
E-mail: afreitag@hup.sjsu.edu
<http://www2.sjsu.edu/depts/ca/sa/hup>

**The California State
University:**
Chancellor's Office
Bakersfield, Channel Islands,
Chico, Dominguez Hills, Fresno,
Fullerton, Hayward, Humboldt,
Long Beach,
Los Angeles, Maritime
Academy, Monterey Bay,
Northridge,
Pomona, Sacramento, San
Bernardino, San Diego, San
Francisco,
San Jose, San Luis Obispo,
San Marcos, Sonoma,
Stanislaus

RULA Study

801 North First Street, Rm. 207
San Jose, Ca. 95110
Phone: (408)277-3038
Fax: (408)288-7894

Dear ,

Thank you for your interest and your offer to participate in the RULA study. I regret to inform you that we are unable to include you in the study because

Your generosity in stepping forward to participate in relevant research is greatly appreciated. Although we cannot include you, I am sending a small token of appreciation and my personal thanks for your willingness.

Sincerely,

Virginia J. Hixson, principle researcher
Graduate Student, Human Factors / Ergonomics
San Jose State University
801 North First Street, San José, 95110
Phone: 408 277-3038
rularesearch@comcast.net

APPENDIX M
Welcome Packet

**San José State
UNIVERSITY**

**Human Performance
Department**

Spartan Complex, SPX 56
One Washington Square
San Jose, CA 95192-0085
Voice: (408) 924-3018
E-mail: hup@sjsu.edu
E-mail: afreitag@hup.sjsu.edu
<http://www2.sjsu.edu/depts/casa/hup>

**The California State
University:**
Chancellor's Office
Bakersfield, Channel
Islands, Chico, Dominguez
Hills, Fresno, Fullerton,
Hayward, Humboldt, Long
Beach,
Los Angeles, Maritime
Academy, Monterey Bay,
Northridge,
Pomona, Sacramento, San
Bernardino, San Diego, San
Francisco,
San Jose, San Luis Obispo,
San Marcos, Sonoma,
Stanislaus

RULA Study

128

801 North First Street, Rm. 207
San Jose, Ca. 95110
Phone: (408)277-3038
Fax: (408)288-7894

Dear

Thank you for your help in this study. You are assisting in the development of knowledge about ergonomics that will be useful for many years to come.

Attached, you will find directions for completion of the study, and a CD with the video files in REALPlayer format. The preferred method is for you to access a webpage using Internet Explorer. This is easier for you, and will allow you to see the final scores your ratings produce.

I have also included a backup form that you may copy 4 times (once for each video) and instructions for your use if you have any difficulty with the webpage.

Please try to complete your ratings within one week after you receive this, and try to do them in one sitting. It should not take longer than an hour.

Thank you once again. I look forward to hearing from you.

Virginia Hixson
Primary Researcher, RULA Study
San José State University.

RULA - A RAPID UPPER LIMB ASSESSMENT TOOL

If you do not have Internet Explorer, go to Other set of Instructions.

If you have any difficulty with the web page, go to the other instructions.

(McAtamney, L. and Corlett, N., 1997)

Rapid Upper Limb Assessment (RULA) is a survey method developed for use in ergonomic investigations of workplaces where work related upper limb disorders are reported. RULA is a screening tool that assesses biomechanical and postural loading on the whole body with particular attention to the neck, trunk and upper limbs. Reliability studies have been conducted using RULA on groups of VDU users and sewing machine operators. A RULA assessment requires little time to complete and the scoring generates an action list which indicated the level of intervention required to reduce the risks of injury due to physical loading on the operator.

- All of the jobs to be evaluated are contained in files on the CD mailed to you. They are saved as *REALPlayer* files. If you do not have *REALPlayer*, it is a free program available from www.downloads.com. Enter *REALPlayer* in the search box. There are several choices. If you do not wish to give your credit card information for a 14 day trial of expanded service, do not use the choices in the upper window, labeled *sponsored sites*. The first choice below that, although it also says *sponsored*, will take you directly to the free download.
- Your rater number is the number on your CD.

Step 1. Accessing the Evaluation with Internet Explorer: General Instructions

- Review all these instructions before you begin rating. If you do not have Internet Explorer, use the other form.
- Start by opening your Word program, and save four blank documents in landscape format, named Task 1, Task 2, Task 3, and Task 4 (or 7, 9, 11, 12 if that is indicated on your disk). You will paste your final score sheets on these pages.
- The rating forms will be accessed on line at. <http://www.ergonomics.co.uk/Rula/Ergo/index.html> This places you in front sheet of the RULA. Choose the first option, **Begin Complete Assessment of Left and Right Sides.**

- In order to set your computer up for viewing, size the **RULA** web page so that it takes up only half of the screen. Then place the CD in your drive and open the first video (the one with the lowest number). Set up the CD viewing area in the open half of your screen. You should be able to see both the video and the score sheet at the same time. You will need to copy the final score sheet and paste it into a word or e-mail document so you may wish to have that program started and ready to go.
- **You will need to view the videos in numerical order, (7, 9, 11, 12 or 1, 2, 3, 4).** You may view each as many times as you like, but do not go back to it once you have started the next video.
- To select a score, click on the picture that looks most like the positions you are observing. Only pick one for each joint. The column on the Left will show you where you are in the evaluation. You may choose a scoring by selecting the position repeated most frequently, the position held the longest, or the position you think is most likely a problem. You can go back to change a score at any time before you press the final **Calculate Score** button. Just select an image from the left column or by use the **BACK** button on your browser.
- View the video at least once for scoring each side of the body. Complete scoring on one side before going on to the next. Once you have gone to the next video, do not go back to a previously rated job task.

Step 2 Observing and selecting the posture(s):

- A RULA scoring represents one part of the work cycle. You must choose which moment (posture) to assess for each joint. It is important to observe all of the postures being used in the task prior to selecting the posture(s) for assessment.
- Depending on what you think most represents the job task, select either the longest held posture, most frequent position, or what appears to be the most strained posture used in the task for each joint.
- For this study, be sure to rate both the right and left sides of the body. You decide which posture from the job task to evaluate.
- When evaluating force, keep in mind that 1 Kilogram = 2.2 pounds. This is the limit for indicating that force is required.

Step 3 Scoring and recording the posture:

- Score the posture of each body part using the on - line forms.
- You will find occasional summary sheets where you can review your scorings.
- Review the scoring and make any adjustments required before moving on to the next area. You can return to a previously scored section by clicking on the image of the part you want to change in the left-hand frame.

Step 4 – Complete Score Sheet

- When you have completed scoring, press the calculate score button. This will take you to the final page. Check your scoring one more time. Then, go to the **edit menu, select all, and copy** to your word program, saving it on your hard drive or copy directly into your e-mail. Use the **Task number as the filename or label**. If it is easier, you may e-mail each score sheet separately. **Do not try to e-mail from the web page. This does not work.**

Step 5 Action Level – Complete the RULA Addendum:

- After you have finished rating all of the videos, note the Action Level calculated. Does this agree with your personal opinion about the job? You can view the videos one last time before deciding. Please use the RULA addendum form that is attached at the end of these directions, to indicate your feelings. Indicate your answers by **Bolding** your choice. Enter any comments you may have. Either copy this and paste it into your final e-mail, or forward the complete sheet back.

Step 6 – E-mail your information

- When you have finished rating, and finished the addendum, forward the RULA addendum back to the study, with your score sheets as attachments. Forward to the research study at rularesearch@comcast.net.
- The ratings will be entered into a database dependant on your assigned rater number, so it will be helpful if you indicate that in your subject line.

RULA ADDENDUM

For Internet Explorer Users Only:

Work Action Levels: The work action level is determined by taking the right and left final scores and assigning them a value according to the following chart:

Right or Left Total	Action level
0 – 2	A. Acceptable if not maintained or repeated for long periods
3 – 4	B. Job task requires further ergonomic investigation
5 – 6	C. Investigate soon and make changes quickly
7 or more	D. Investigate and change immediately

Does the RULA rating agree with your general evaluation as to the task risk level as performed in the video?

Task		Disagree	Agree
1	The RULA score agrees with my opinion of the task risk.	1. 2. 3. 4. 5. 6. 7. 8. 9. 10	
2	The RULA score agrees with my opinion of the task risk.	1. 2. 3. 4. 5. 6. 7. 8. 9. 10	
3	The RULA score agrees with my opinion of the task risk.	1. 2. 3. 4. 5. 6. 7. 8. 9. 10	
4	The RULA score agrees with my opinion of the task risk.	1. 2. 3. 4. 5. 6. 7. 8. 9. 10	

RULA - A RAPID UPPER LIMB ASSESSMENT TOOL

(McAtamney, L. and Corlett, N., 1997)

Rapid Upper Limb Assessment (RULA) is a survey method developed for use in ergonomic investigations of workplaces where work related upper limb disorders are reported. RULA is a screening tool that assesses biomechanical and postural loading on the whole body with particular attention to the neck, trunk and upper limbs. Reliability studies have been conducted using RULA on groups of VDU users and sewing machine operators. A RULA assessment requires little time to complete and the scoring generates an action list which indicated the level of intervention required to reduce the risks of injury due to physical loading on the operator.

- All of the jobs to be evaluated are contained in files on the CD mailed to you. They are saved as *REALPlayer* files. If you do not have *REALPlayer*, it is a free program available from www.downloads.com. Enter *REALPlayer* in the search box. There are several choices. If you do not wish to give your credit card information for a 14 day trial of expanded service, do not use the choices in the upper window, labeled *sponsored sites*. The first choice below that, although it also says *sponsored*, will take you directly to the free download.

Step 1. Accessing the Evaluation Using the 'Word' File: General Instructions

- **The Web-page will only work correctly using Internet Explorer. If you do not use that browser, you will be using the *RULAForm* file e-mailed to you. Review all these instructions before you begin rating.**
- Open the *RULAForm* file and save 4 copies to your hard drive, named Task 1, Task2, Task 3, and Task 4 (or if your disk indicates, 7, 9, 11, 12).
- In order to set your computer up for viewing, size the RULA form page so that it takes up only half of the screen. Then, place the CD in your drive. View the videos in numerical order, **(7, 9, 11, 12 or 1, 2, 3, 4)**. Open the first video.
- Set up the CD viewing area in the open half of your screen. You should be able to see both the video and the score sheet at the same time. You may view each video as many times as you like, but do not go back to it once you have started the next video.
- To select a score, Put an 'X' in the box under or beside the picture or description that looks most like, or describes best, the positions you are observing. Only pick one for each joint unless 'extra' is indicated. Then, mark the extra item if appropriate. You may choose a scoring by selecting the position repeated most frequently, the position held the longest, or the

position you think is most likely a problem. You can go back to change a score at any time.

- View the video at least once for scoring each side of the body. Complete scoring on one side before going on to the next. Once you have gone to the next video, do not go back to a previously rated job task.

Step 2 Observing and selecting the posture(s):

- A RULA scoring represents one part of the work cycle. You must choose which moment (posture) to assess for each joint. It is important to observe all of the postures being used in the tasks prior to selecting the posture (s) for assessment.
- Depending on what you think most represents the job task, select either the longest held posture, most frequent position, or what appears to be the most strained posture(s) used in the task for each joint.
- For this study, be sure to rate both the right and left sides of the body. You decide which posture from the job task to evaluate.
- When evaluating force, keep in mind that 1 Kilogram = 2.2 pounds.

Step 3 Scoring and recording the posture:

- Score the posture of each body part using the Supplied forms.. Just place an X in the box under the picture most resembling what you see in the video. Be sure to choose one answer (as indicated) in each section. Guess if you have to. Review the scoring and make any adjustments required before moving on to the next job. Then save your file and open the form for the next job. Save each job scoring separately.

Step 6 – E-mail your information

- When you have finished rating, send or forward the 4 RULA forms you have saved on your hard drive as attachments. Forward or send to the research study at rularesearch@comcast.net . Unless you can compress or 'zip' the files, please send them each in a separate e-mail, due to their size. The ratings will be entered into a database dependant on your assigned rater number, so it will be helpful if you indicate that in your subject line. Your rater number is the number on your disk.
- Should you wish a summary of your job scoring results, or a copy of the final paper, please let me know and I will try to comply, although it may take some time.

APPENDIX N

Thank You Letter

RULA Research Study
 801 North First St. #207
 San Jose, CA 95110
 December , 2004

San José State UNIVERSITY

Human Performance Department

Spartan Complex, SPX 56
 One Washington Square
 San Jose, CA 95192-0085
 Voice: (408) 924-3018
 E-mail: hup@sjsu.edu
 E-mail: afreitag@hup.sjsu.edu
<http://www2.sjsu.edu/depts/casa/hup>

Dear Participant,

Once again, I would like to thank you for your generous donation of time and effort in participating in the RULA Study. It has been an interesting and involving experience for me. I hope it was interesting for you. Your participation has been invaluable.

I have included a staple remover, a pen light, and a booklet of information on ergonomics as a small token of appreciation for your help.

If you have asked for a copy of the study, it will be forwarded to you following its completion in February or March. Should you decide in the next few months that you would like a copy, please contact me at the address above or at the e-mail below.

With thanks and appreciation,

Virginia J. Hixson
 Primary Researcher, RULA Study
rularesearch@comcast.net

**The California State
University:**
 Chancellor's Office
 Bakersfield, Channel Islands,
 Chico, Dominguez Hills,
 Fresno, Fullerton, Hayward,
 Humboldt, Long Beach,
 Los Angeles, Maritime
 Academy, Monterey Bay,
 Northridge,
 Pomona, Sacramento, San
 Bernardino, San Diego, San
 Francisco,
 San Jose, San Luis Obispo,
 San Marcos, Sonoma,
 Stanislaus