AD_____

Award Number: MIPR 0EC5E3M0081

TITLE: Tele-Ergonomics Assessment Methodologies Study

PRINCIPAL INVESTIGATOR: Mary Lopez

CONTRACTING ORGANIZATION: Army Center for Health Promotion
& Preventive Medicine
Aberdeen Proving Ground, Maryland
21010-5422

REPORT DATE: October 2001

TYPE OF REPORT: Final

PREPARED FOR: U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

DISTRIBUTION STATEMENT: Approved for Public Release;
Distribution Unlimited

The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision unless so designated by other documentation.

20011029 040

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	October 2001	Final (15 Feb 00 - 30 Sep 01)

4. TITLE AND SUBTITLE
Tele-Ergonomics Assessment Methodologies Study

5. FUNDING NUMBERS
MIPR 0EC5E3M0081

6. AUTHOR(S)
Mary Lopez

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Army Center for Health Promotion & Preventive Medicine
Aberdeen Proving Ground, Maryland 21010-5422

E-Mail:

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for Public Release; Distribution Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 Words)*

14. SUBJECT TERMS

15. NUMBER OF PAGES
21

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

DHP RFS
Final Report

Tele-Ergonomics Assessment Methodologies Study
Proposal Number: 1999000252

Mary Sullivan Lopez PhD

Abstract

Problems

The two primary problems encountered in this study were with the Institutional Review Board (IRB) approval and unexpected staff turnover. This minimal risk proposal was submitted to the MRMC IRB for approval as CHPPM does not have an IRB. The MRMC IRB had been used as the primary IRB in the past and it was assumed that the MRMC IRB approval was all that would be required; however, after the proposal had been reviewed, corrected and re-submitted, the PI was informed that the proposal would need to be submitted to each of the IRBs for the target bases. Since time was a concern, it was decided to re-target bases under one IRB rather than submit the proposal to four different IRBs. The target bases were changed to Fort Drum, Fort Eustis, Fort Knox, Fort Lee and Fort Bragg. All of these bases fall under the WRAMC IRB. The proposal received WRAMC IRB approval without any problem. Unfortunately, this time delay could have been avoided if the PI had been informed that the MRMC approval alone would not suffice.

The unexpected staff turnover created delays in the final analysis of the data. All of the data had been collected prior to the staff member's departure; however, not all of the data had been entered for analysis and only a very few analyses had been conducted.

Deliverables

The primary deliverable is the final tele-ergonomics methodology and the revised assessment tools package. Based on the study results, the assessment tools package is being revised to include decision charts and other user- friendly features. The assessment tools are being structured to allow development of computer programs to assist in the local data collection. This package addresses both injury prevention and the management of soldier/worker return to work. Return-to-work assessment, planning and accommodation are critical pieces of clinical management of injuries as these elements reduce lost work time / profile periods as well as reduce or prevent re- injury. Both prevention and return-to-work impact on health care system utilization by reducing the occurrence and severity of injuries.

The success of the tele-ergonomics methodology is primarily evaluated by process measures, including the accuracy and feasibility of the methodology; decreased response time to evaluate a problematic job, task, tool or equipment; increased access to expert ergonomist evaluations; and the quality of the evaluation and recommendations. Although decreased injury rates and decreased limited duty/lost duty time could be attributed to the tele-ergonomics methodology, many other local Ergonomics Program features and initiatives contribute to this outcome. The specific and quantifiable contribution of the tele-ergonomics package to the reduction of these outcomes measures is difficult to impossible to identify with confidence.

The true value of the final product is in the distribution of the tele-ergonomics methodology and revised tool package to all Army installations, facilities, depots and activities. Local Ergonomics Programs are frequently understaffed and lack the expert ergonomists' skills and knowledge. This package will dramatically increase local programs' access to the experts and enhance the local programs' functioning, responsiveness and quality as well as contribute to the overall program goal of reducing injuries and lost work time.

The package will also be included in the next build of the Defense Occupational and Environmental Health Readiness System (DOEHRS) and in the Deployment Surveillance initiative. In addition, 91S and local technician training requirements and program will be submitted for inclusion in the School training, included in 91S continuing education initiatives and included in the Army 40-hour Applied Ergonomics Course. Finally, the package will be considered for DOD-wide distribution through the DOD Ergonomics Working Group.

Expenditures

	3Q FY 00	4Q FY 00	1Q FY 01	2Q FY 01	
Element of Resource (EOR)	Apr 1 - May 31	Jun 1 - Sep 30	Oct 1 - Dec 31	Jan 1 - Mar 31	TOTALS
Travel 2100	0.00	35,000.00	0.00	0.00	35,000.00
Shipping 2200	0.00	0.00	0.00	0.00	0.00
Rent & Communications 2200	0.00	0.00	0.00	0.00	0.00
Contract for Services 2500	0.00	105,000.00	0.00	0.00	105,000.00
Supplies 2600	0.00	1,500.00	0.00	0.00	1,500.00
Equipment 3100	0.00	5,500.00	0.00	0.00	5,500.00
GRAND TOTALS	0.00	147,000.00	0.00	0.00	147,000.00

Financials

All of the Tele-Medicine funds were spent or obligated as outlined in Expenditure Section by the end of 4th quarter 00. Funds were transferred to the Oak Ridge Institute for Science and Engineering (ORISE) and the USACHPPM Statistician contract to cover the staffing and related project expenses. Funds to cover travel expenses (noted above) were transferred to ORISE in the 4th quarter to cover ORISE participant travel to complete the data collection phase.

Final Results

In addition to the three original goals identified for the study assessing the amount of agreement between the on- site technicians and on-site and off-site ergonomists, the amount and type of error was also assessed in the analysis. Two types of errors were identified in the analysis: 1. Technician judgement error. These errors were identified based on the comparison between the technician and the on-site ergonomist. Using the on-site ergonomist as the 'gold standard', both 'false negative' (technician decision that it was not necessary to use a particular tool when the on-site ergonomist decided to use the

instrument) and 'false positive' (technician decision to use a particular tool when the on-site ergonomist did not use the instrument) errors were identified. 2. Technician measurement process error. These errors were identified by incomplete, inaccurate or inappropriate data for each of the tools. The results of the agreement and error assessments for each of the assessment tools are presented below.

Borg Scale The Borg Scale is a 15-point scale that records the soldier's self-assessment of physical exertion required by the task. The soldier was asked to rate his/her level of exertion during the task on the Borg Scale when the task was completed. a. Agreement. A total of 97 tasks had valid Borg scale scores recorded by both the on site ergonomists and the technicians. Of these 97 tasks, 65 (67%) were recorded the same by the on site ergonomists and the technicians. The technician recorded 16 (16.5%) scores of the tasks higher than the on site ergonomist and recorded 16 (16.5%) of the tasks lower than the on site ergonomist. The average Borg scale score for the on site ergonomist was 10.5 +/- 3.2 and 11.0 +/- 3.9 for the technician. The mean difference in Borg scale ratings from the technician to the on site ergonomist was –0.4 +/- 3.1. No statistically significant difference in the Borg scale rating was observed between the on-site ergonomists and the technicians using a Wilcoxon Signed Rank test. Agreement between the ergonomists and technicians was measured with the weighted Kappa statistic, 0.65 (0.48, 0.81) and tested by the marginal homogeneity test. Good agreement was found and no significant difference was observed between the ergonomist and technician Borg scale ratings. b. Error. A total of 108 tasks had correct values from the on site ergonomist. Of those 108, 11 (10.2%) had an incorrect or no value given by the on site technician.

Level 1 Guide The Level 1 Guide is an assessment tool which requires the classification of the type of task and the recording of observations and frequency of specific risk factors and postures by body region.

Overall Level 1 Guide: a. Agreement. A total of 102 tasks were rated with valid scores by both the on-site ergonomists and the technicians. Of these 102 tasks, 44 (43.1%) were rated the same by both the ergonomists and the technicians. The technicians rated 30 (29.4%)of the tasks higher than the on site ergonomist and 28 (27.4%) of the tasks lower than the on site ergonomist. The average Level 1 Rating was 1.5 +/- 1.3 for the on site ergonomist and 1.4 +/- 1.2 for the technician. The mean difference in matched pairs of Level 1 ratings was 0.02 +/- 1.49. No statistically significant difference in the Level 1 Rating was observed between the on-site ergonomists and the technicians using a Wilcoxon Signed Rank test. Agreement between the ergonomists and technicians was measured with the weighted Kappa statistic, 0.30 (0.13, 0.48) and tested by the marginal homogeneity test. Fair to good agreement was found and no significant difference was observed between the ergonomists' and technicians' Level 1 Ratings. b. Error. A total of 122 tasks were given valid scores by the onsite ergonomist. The technician made a judgemental error on 31 (25.4%) of the 122 tasks and a measurement error on 20 (16.4%) of the tasks.

Body Region: a. Agreement. A total of 102 tasks were given valid body region scores by both the on-site ergonomists and technicians. Of these 102 tasks, 43 (42.2%) were given the same body region score by both the ergonomists and technicians. The technicians scored 59 (57.8%) of the tasks with different body regions than the on-site ergonomist. Agreement between the ergonomists and technicians was measured with a Kappa statistic, 0.22 (0.10, 0.34) and tested by the marginal homogeneity test. Poor agreement was found, but no significant difference was observed between the ergonomists' and technicians' body region scoring. b. Error. Of the 125 tasks, the on-site ergonomist

recorded data for 122 tasks. A judgment error was made by the technician on 31 (25.4%) of the 122 validly scored tasks and a measurement error was made on 20 (16.4%).

Identical error findings (above) were observed for each body region rated separately, therefore the error results are not presented in the body regions sections.

Shoulder/Neck Rating: Agreement. A total of 101 tasks were rated with valid scores by both the on site ergonomists and technicians. Of these 101 tasks, 26 (25.7%) were rated the same by the on site ergonomists technicians. The technician rated 38 (37.6%) of the tasks higher and 37 (36.6%) of the tasks lower than the on site ergonomist. The median (25th, 75th percentiles) Shoulder / Neck rating for the on site ergonomist was 2 (-2, 5) and 1 (-2, 5) for the technician (median values are reported because they are not affected by the negative coding scheme). No statistically significant difference in the Shoulder / Neck rating was observed between the on-site ergonomists and technicians using a Wilcoxon Signed Rank test. Agreement between the ergonomists and technicians was measured and tested with the weighted Kappa statistic, 0.11 (-0.04, 0.28). Poor agreement was found between the ergonomists and technicians in Shoulder / Neck ratings and the agreement that was observed is due to purely random variation. Hand/Wrist/Arm Rating: Agreement. A total of 102 tasks were rated with valid scores by both the on-site ergonomists and technicians. Of these 102 tasks, 28 (27.4%) were rated the same by the on site ergonomists and technicians. The technician rated 36 (35.3%) of the tasks higher and 38 (37.2%) of the tasks lower than the on site ergonomist. The median (25th, 75th percentiles) Hand / Wrist /Arm Rating for the on site ergonomist was 2 (-2, 5) and 2 (-2, 5.25) for the technician (median values are reported because they are not affected by the negative coding scheme). No statistically significant difference in the Hand / Wrist /Arm Rating was observed between the on-site ergonomists and technicians using a Wilcoxon Signed Rank test. Agreement between the ergonomists and technicians was measured and tested with the weighted Kappa statistic, 0.13 (-0.03, 0.30). Poor agreement was found between the ergonomists and technicians in Hand / Wrist /Arm Rating and the agreement that was observed is due to purely random variation. Back/Torso Rating: Agreement. A total of 102 tasks were rated with valid scores by both the on site ergonomists and technicians. Of these 102 tasks, 24 (23.5%) were rated the same by the on site ergonomists and technicians. The technicians rated 35 (34.3%) of the tasks higher and 43 (42.2%) of the tasks lower than the on site ergonomist. The median (25th, 75th percentiles) Back / Torso Rating for the on site ergonomist was 2 (-2, 6) and 1 (-2, 5) for the technicians (median values are reported because they are not affected by the negative coding scheme). No statistically significant difference in the Back / Torso Rating was observed between the on-site ergonomists and technicians using a Wilcoxon Signed Rank test. Agreement between the ergonomists and technicians was measured and tested with the weighted Kappa statistic, 0.44 (0.28, 0.60). Good agreement was found between the ergonomists in Back / Torso Rating, which was also significantly different from 0.0 or no agreement, $p<0.01$. Legs/Feet Rating: Agreement. A total of 102 tasks were rated with valid scores by both the on site ergonomists and technicians. Of these 102 tasks, 32 (31.4%) were rated the same by the on site ergonomists and technicians. The technician rated 36 (35.3%) of the tasks higher and 34 (33.3%) of the tasks lower than the on site ergonomist. The median (25th, 75th percentiles) Legs/Feet Rating for the on site ergonomist was 0 (-2, 3) and 1.5 (-2, 2) for the technician (median values are reported because they are not affected by the negative coding scheme). No statistically significant difference in the Legs/Feet Rating was observed between the on site ergonomists and technicians using a Wilcoxon Signed Rank test. Agreement between the ergonomists and technicians was measured and tested with the weighted Kappa statistic, 0.28 (0.12, 0.44). Fair agreement was found between the ergonomists and technicians in Legs/Feet Rating,

which was also significantly different from 0.0 or no agreement, p<0.01. Head/Eyes Rating: Agreement. A total of 100 tasks were rated with valid scores by both the on site ergonomists and technicians. Of these 100 tasks, 62 (62.0%) were rated the same by the on site ergonomists and technicians. The technicians rated 25 (25.0%) of the tasks higher and 13 (13.0%) of the tasks lower than the on site ergonomist. The median (25th, 75th percentiles) Head/Eyes Rating for the on site ergonomist was 0 (-2, 0) and 0 (-2, 0) for the technician (median values are reported because they are not affected by the negative coding scheme). No statistically significant difference in the Head/Eyes Rating was observed between the on and off site ergonomists using a Wilcoxon Signed Rank test. Agreement between the ergonomists and technicians was measured and tested with the weighted Kappa statistic, 0.21 (0.00, 0.42). Poor agreement was found between the ergonomists and technicians in Head/Eyes Rating, which was also significantly different from 0.0 or no agreement, p<0.05. Environmental Rating: Agreement. A total of 101 tasks were rated with valid scores by both the on site ergonomists and technicians. Of these 101 tasks, 40 (39.6%) were rated the same by the on site ergonomists and technicians. The technicians rated 34 (33.7%) of the tasks higher and 27 (26.7%) of the tasks lower than the on site ergonomist. The median (25th, 75th percentiles) Environmental Rating for the on site ergonomist was 0 (-2, 1) and 0 (-2, 1) for the technician (median values are reported because they are not affected by the negative coding scheme). No statistically significant difference in the Environmental Rating was observed between the on site ergonomists and technicians using a Wilcoxon Signed Rank test. Agreement between the ergonomists and technicians was measured and tested with the weighted Kappa statistic, 0.12 (-0.11, 0.34). Poor agreement was found between the ergonomists and technicians in Environmental Rating and the agreement that was observed is due to purely random variation. NIOSH Revised Lifting Equation This assessment tool is based on measurements of six lift characteristics. These measurements are entered into a calculation which results in a recommended weight limit and a risk index for the lift. The on-site ergonomist and technicians were required to identify any lifts requiring assessment and measure the lift up to a total of five lifts per task. Comparison of the on site ergonomist to the technicians is most valid for the NIOSH Lift rating for lifts 1 and 2 because the majority of the lifts 3-5 were considered not necessary to be rated. As there were minimal differences between lifts 3, 4 and 5, only lift 3 is presented here.

NIOSH Lift 1 Rating. a. Agreement. Of the 125 tasks that were rated by both the on-site ergonomists and technicians, 78 (62.4%) had a valid score from both ergonomists and technicians. Of those 78 tasks, 68 (87.2%) were rated the same by both ergonomists and technicians. The technician rated 5 (6.4%) as not necessary for rating when the on site ergonomist rated them and 5 (6.4%) with a rating when the on site ergonomist rated them as not necessary for rating. Agreement between the ergonomists and technicians was measured with the Kappa statistic, 0.65 (0.45, 0.85) and tested by the marginal homogeneity test. Good agreement was found and no significant difference was observed between the ergonomists' and technicians' NIOSH Lift 1 ratings. b. Error. Of the 125 tasks, 108 were completed with valid scores by the ergonomist. Of those 108, the technician made judgemental errors on 10 (9.2%) and measurement errors on 30 (27.8%).

NIOSH Lift 2 Rating. a. Agreement. Of the 125 tasks that were rated by both the on-site ergonomists and technicians, 102 (81.6%) had a valid score from both ergonomists and technicians. Of those 102 tasks, 92 (90.2%) were rated the same by the on- site ergonomists and technicians. The technicians rated 9 (8.8%) as not necessary for rating when the on site ergonomist rated them and 1 (1.0%) with a rating when the on site

ergonomist rated them as not necessary for rating. Agreement between the ergonomists and technicians was measured with the Kappa statistic, 0.56 (0.33, 0.80) and tested by the marginal homogeneity test. The Kappa statistic indicated good agreement, but the marginal homogeneity test was significant indicating a significant difference between ergonomists for the NIOSH Lift 2 ratings. b. Error. Of the 125 tasks, 116 were completed with valid scores by the ergonomist. Of those 116, the technician made judgemental errors on 10 (8.6%) and measurement errors on 14 (12.1%).

NIOSH Lift 3 Rating. a. Agreement. Of the 125 tasks that were rated by both on-site ergonomists and technicians, 107 (85.6%) had a valid score from both ergonomists and technicians. Of those 107 tasks, 101 (94.4%) were rated the same by both ergonomists and technicians. The technicians rated 3 (2.8%) as not necessary for rating when the on site ergonomist rated them and 3 (2.8%) with a rating when the on site ergonomist rated them as not necessary for rating. Agreement between the ergonomists and technicians was measured with the Kappa statistic, 0.37 (-0.02, 0.77) and tested by the marginal homogeneity test. Fair agreement was found and no significant difference was observed between the ergonomists' and technicians' NIOSH Lift 3 ratings. b. Error. Of the 125 tasks, the ergonomist had valid scores on 119 tasks. The technician made judgemental errors on 6 (5%) and measurement errors on 12 (10.3%).

Rodgers Methodology: This exposure risk assessment tool evaluates continuous effort and efforts/minute and results in a priority for change rating. a. Agreement. The specific body regions are discussed below. Overall, there was poor agreement between the on- site ergonomists and the technicians in their rating of body regions using Rodgers methodology. Ratings were given by each ergonomist and technician, scored as Moderate, High or Very High. Some ratings were blank and others incorrect. Therefore, only tasks with valid scores by both the on-site ergonomists and technicians were used. b. Error. The number of tasks rated by the on-site ergonomist ranged from 103 to 111 of the total 125 tasks. Across all body regions, of the tasks rated by the on-site ergonomist, 30.3% to 38.7% of the tasks were not rated by the technician (judgement error).

Neck/ Shoulder – Right: a. Agreement. Of the 125 tasks reviewed by both on-site ergonomists and technicians, 74 (59.2%) had valid ratings by both ergonomists and technicians for the right neck / shoulder. Of those 74 valid ratings, 57 (77.0%) were rated the same by both on-site ergonomists and technicians. The technicians rated 12 (16.2%) lower and 5 (6.8%) higher than the on site ergonomist. Agreement between the ergonomists and technicians was measured with the weighted Kappa statistic, 0.12 (-0.15, 0.39) and tested by the marginal homogeneity test. Poor agreement was found between the on-site ergonomists and technicians and the agreement that was observed is due to purely random variation (Table 1).

b. Error. The on site ergonomist had valid scores on 109 tasks. Of these, the technician made judgement errors on 35 (32.1%).

Neck / Shoulder – Left: a. Agreement. Of the 125 tasks reviewed by both the on-site ergonomists and technicians, 76 (60.8%) had valid ratings by both ergonomists and technicians for the left neck / shoulder. Of those 76 valid ratings, 59 (77.6%) were rated the same by both ergonomists and technicians. The technicians rated 12 (15.8%) lower and 5 (6.6%) higher than the on site ergonomist. Agreement between the ergonomists and technicians was measured with the weighted Kappa statistic, 0.18 (-0.07, 0.44) and tested by the marginal homogeneity test. Poor agreement was found between the on site ergonomists technicians and the agreement that was observed is due to purely random

variation (Table 2). b. Error. The on site ergonomist had valid scores on 109 tasks. Of these, the technician made judgement errors on 33 (30.3%).

Back: a. Agreement. Of the 125 tasks reviewed by both the on- site ergonomists and technicians, 75 (60%) had valid ratings by both ergonomists and technicians for the back. Of those 75 valid ratings, 51 (68%) were rated the same by both the ergonomists and technicians. The technicians rated 16 (21.3%) lower and 8 (10.7%) higher than the on site ergonomist. Agreement between the ergonomists and technicians was measured with the weighted Kappa statistic, 0.05 (-0.18, 0.27) and tested by the marginal homogeneity test. Poor agreement was found between the on-site ergonomists and technicians and the agreement that was observed is due to purely random variation (Table 3). b. Error. The on site ergonomist had valid scores on 109 tasks. Of these, the technician made judgement errors on 34 (31.2%). Arm - Right: a. Agreement. Of the 125 tasks reviewed by both the on- site ergonomists and technicians, 69 (55.2%) had valid ratings by both ergonomists and technicians for the right arm. Of those 69 valid ratings, 51 (73.9%) were rated the same by both ergonomists and technicians. The technicians rated 13 (18.8%) lower and 5 (7.2%) higher than the on site ergonomist. Agreement between the ergonomists and technicians was measured with the weighted Kappa statistic, 0.11 (-0.11, 0.33) and tested by the marginal homogeneity test. Poor agreement was found between the on-site ergonomists and technicians and the agreement that was observed is due to purely random variation (Table 4). b. Error. The on site ergonomist had valid scores on 102 tasks. Of these, the technician made judgement errors on 33 (32.4%).

Arm - Left: a. Agreement. Of the 125 tasks reviewed by both ergonomists, 68 (54.4%) had valid ratings by both the on- site ergonomists and technicians for the left arm. Of those 68 valid ratings, 53 (77.9%) were rated the same by both ergonomists and technicians. The technicians rated 8 (11.8%) lower and 7 (10.3%) higher than the on site ergonomist. Agreement between the ergonomists and technicians was measured with the weighted Kappa statistic, 0.03 (-0.18, 0.23) and tested by the marginal homogeneity test. Poor agreement was found between the on-site ergonomists and technicians and the agreement that was observed is due to purely random variation (Table 5). b. Error. The on site ergonomist had valid scores on 103 tasks. Of these, the technician made judgement errors on 35 (34.0%).

Wrist - Right: a. Agreement. Of the 125 tasks reviewed by both the on- site ergonomists and technicians, 65 (52%) had valid ratings by both ergonomists and technicians for the right wrist. Of those 65 valid ratings, 39 (60%) were rated the same by both ergonomists and technicians. The technicians rated 20 (30.8%) lower and 6 (9.2%) higher than the on site ergonomist. Agreement between the ergonomists and technicians was measured with the weighted Kappa statistic, 0.13 (-0.08, 0.35) and tested by the marginal homogeneity test. Poor agreement was found between the on site ergonomists and technicians and the agreement that was observed is due to purely random variation. In addition, a significant difference was observed between the ergonomists and technicians in the rating of right wrist by Rodgers Methodology, $p<0.05$ (Table 6). b. Error. The on site ergonomist had valid scores on 104 tasks. Of these, the technician made judgement errors on 39 (37.5%).

Wrist - Left: a. Agreement. Of the 125 tasks reviewed by both the on- site ergonomists and technicians, 67 (53.6%) had valid ratings by both ergonomists and technicians for the left wrist. Of those 67 valid ratings, 40 (59.7%) were rated the same by both ergonomists and technicians. The technicians rated 18 (26.9%) lower and 9 (13.4%) higher than the on site ergonomist. Agreement between the ergonomists and technicians

was measured with the weighted Kappa statistic, -0.01 (-0.19, 0.17) and tested by the marginal homogeneity test. Poor agreement was found between the on site ergonomists and technicians and the agreement that was observed is due to purely random variation (Table 7). b. Error. The on site ergonomist had valid scores on 104 tasks. Of these, the technician made judgement errors on 37 (35.6%).

Legs - Right: a. Agreement. Of the 125 tasks reviewed by both the on- site ergonomists and technicians, 74 (59.2%) had valid ratings by both ergonomists and technicians for the right leg. Of those 74 valid ratings, 61 (82.4%) were rated the same by both ergonomists and technicians. The technicians rated 7 (9.5%) lower and 6 (8.1%) higher than the on site ergonomist. Agreement between the ergonomists and technicians was measured with the weighted Kappa statistic, 0.02 (-0.18, 0.22) and tested by the marginal homogeneity test. Poor agreement was found between the on-site ergonomists and technicians and the agreement that was observed is due to purely random variation (Table 8). b. Error. The on site ergonomist had valid scores on 111 tasks. Of these, the technician made judgement errors on 37 (33.3%).

Legs - Left: a. Agreement. Of the 125 tasks reviewed by both the on- site ergonomists and technicians, 75 (60%) had valid ratings by both ergonomists and technicians for the left leg. Of those 75 valid ratings, 62 (82.7%) were rated the same by both ergonomists and technicians. The technicians rated 6 (8%) lower and 7 (9.3%) higher than the on site ergonomist. Agreement between the ergonomists and technicians was measured with the weighted Kappa statistic, 0.13 (-0.12, 0.37) and tested by the marginal homogeneity test. Poor agreement was found between the on site ergonomists and technicians and the agreement that was observed is due to purely random variation (Table 9). b. Error. The on site ergonomist had valid scores on 111 tasks. Of these, the technician made judgement errors on 36 (32.4%). Ankles - Right: a. Agreement. Of the 125 tasks reviewed by both the on- site ergonomists and technicians, 68 (54.4%) had valid ratings by both ergonomists and technicians for the right ankles. Of those 68 valid ratings, 54 (79.4%) were rated the same by both ergonomists and technicians. The technicians rated 8 (11.8%) lower and 6 (8.8%) higher than the on site ergonomist. Agreement between the ergonomists and technicians was measured with the weighted Kappa statistic, 0.07 (-0.15, 0.30) and tested by the marginal homogeneity test. Poor agreement was found between the on site ergonomists and technicians and the agreement that was observed is due to purely random variation (Table 10). b. Error. The on site ergonomist had valid scores on 111 tasks. Of these, the technician made judgement errors on 43 (38.7%).

Ankles - Left: a. Agreement. Of the 125 tasks reviewed by both the on- site ergonomists and technicians, 68 (54.4%) had valid ratings by both ergonomists and technicians for the left ankles. Of those 68 valid ratings, 56 (82.4%) were rated the same by both ergonomists and technicians. The technicians rated 6 (8.8%) lower and 6 (8.8%) higher than the on site ergonomist. Agreement between the ergonomists and technicians was measured with the weighted Kappa statistic, 0.13 (-0.12, 0.38) and tested by the marginal homogeneity test. Poor agreement was found between the on site ergonomists and technicians and the agreement that was observed is due to purely random variation (Table 11). b. Error. The on site ergonomist had valid scores on 111 tasks. Of these, the technician made judgement errors on 43 (38.7%).

Ovako Working Posture Analysis System (OWAS). The OWAS assesses the presence of high risk static and dynamic postures of the trunk, upper limbs, lower limbs, head and neck, and the load of stress experienced by the body. This method provides a measure of the frequency of high-risk static and dynamic postures in each of the above- specified

anatomic regions. Load is assessed by classifying the weight lifted or strength required into three categories: <10 kg, 10-20 kg, > 20 kg. By summing observations, the OWAS provides the percentage of time in selected postures. The OWAS evaluation is based on a time-sampling of a recorded videotape. The off-site ergonomist's ability to assess the task using the OWAS is dependant on the technician's videotaping skills, focus and concentration. The total of the OWAS Categories 1-4 was calculated and a percent of the total score was used for each OWAS category. The on site and off site ergonomists were compared using the percentages for each category with a paired t-test (Table 12).

Rapid Upper Limb Assessment (RULA): The RULA assessment method measures working posture, muscle use and force required to perform job tasks. It produces a summary score representing all measured variables and a priority for change score. The RULA is also based on a time-sampling of a recorded videotape. The off-site ergonomists' assessment using RULA is dependent on the technician's videotaping skills. The total of the RULA Categories 1-4 was calculated and a percent of the total score was used for each RULA category. The on site and off site ergonomists were compared using the percentages for each category with a paired t-test (Table 13).

Technician Usability Assessment. After the task data had been collected, the technicians completed a questionnaire-based rating of each assessment tool to determine the usability of the tools. The Borg Scale was rated the most favorable for every question. The mean responses from the assessment tool rating questionnaire are provided in Table 14. Because every subject scored each method for every question, a repeated measures analysis of variance was used to compare the methods. If a significant method effect was observed, then a Tukey's multiple comparisons test was used to make the pair-wise comparisons. Statistical significance was defined as $p<0.05$. Questions 1, 2, 4 and 6 showed significant method effects, $p<0.05$. While the mean method scores for Question 10 appeared to be different, they failed to reach statistical significance, $p=0.072$. No other questions showed significant differences between the methods used. Question 1: How easy was it to collect the information? The mean score for NIOSH Lift Equation was significantly different than all other method's mean scores, $p<0.05$. The mean score for the Rodgers Methodology was significantly different from the mean score for the Borg scale method, $p<0.05$ (Figure 1). Question 2: If you had to collect the same information in the field, how easy do you think it would be? The mean score for the NIOSH Lift Equation was significantly different from the mean score for the Borg scale method, $p<0.05$ (Figure 2). Question 4: How much time did it take to collect this information? The mean score for the Video and NIOSH Lift Equation methods was significantly different from the mean score for the Borg scale method, $p<0.05$ (Figure 3). Question 6: How much time will it take to collect this information in a deployed environment? The mean score for the Borg Scale method was significantly different than all other method's mean scores, $p<0.05$ (Figure 4). Question 10: How complete were the instructions for the assessment method? Although differences in the mean scores did not reach statistical significance, responses to this question are relevant for practical purposes (Figure 5).

Conclusions One of the primary goals of this research was the identification of an ergonomic assessment tool that could easily be used by unit health and safety personnel in the garrison, field, and deployed environments. The assessment tools were evaluated in three general areas – agreement between the on-site ergonomist and the technician and off- site ergonomist; error potential; and usability. Good agreement was seen with the Borg scale. Fair to good agreement was seen with the Level 1 Guides; however, this agreement was not seen in the individual scales of the instrument. Good to fair agreement was seen with lifts 1-2 for the NIOSH Lifting Equation. The Rodgers methodology

showed poor agreement in general and in the individual body categories. Both the OWAS and RULA were dependent on the quality of the videotape and showed significant differences between the on- and off-site ergonomists. The Borg Scale ranked low in judgement and measurement errors. The Level 1 Guides had significantly more errors, ranking medium in both judgement and measurement errors. The NIOSH Lifting Equation had fewer judgement errors but significantly more measurement errors. The Rodgers Methodology had some measurement errors, but significantly more judgement errors. The technicians involved in this study rated the Borg Scale as the easiest method to use, as well as the method which took the least amount of time to collect. However, the perceived ease of use of the Borg Scale was not significantly greater than the Level 1 Assessment, Rodgers, or the Video methods.

Projected Costs

The next step is to revise the technician's assessment tool package. Only the Borg scale and the videotaping will be included in the package and the package will be re- formatted to provide a decision tree, clearer and more structured instructions and a training session. This package will be posted on the Ergonomics web page for easier access. In addition, modifications to the 91S curriculum will be proposed and developed to provide a stronger background in this type of data collection. This revised methodology will be presented and tested for use in deployed environments.

At a local level, the projected costs are minimal. The web- accessible tools and self-training will be available at no cost. The only additional cost will be the manpower time required to collect this data and the cost of a video camera; however, those costs will be offset by the reduced time to conduct evaluations due to the greater structure provided and the cost-savings in the expert ergonomist consultations. In addition, any local costs will also be offset by the reduced injury risk to both military and civilian personnel and the more timely response to problem areas.

On an AMEDD-wide level, the projected costs are also minimal. The modifications to the assessment tool package will require some manpower time; however, as was noted previously, those costs will be easily offset by eliminating the travel time and costs and response time delays as well as increasing access to expert consultation. The proposed curriculum changes will also require some manpower time investment, but continuous updating and quality improvement of the curriculum is expected and accounted for in education.

Comments

It is clear from this study that the technicians require more structure in a user-friendly format to reduce the judgement and measurement errors. The technicians also require hands on training in the measurement techniques. It is important to note that the technicians' self-reported comfort level with the assessment tools and videotaping increased dramatically with even a small amount of practice. The Borg scale was clearly the best assessment tool to include in the package. The Level 1 Guide has potential; however, more training is required to use this tool and the length of time required to complete the assessment may be prohibitive in some situations. The most critical information source for the off-site ergonomist was the videotape recording of the task. This was also the root cause for the lack of agreement between the on-site and off-site ergonomists. Clearer, more structured and user friendly instructions and practice are required before the technician-collected data will be meaningful.

Work-related musculoskeletal disorders are the greatest readiness concern facing the Department of Defense. These injuries represent the greatest source of disease non- battle injuries and are the primary reason for the majority of physical limitation profiles. Ergonomic redesigns of tasks, tools and equipment based on accurate ergonomic assessments can reduce injuries and re-injuries, reduce lost work time and limited duty days, facilitate return to work and improve overall unit readiness. Results of this study will have far-reaching effects by providing the necessary assessment tools and processes to conduct accurate and timely ergonomic assessments in all military environments and locations.

TATRC Scientific Review

TATRC Acquisition Review

Supporting Graphs/Charts

See Attached

Table 1
Neck / Shoulder - Right:

Technician

On-Site	Moderate	High	Very High
Moderate	56	2	2
High	5	0	1
Very High	7	0	1

Table 2
Neck / Shoulder - Left:

Technician

On-Site	Moderate	High	Very High
Moderate	58	2	2
High	4	0	1
Very High	7	1	1

Table 3
Back:

Technician

On-Site	Moderate	High	Very High
Moderate	50	2	6
High	6	0	0
Very High	8	2	1

Table 4
Arm - Right:

Technician

On-Site	Moderate	High	Very High
Moderate	48	1	4
High	7	3	0
Very High	4	2	0

Table 5
Arm - Left:

Technician

On-Site	Moderate	High	Very High
Moderate	52	3	4
High	4	1	0
Very High	3	1	0

Table 6
Wrist - Right:

Technician

On-Site	Moderate	High	Very High
Moderate	36	0	3
High	11	2	3
Very High	8	1	1

Table 7
Wrist - Left:

Technician

On-Site	Moderate	High	Very High
Moderate	39	2	4
High	11	1	3
Very High	7	0	0

Table 8
Legs - Right:

Technician

On-Site	Moderate	High	Very High
Moderate	61	2	4
High	3	0	0
Very High	3	1	0

Table 9
Legs - Left:

Technician

On-Site	Moderate	High	Very High
Moderate	62	2	4
High	3	0	1
Very High	2	1	0

Table 10
Ankles - Right:

	Technician		
On-Site	Moderate	High	Very High
Moderate	54	1	4
High	3	0	1
Very High	4	1	0

Table 11
Ankles - Left:

	Technician		
On-Site	Moderate	High	Very High
Moderate	56	1	4
High	3	0	1
Very High	2	1	0

Table 12
Mean ± SEM OWAS by category (n=125)

	OWAS 1 (%)	OWAS 2 (%)	OWAS 3 (%)	OWAS 4 (%)
On Site	68.0 ± 2.4	21.8 ± 1.9	6.0 ± 1.2	4.2 ± 1.1
Off Site *	51.9 ± 2.7	37.4 ± 2.5	8.6 ± 1.4	2.2 ± 0.9

* Significantly different than the on site ergonomist's reading for OWAS 1, OWAS 2 and OWAS 4, $p<0.05$.

Table 13
Mean ± SEM RULA by category (n=125)

	RULA 1 (%)	RULA 2 (%)	RULA 3 (%)	RULA 4 (%)
On Site	24.3 ± 2.0	44.1 ± 2.2	24.9 ± 1.9	6.7 ± 1.2
Off Site *	39.2 ± 2.4	43.9 ± 2.3	13.0 ± 1.8	3.9 ± 1.1

* Significantly different than the on site ergonomist's reading for RULA 1, RULA 3 and RULA 4, $p<0.05$.

Table 14
Questionnaire Responses – Mean Values.

Question	Video Method	NIOSH Lift Equation	Borg Scale	Rodgers Methodology	Level 1 Guide
1. How easy was it to collect the information?	2.33	3.78	1.44	2.56	2.22
2. If you had to collect the same information in the field, how easy do you think it would be?	2.56	3.44	2.22	3.22	2.56
3. If you had to collect the same information in a deployed environment, how easy do you think it would be?	2.67	2.89	2.33	3	2.44
4.? How much time did it take to collect this information?	4.22	3.89	2.33	3.22	3.11
5.? How much time will it take to collect this information in the field?	3.78	3.78	2.78	3.44	3.44
6.? How much time will it take to collect this information in a deployed environment?	3.78	3.78	2.33	3.11	3.33
7. How "user-friendly" was this assessment method?	2.44	2.22	1.56	2.44	2.44
8. How helpful were the instructions for this assessment method?	2.33	2.11	1.67	2.33	2.56
9. How clear were the instructions for this assessment method?	2.22	2.11	1.67	2.44	2.56
10. How complete were the instructions for this assessment method?	2.11	2.11	1.56	2.33	2.56
11. Overall, how accurate was the data	2.22	2.78	2	2.44	2.33

you collected with this assessment method?					
12.* How many task assessments did you perform with this assessment method before you felt the data collected was accurate? Please provide a specific number of tasks.	6.44	8.78	4.11	7.33	7
13.* How many task assessments did you perform before you felt comfortable with this assessment method? Please provide a specific number of tasks.	4.89	9.11	4.44	7.78	7.11

? These questions were on a Likert scale. They did not ask for a specific amount of time.

* These questions were not on the Likert scale. They asked for a specific number of tasks.

Figure 1 : How easy was it to collect the information?

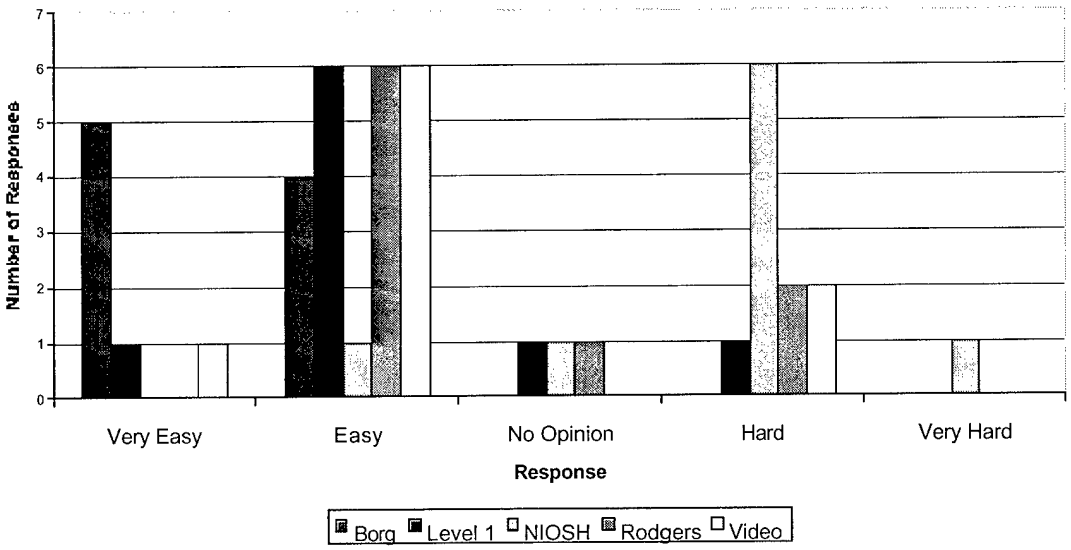

Figure 2 : If you had to collect the same information in the field, how easy do you think it would be?

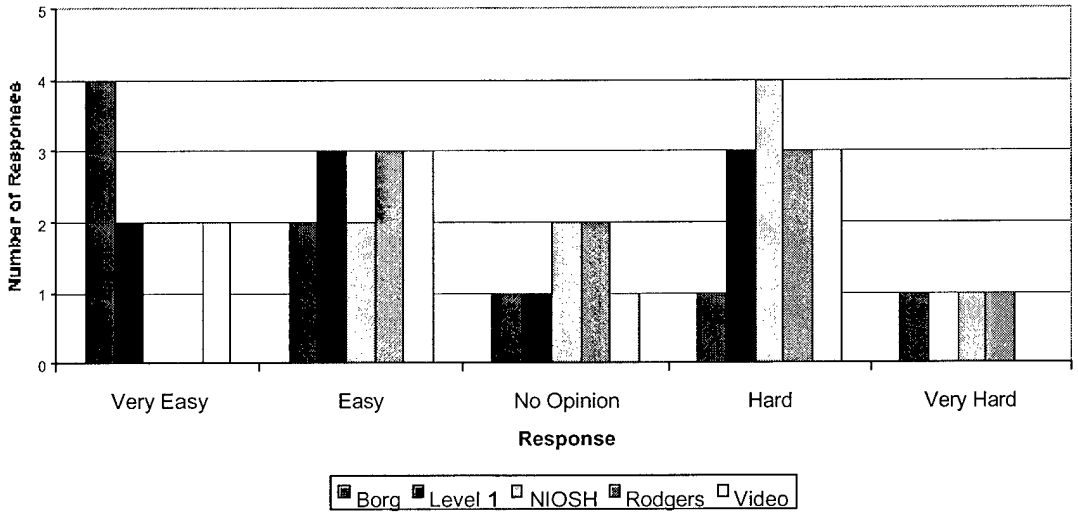

Figure 3 : How much time did it take to collect this information?

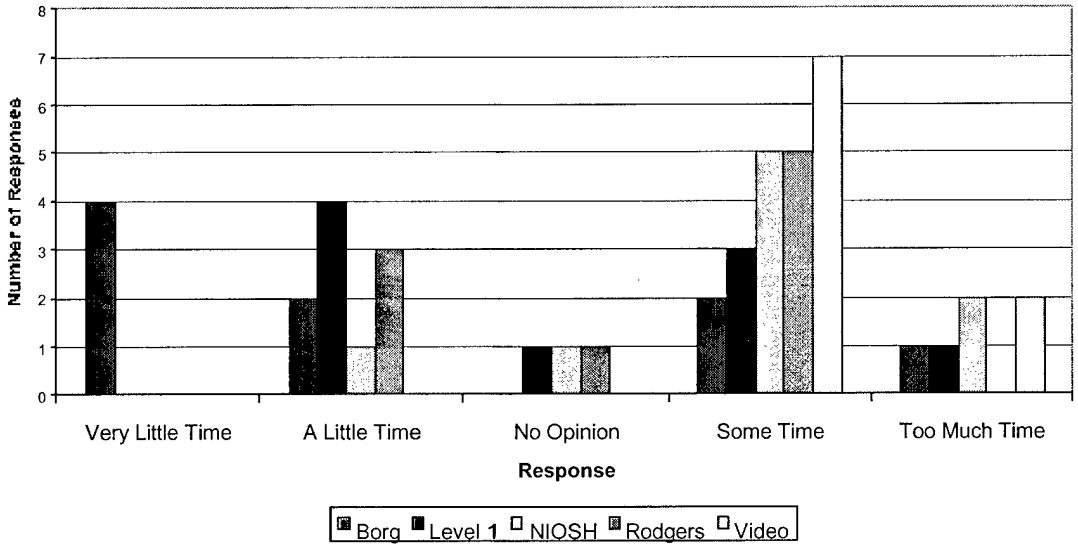

Figure 4 : How much time will it take to collect this information in a deployed environment?

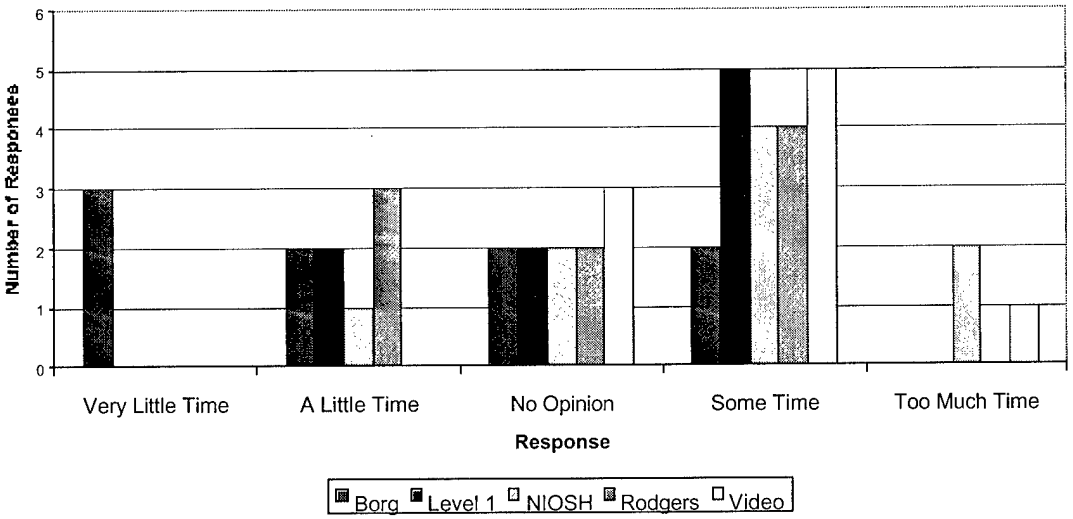
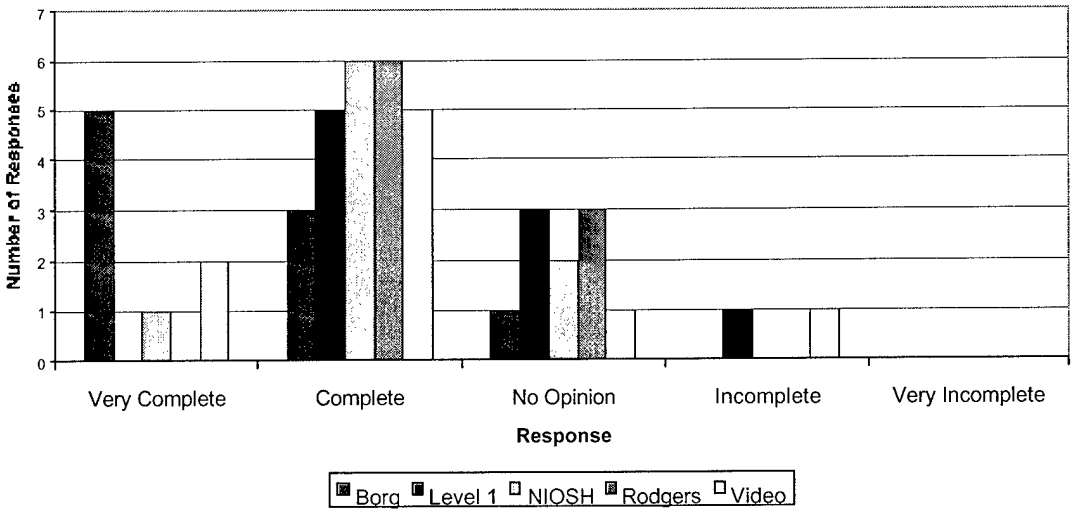
Figure 5 : How complete were the instructions for this assessment method?