APPENDIX:

Methods for a time-based method of computer-assisted posture analysis

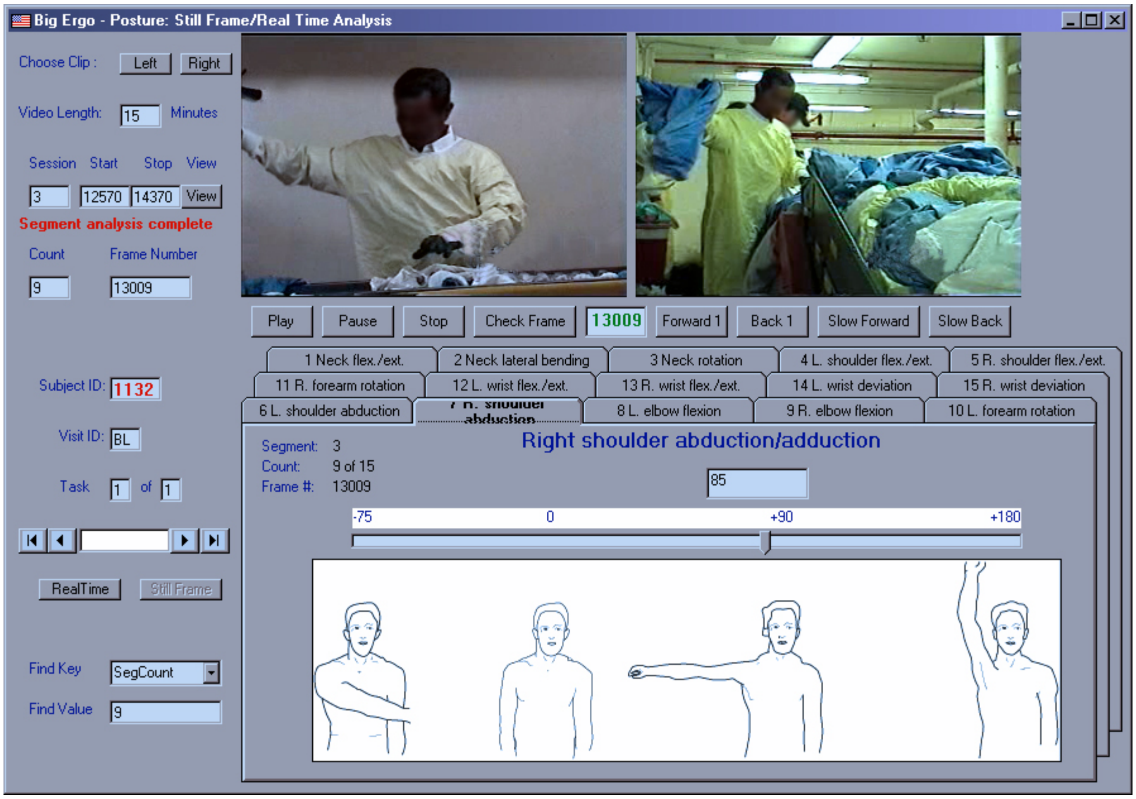
This appendix supplements the posture analysis methods described in the main paper by providing additional details that, while not crucial to understanding the manuscript, do provide additional context for the discriminating reader. In 2006, some of this content was included in a poster presented at the International Ergonomics Association Conference (Burt 2006). The shoulder posture data analyzed for this study come from a large research project that assessed occupational risk factors for hand, wrist, elbow, and shoulder outcomes. This appendix presents additional information relevant to the upper arm flexion and abduction posture variables presented our prospective rotator cuff syndrome study. Posture assessment methods were designed to be an accurate and practical approach for a large, complex, multi-year field study that included task-level exposure assessments for each participant.

This project used a time-based approach of posture analysis using a computer program to assess upper limb postures from digital videos taken of the study participants performing their jobs. Despite recent advances in direct measures of upper limb posture, there are still barriers today to measuring upper limb posture in workplace settings without disrupting the workers' activities. When this study was designed in the early 2000s, the methods developed and used for this study were the best choice. Using a time-based method reduced analyst categorization bias. Analysts determined posture based on a visual analog scale with visual prompts (Supplemental Figure 1A and 1B). To reduce bias, the analysts assigned a specific angle to each sampled frame individually, rather than selecting from a category.

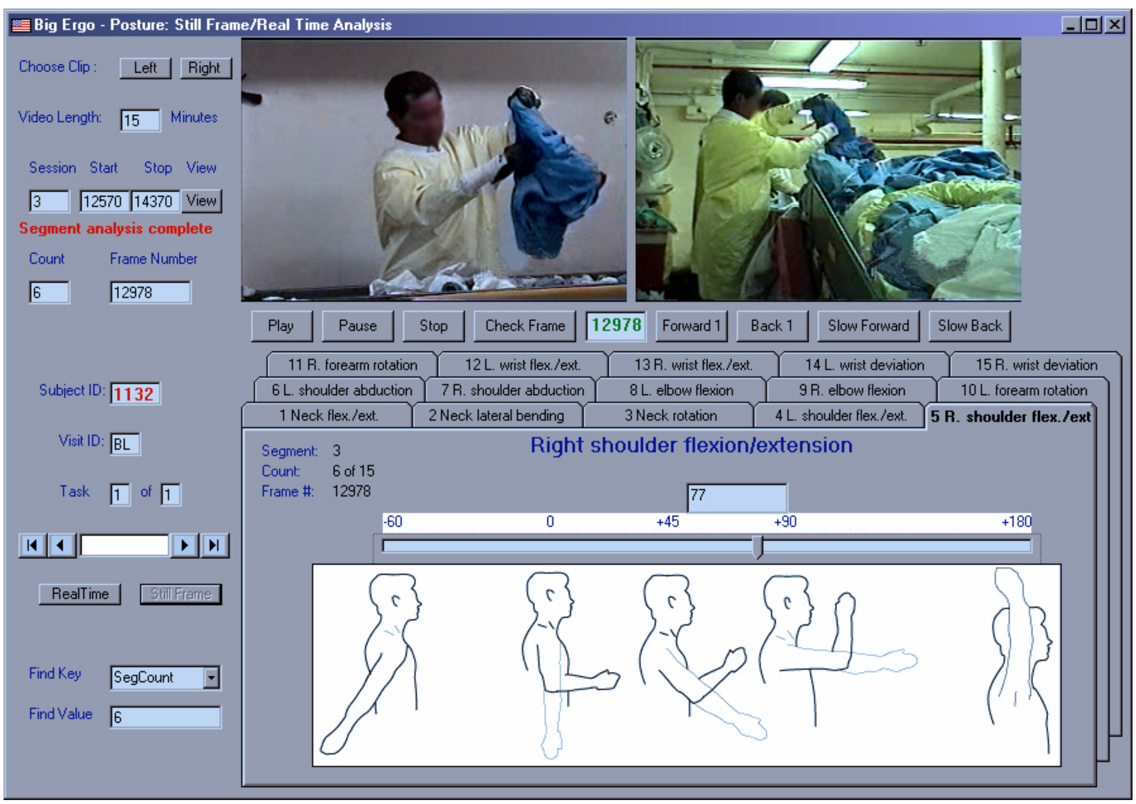
Field video data collection

Two cameras were used to collect video data in the field. Camera operators attempted to capture simultaneously the sagittal and frontal view of work activities for each workers' tasks while keeping both hands, arms, and shoulders visible. The cameras were synchronized by focusing on a flashlight as it was turned on and off. Single task jobs were filmed for 17 minutes; for multi-task jobs, each task was filmed

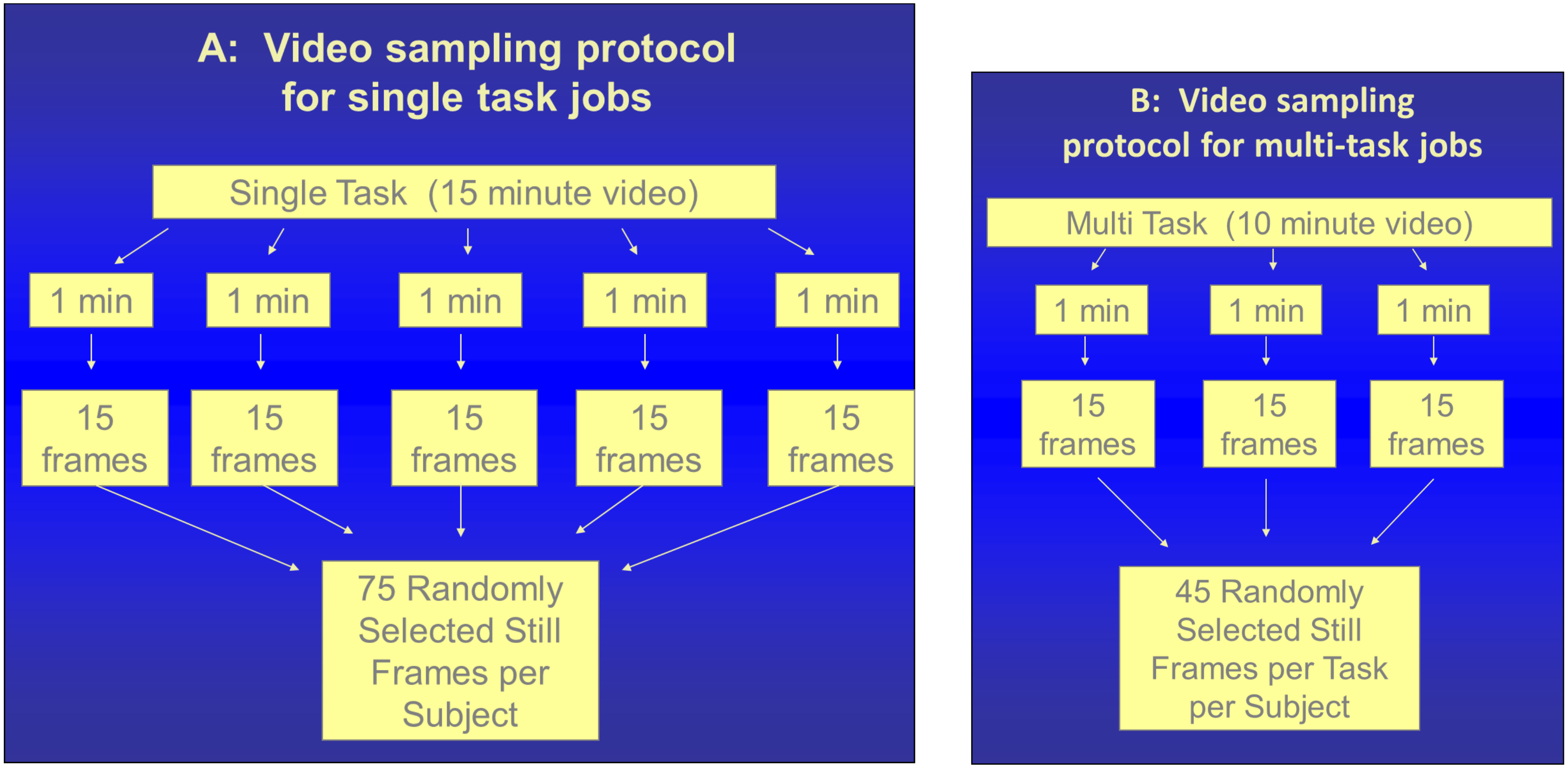
A.



B.



Supplemental Figure 1. The graphic interface of a Visual Basic computer program incorporated synchronized playback of the two camera angles with a set of 15 scales depicting the range of motion of joint articulations. Scales depict the full range of joint articulation for upper arm-trunk angles in the A. frontal plane (abduction), and B. sagittal plane (flexion/extension.



Supplemental Figure 2. Video sampling protocol for selecting random frames for posture analysis for: A. single task jobs and B. multi-task jobs.

for 12 minutes. The filming time was longer than the final tape used for analysis to allow for loss of footage when the tape was digitized. In the laboratory, videotapes were converted to digital video files and cut to exactly 15 minutes (single task jobs) or 10 minutes (multi-task jobs). The first minute was not used for analysis, as it showed the cameras synchronizing on a flashlight, being moved into position, and then identifying the subject for the video analysts. The last minute of video is not used for analysis. The two videos were incorporated into a computer-based analysis program that was used to quantify posture data for each task.

Video frame sampling protocol

We analyzed upper arm posture angles for each still frame and each arm using two visual analog scales accompanied by two scales depicting the full range of joint articulation for upper arm-trunk angles in two planes of motion — sagittal (60° extension–180° flexion) and frontal (75° adduction–180° abduction). Supplemental Figure 1A and 1B includes two screenshots of the program's interface for rating upper arm abduction (A) and upper arm flexion/extension (B). To conduct the posture analyses for this study, we selected random sets of one-minute video segments, as described in Supplemental Figure 2 (A & B): five randomly selected, non-overlapping, one-minute segments for single task jobs (A); and three randomly selected, non-overlapping, one-minute segments for each task in multiple task jobs (B). The 15 frames were randomly selected within each of the non-overlapping one-minute segments. For a single task job, the one-minute segments were selected within these ranges:

One -minute video segments	Starting range (minutes)	Ending range (minutes)
Segment 1	1 (frame #1800)–3 (frame #5400)	4 (frame #7200)
Segment 2	4-6	7
Segment 3	7-9	10
Segment 4	10–12	13
Segment 5	13–15	16

The theory behind the posture sampling design was that the 75 samples were representative of the postures assumed during the videotaped job tasks, which themselves were assumed to be representative of the task being analyzed.

Computer-based exposure analysis

The user interface programmed in VisualBasic6 incorporated synchronized video playback of a worker performing his or her job task from the two camera angles with a set of 15 visual scales depicting the range of motion of each joint articulation. The analyst viewed the videos in real time to become familiar with the task before rating postures. The previously sampled video frame numbers were provided to the video analysts. The analyst then rated the angle of the upper arm posture observed in each of the randomly selected still frames. Analysts referred to posture illustrations on the screen as a guide using superimposed scales depicting degrees of deviation from neutral. The analyst then clicked and dragged the cursor to a point on the scale that represented the best match between the observed posture and the illustrations. A direct visual comparison using posture illustrations simplified the rating of observed postures by eliminated the need for analysts 1) to learn terminology for particular joint motions (e.g., ulnar or radial deviation), or 2) to judge the degrees of deviation numerically. After all scales were rated, the rater advanced to the next random still frame and the process began again for each side and each joint. Sometimes scales were left blank because not all upper limb joints were visible in all randomly selected frames. When a scale was left blank, the program gave the option to go back and complete that scale or continue.

Percent-time posture variables

After video analyses were completed, the database of angle associated with each video frame were imported into SAS. In SAS, we used the cut-point for a posture category (e.g. $\geq 45°$) to categorize each frame as within or outside the specified range. Task-level values for percent time spent in a posture category were calculated by dividing the sum of frames within the category by the total number of sampled frames. We limited our analyses to results for the workers' dominant arm. Time weighted averages (TWAs) were used to estimate percent time per shift spent in each posture category.