Postural Observation of Shoulder Flexion during Asymmetric Lifting Tasks

Xu Xu¹, Chien-Chi Chang¹, Gert S. Faber²,
Idsart Kingma², and Jack T. Dennerlein^{3,4}

¹Liberty Mutual Research Institute for Safety, 71 Frankland Road,
Hopkinton, MA 01748 U.S.A.

²Institute for Fundamental and Clinical Human Movement Sciences, Faculty of Human
Movement Sciences, VU University, Van der Boechorststraat 9,
1081 BT Amsterdam, The Netherlands

³Department of Environmental Health, Harvard School of Public Health, 665 Huntington
Avenue, Boston, MA 02115 U.S.A.

⁴Department of Orthopaedic Surgery, Brigham and Women's Hospital, Harvard Medical
School, 75 Francis Street Boston, MA 02115 U.S.A.

{Xu.Xu, chien-chi.chang}@LibertyMutual.com,
{gfaber, jax}@hsph.harvard.edu, i_kingma@fbw.vu.nl

Abstract. This study was to evaluate the observation error of the shoulder flexion angle during an asymmetric lifting task. The results indicated the average absolute estimate error was 14.7 degrees and the correlation coefficient between the measured and estimated shoulder flexion was 0.91. The observation error may be due to the arm abduction.

Keywords: Shoulder flexion, Posture observation, Side-view, Lifting tasks.

1 Introduction

Shoulder musculoskeletal disorders (MSD) have been a major occupational injury. Some studies found that shoulder joint deviation can lead to shoulder joint injury or discomfort (Holmstrom et al., 1992). One way to monitor awkward shoulder postures is by postural observation. Although postural observation is not as accurate as using laboratory equipment, it is still widely adopted by ergonomists to assess mechanical exposure as it does not require specialized equipment and does not involve strong interference with the normal operations of those being surveyed. A previous study indicated that observers could provide good estimates on shoulder flexion when the arms moved in the sagittal plane (Genaidy et al., 1993). On the other hand, a more recent study indicated that the observation error of shoulder posture was large during lifting tasks (Lu et al., In press).

The main objective of this study was to evaluate the observation error of the shoulder flexion angle during an asymmetric lifting task. A lifting task was designed

to provide motion tracking system-based direct measurement of shoulder flexion as well as video clips with which the shoulder flexion could be estimated by the raters with a customized program.

2 Method

Twelve healthy male lifters (age: 47.5 (11.3) years, height: 1.74 (0.07) m, weight: 84.5 (12.7) kg) performing various lifting tasks in a laboratory were recorded by a side-view camcorder and a synchronized motion tracking system. The task involved lifting a plastic crate weighing 10 kg with three vertical lifting ranges (floor to knuckle height, floor to shoulder height, and knuckle height to shoulder height) and three end-of-lift asymmetric angles (0 deg, 30 deg to the right, and 60 deg to the right). For each lifting condition, two repetitions were performed.

A customized computer program extracted four frames from each video clip of lifting tasks at time T , $T+\Delta t/3$, $T+2\Delta t/3$, and $T+\Delta t$, where T was the starting time of the lift and Δt was the time needed for performing the lifting task. Ten raters (age: 37.0 (16.7) years) estimated shoulder flexion angle for each of the four frames. The sequence of video clips was randomized for each rater. Before the observation, training was provided to the raters with 3 video clips. For each frame, the measured shoulder flexion angle was extracted from the synchronized motion tracking system. The measured shoulder flexion angle subtracted from the estimated shoulder flexion angle was defined as the estimate error. The averages of the absolute estimate error among all frames and the correlation coefficient between the measured and estimated shoulder flexion angle were calculated.

3 Results and Discussion

The average absolute estimate error was 14.7 degrees for shoulder flexion. The correlation coefficient between the measured and estimated shoulder flexion was 0.91. Figure 1- left shows that there were a few trials where the rater-estimated shoulder flexion was around 0 degrees (upper arm was horizontal to the ground) while the measured angle was around -90 degree (upper arm was vertical to the ground and at the side of the trunk). Such discrepancy may be due to the arm abduction (Figure 1 - right). During the lifting experiment, lifters tended to have approximate 90-degree shoulder abduction when the box reached the highest point during the lift. In this case, the raters may estimate the shoulder flexion as 0 degrees when they observe such posture from the side view. However, the motion tracking system yielded the shoulder flexion as -90 degrees based on Euler angles decomposition. It is unclear whether estimating the 3-D shoulder angle can improve the observing accuracy because previous research (Lowe, 2004) found that observers had low precision on 3-D shoulder angle estimations.

Fig. 1. Left: Measured shoulder flexion angle vs. estimated shoulder flexion angle. Right: Shoulder abduction angle vs. estimation error of shoulder flexion.

References

1. Genaidy, A.M., Simmons, R.J., Guo, L., Hidalgo, J.A.: CAN visual-perception be used to estimate body part angles. *Ergonomics* 36, 323–329 (1993)
2. Holmstrom, E.B., Lindell, J., Moritz, U.: Low back and neck/shoulder pain in construction workers: occupational workload and psychosocial risk factors. Part 2: Relationship to neck and shoulder pain. *Spine* 17, 672–677 (1992)
3. Lowe, B.D.: Accuracy and validity of observational estimates of shoulder and elbow posture. *Appl. Ergon.* 35, 159–171 (2004)
4. Lu, M.-L., Waters, T., Werren, D., Piacitelli, L.: Human posture simulation to assess cumulative spinal load due to manual lifting. Part II: accuracy and precision. *Theoretical Issues in Ergonomics Science* (in press)