RECOMMENDED LIMITS FOR ONE-HANDED LIFTING AND LOWERING

Eric B. Weston, Alex Aurand, Jonathan S. Dufour, Gregory G. Knapik, W. Gary Allread, William S. Marras
Spine Research Institute, The Ohio State University, Columbus, OH USA

SUMMARY

Multiple tools exist to estimate the risk associated with lifts performed in occupational environments using two hands, but no prior studies have presented guidelines that can be utilized for one-handed lifting scenarios. This document describes the development of a new set of one-handed lifting (and lowering) guidelines and instructs practitioners on how to implement them to help reduce the risk of low back disorders.

BACKGROUND

Low back disorders (LBDs) represent the number one cause of disability globally, and more than 80% of the population experiences low back pain at least once in their lifetime[1]. These LBDs carry an immense economic burden, in which annual direct treatment costs in the United State exceed $100 billion[2]. Links have long been established between occupational exposures and LBDs, especially lifting[3-4].

The vast majority of studies performed relative to lifting in occupational environments have focused on scenarios where two hands are used to lift an object, and results of these studies have led to two-handed lifting guidelines like the Revised NIOSH Lifting Equation[5] or the BWC/OSU Lifting Guidelines[6]. Far fewer studies have examined one-handed lifting scenarios, common to lifting objects from industrial storage bins, stocking products onto shelves, or lifting objects with only one handle. Moreover, no studies have presented guidelines for one-handed lifting, and the lifting guidelines applicable for two-handed exertions are not applicable to one-handed exertions. ***Thus, there remains a need for clear, applicable guidelines for one-handed lifting.***

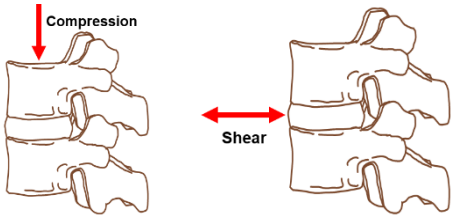
This study used biomechanical information collected from 30 human subjects in a laboratory to develop one-handed lifting and lowering guidelines for practitioners that are ***protective of the lower back***. A subject data – driven biomechanical spine model predicted the loads on the spine under various lifting conditions. Subjects lifted and lowered medicine balls with one hand while standing on a force plate (Figure 1).

Subjects lifted from/lowered to heights between their ankle and waist, asymmetries between 0 and 90 degrees, and reach distances both close (16 in.) and far (28 in.) from the body. Weights were between 6 and 25 pounds.

Figure 1. Subject performing a one-handed lifting trial.

NOTES ABOUT THE GUIDELINES

- These guidelines were ***designed to protect against LBDs***. Risk of other types of injury (i.e., the shoulders) were not examined in this study.
- The guidelines were created based upon evaluating risk according to several criteria, including ***1) loading, 2) strength, and 3) lift frequency.***
- ***Loading*** on the spine in both *compression* and in *shear* were compared to their risk thresholds[5, 7] to determine risk along each dimension.



- Subject ***strength*** was factored into the guidelines based upon the percentage of males and females able to complete the task in the laboratory.
- ***Lift frequency*** was introduced in overall risk determination based upon jobs classified as either high or low risk in a prior study[8]. 4.25 exertions/minute (or 255 exertions/hour) or less are acceptable, but frequencies exceeding this value increase the overall risk for the exertion in question.
- The guidelines proposed ***do not differ based on the gender of the worker.***

USING THE GUIDELINES

It will be necessary to enter several pieces of information about the one-handed lifting or lowering task being tested into the online web interface in order to estimate biomechanical risk.

Measuring Lift/Lower Height

Measure and record the vertical height between the ground and the hands at the lift origin or lowering destination, in inches. The guidelines can accommodate vertical heights of 5-40 inches. Note that 6 inches corresponds to approximately ankle height (i.e., load on the floor), 20 inches corresponds to approximately knee height, and 36 inches corresponds to approximately waist height.

Measuring Reach Distance

Measure and record the horizontal distance between the mid-point of the ankles and the midpoint of the hands (projected to the floor) at the lift origin or lower destination, in inches. The guidelines can accommodate reach distances of 16-28 inches.

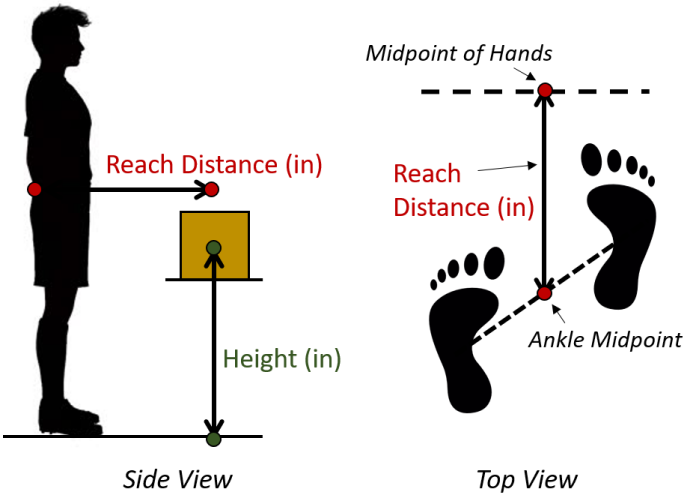


Figure 2. Measurement of lift/lower height and reach distance

Measuring Asymmetry

Measure the angle between the feet and the load that is to be lifted or lowered, in degrees. The guidelines can accommodate angles of 0-90 degrees. It is important to note that these guidelines are only applicable for lifts where the angle of asymmetry and the hand being used to lift the load are on the same side of the body (that is, the worker twists right and picks the object up with the right hand or twists left and picks the object up with the left hand).

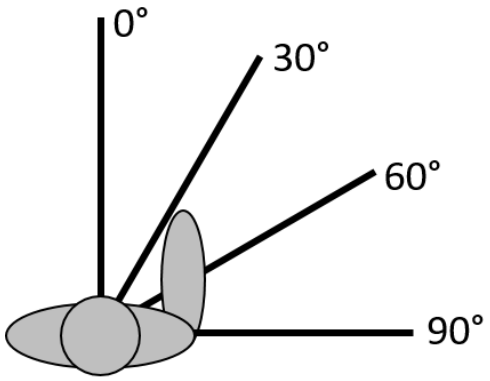


Figure 3. Measurement of asymmetry

Measuring Object Weight

Determine the weight of the object lifted or lowered, in pounds. If the weight lifted varies from lift to lift, use the maximum weight lifted to determine risk. The guidelines can accommodate weights of 0-25 pounds.

Measuring Lift/Lower Frequency

Determine the average number of lifts or lowers per minute. This can be done by counting the total number of lifts or lowers a worker performs during some sampling period, usually between 10-15 minutes. Divide the total number of lifts performed by the duration of the sampling period (in minutes), and that will be the lift/lower frequency. The guidelines can accommodate lift/lower frequencies of 0.2-15 per minute.

Interpreting Risk

The web interface will calculate the risk associated with performing that particular type of exertion and assign it a risk level of either low, medium, or high (Figure 4).

Low. Can be viewed as acceptable. The exertion is safe for at least 80% of the population from a spinal loading perspective, and greater than 75% of both males and females could complete the task.
Medium. It is *recommended* that changes to the task be made to make it safer. The exertion is safe for 50-80% of the population from a spinal loading perspective, or 25-50% of males or females could not complete the task.
High. It is *strongly recommended* that changes to the task be made to make it safer. The exertion is safe for less than 50% of the population from a spinal loading perspective, or more than 50% of males or females could not complete the task.

Figure 4. Risk levels as outputs to the online one-handed lifting guidelines and their meaning to the practitioner.

GUIDELINES

The online tool interpolates across studied conditions to allow for continuous data entry at exact heights, asymmetries, reach distances, and object weights. However, Figure 5 shows a snapshot of the risk levels for one-handed lifting and lowering at the boundaries of what was tested in the laboratory.

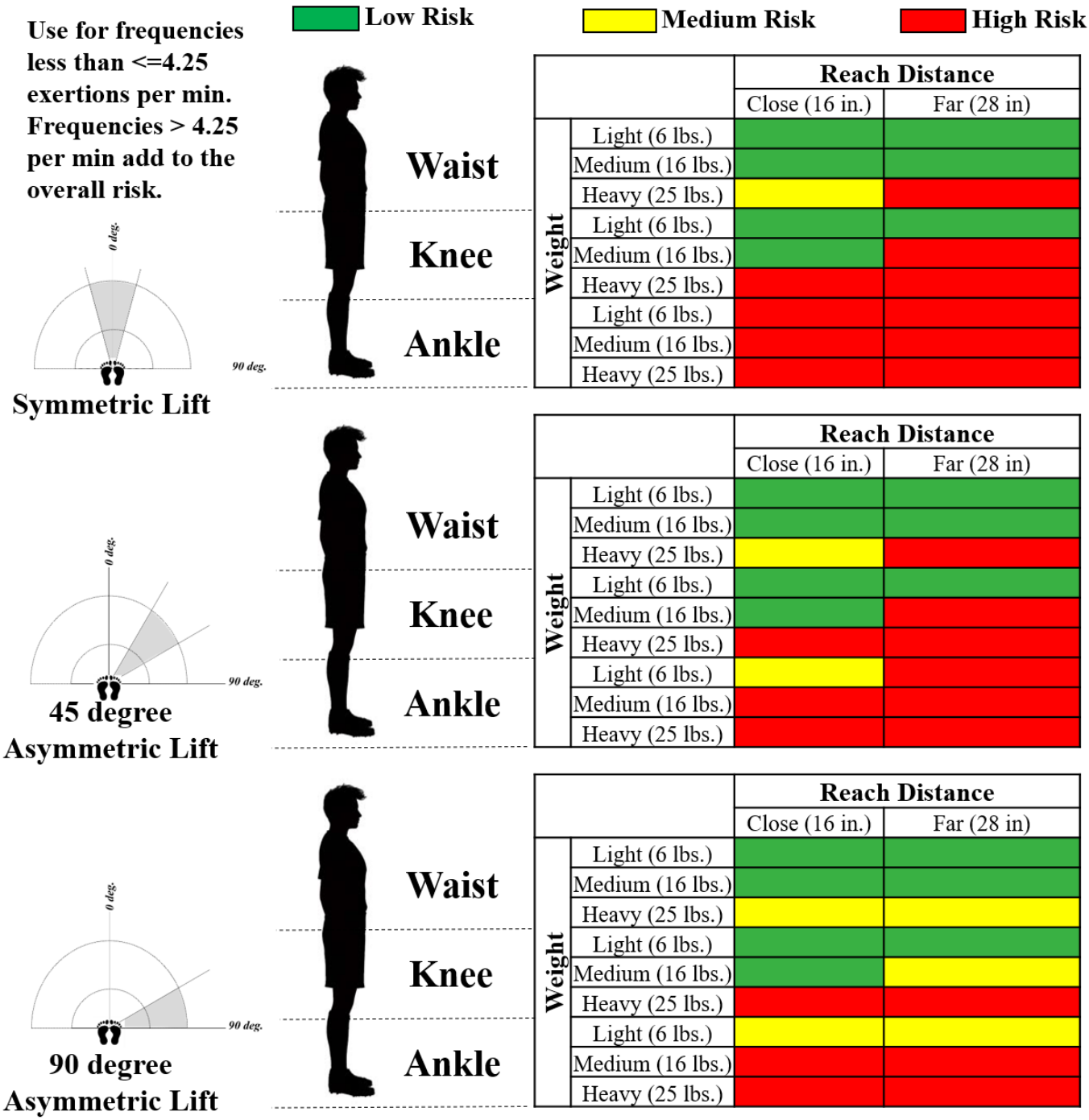


Figure 5. Risk classification at the boundary conditions. Assumes lift/lower frequencies under 4.25 exertions per minute, or 255 exertions per hour. Lift/lower frequencies above 4.25 per minute would increase risk classification (i.e., low to medium, medium to high).

ACKNOWLEDGEMENTS

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REFERENCES

[1] Luo, X., et al., 2004. Estimates and patterns of direct health care expenditures among individuals with back pain in the united states. *Spine,* 29 (1), 79-86.

[2] Pai, S. & Sundaram, L.J., 2004. Low back pain: An economic assessment in the united states. *The Orthopedic clinics of North America,* 35 (1), 1-5.

[3] Coenen, P., et al., 2014. The effect of lifting during work on low back pain: A health impact assessment based on a meta-analysis. *Occup Environ Med,* 71 (12), 871-7.

[4] Griffith, L.E., et al., 2012. Individual participant data meta-analysis of mechanical workplace risk factors and low back pain. *American Journal of Public Health,* 102 (2), 309-318.

[5] Waters, T.R., Putz-Anderson, V., Garg, A. & Fine, L.J., 1993. Revised NIOSH equation for the design and evaluation of manual lifting tasks. *Ergonomics,* 36 (7), 749-76.

[6] Ferguson, S.A., Marras, W.S. & Burr, D., 2005. Workplace design guidelines for asymptomatic vs. Low-back-injured workers. *Appl Ergon,* 36 (1), 85-95.

[7] Gallagher, S. & Marras, W.S., 2012. Tolerance of the lumbar spine to shear: A review and recommended exposure limits. *Clin Biomech (Bristol, Avon),* 27 (10), 973-8.

[8] Marras, W.S., et al., 1993. The role of dynamic three-dimensional trunk motion in occupationally-related low back disorders. The effects of workplace factors, trunk position, and trunk motion characteristics on risk of injury. *Spine (Phila Pa 1976),* 18 (5), 617-28.

FOR MORE INFORMATION

More information about our laboratory and our prior work can be found at https://spine.osu.edu.

More information about the Ohio Bureau of Workers' Compensation (BWC) can be found on their website at http://www.bwc.ohio.gov/Default.aspx.