Biomechanical Analysis of Spinal Load in Motor-Manual Cutting

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ABSTRACT

Two Norwegian cutting instructors have been used as models for demonstration of "correct" and "poor" working postures in motor-manual cutting. This enabled estimation of the intervertebral disc compression forces at L5/S1-level. The results,when related to defined lifting hazard levels shows that the compressive forces are greater in all "poor" postures compared with corresponding "correct" postures. Furthermore, relating to the lifting hazard levels, it becomes obvious that even correct working techniques in the felling and bunching sequences entails hazardous compressive forces in the lumbar column. This is probably one of the main causes of the high incidence of lower back injuries among loggers. Training courses for better technique and adminstrative or engineering controls to eliminate the peak loads are still needed in forestry.

Key Words: *Logger, Spinal Load, Lower Back Pain, Motor-manual Cutting.*

INTRODUCTION

In Norway the most frequent health complaint among power saw operators is lower back pain. In spite of the present high level of mechanization of forest operations, motor-manual cutting still represents a large portion of the annual cut . As an attempt to do this work with less strain and to prevent lower back diseases, courses in cutting technique are offered in all forest districts in Norway.

This paper attempts to estimate the load in the lumbar spine in selected work operations with "correct" and "poor" working techniques, and compares these loads to suggested human performance limits. The project was carried out cooperatively between Norwegian Forest Research Institute and "Activity in Forestry",the institution which educates the cutting instructors in Norway.

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MATERIALS AND METHODS

Two cutting instructors demonstrated four typical work operations in motor-manual cutting with "correct" and "poor" working techniques. "Poor" technique is defined as lifting with the back bent from a stooped posture (torso lift). "Correct" technique is defined as lifting with back straight from a squat posture with the load as close to the body as possible (leg lift). Figure 1 show "correct" and "poor" techniques in the felling operation.

The quality to be discussed, spinal load, is defined as the degree of compression in the intervertabral disc between the fifth lumbar vertebrae and sacrum, called the L5/S1 disc. The intervertebral disc is an important structure in lower back pain syndromes. It is formed by two distinct structures, the nucleus pulposus, which is surrounded by the annulusus fibrosus. The disc is separated from the vertebral bodies by cartilage endplates. Excessive compressive forces can break the cartilage endplate, which in turn affects the nutrition of the disc. After a time this allows the watery gel in the nucleus to protrude towards the annulus, in the worst cases affecting the Sciatic nerve. (2,3).

The analyses are calculated on a personal computer using the software "2D Static Strength Prediction Program," Center for Ergonomics, Michigan, USA. Model inputs are the subject's anthrophometry, body posture, load magnitude and direction acting on the hands. Body postures and joint positions were measured by photgraphy and goniometer respectively. The load magnitudes were measured with strain gauges.

The defined hazard levels are specified by NIOSH (4). The limits referred to here are the biomechanical aspect of this system, which is originally based on consideration of epidemiology, physiology, psychophysiology and biomechanics. The ACTION LIMIT (AL) is established at L5/S1 compression about the 3400 Newtons [770 lbs.] level, which can be tolerated by most people. The MAXIMUM PERMISSIBLE LIMIT (MPL) is established at about 6400 Newtons[1430 lbs.], and can not be tolerated by most people.

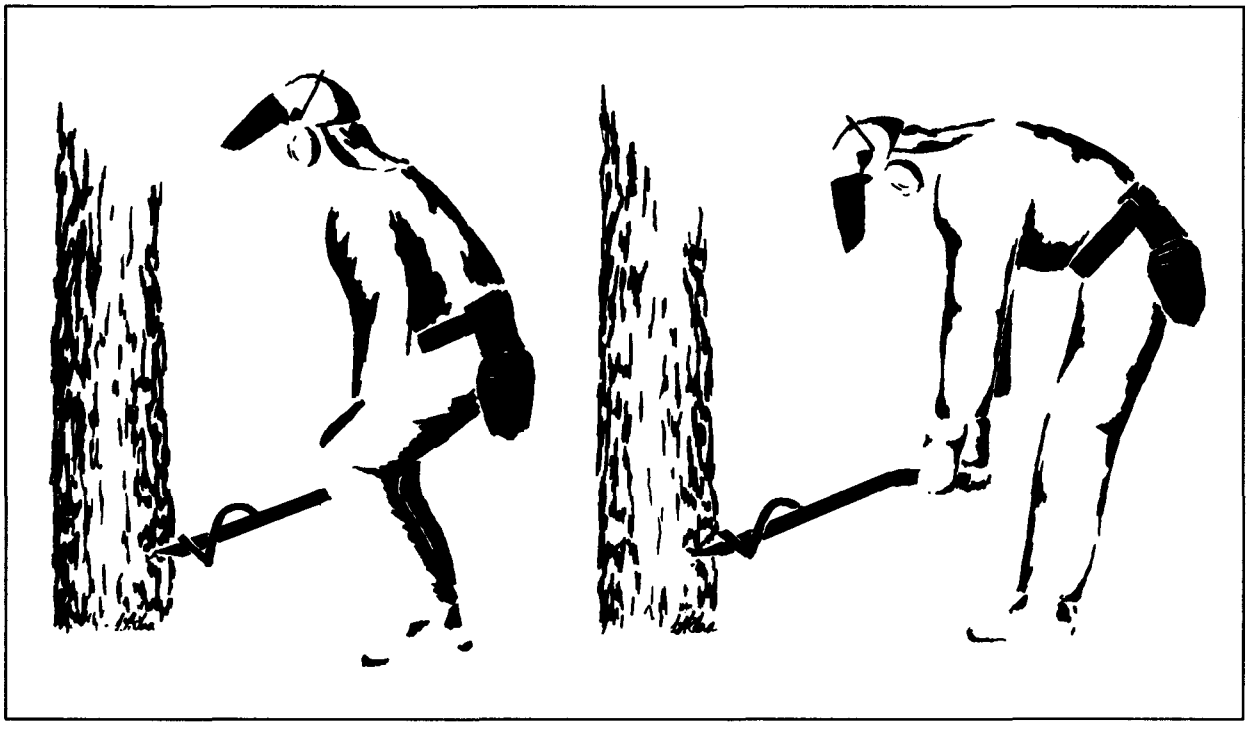

Figure 1. Working techniques in the felling operation demonstrated by cutting instructor 2. To the left: Lifting with straight legs and bent back - "poor" technique. To the right: Lifting with the legs bent and the load held closed to the body - "correct" technique.

RESULTS AND DISCUSSION

Compressive forces in the L5/S1 disc were calculated for both instructors demonstrating the two different techniques in the operations felling, limbing above and below trunk and bunching. Figure 1 shows the body postures demonstrated by instructor 2 in the felling operation. The load magnitude was measured to be 686 Newtons. The estimated back compression for these tasks were 4719 Newtons for the "correct" posture and 6681 Newtons for the "poor" posture. Figures 2 and 3 show the results for the two instructors in the different operations. As shown in the figures, the compressive forces are greater in all "poor" postures compared with corresponding "correct" postures for both instructors in all operations. Both inthe felling and bunching operations there are compressive values above the AL limit with "correct" technique and above MPL with "poor" technique.

According to NIOSH (4), lifting tasks "above MPL should be considered as unacceptable, and engineering controls should sought to redesign the lifting conditions." Adminstrative or engineering controls, such as training, careful employee selection or job redesign are required for those between AL and MPL. For the forest industry this means that training courses carried out by professional instructors should be an important part of a preventive program. Other control planning could be to improve the logger's felling equipment or let the forwarder do more of the bunching operations to eliminate the peak loads in these operations.

It is obvious that a simple sagital-plane model like this can not predict all harmful effects in manual handling. Shearing or torsional loads acting on the internal structures of the back are undoubtly harmful, but are beyond the scope of this study. In spite of this limitation the analysis creates a basis for understanding how loads held in various body postures in motor-manual cutting can create harmful compressive disc forces (1,2).

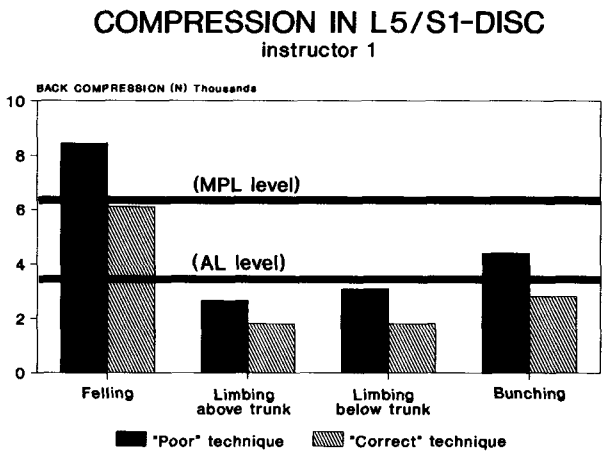

Figure 2. L5/S1 intervertebral disc compression estimated from body postures in motor-manual cutting. Demonstrated by cutting instructor 1 and compared to lifting hazard levels, Action Limit (AL) and Maximum Permissible Limit (MPL), specified by National Institute of Occupational Safety and Health, USA.

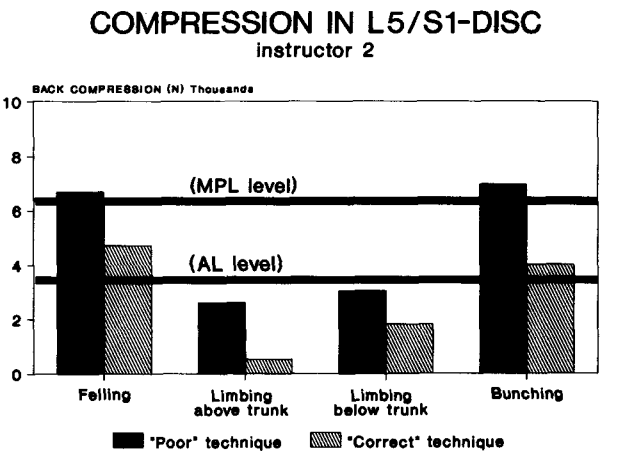

Figure 3. L5/S1 intervertebral disc compression estimated from body postures in motor-manual cutting. Demonstrated by cutting instructor 2 and compared to lifting hazard levels, Action Limit (AL) and Maximum Permissible Limit (MPL), specified by the National Institute of Occupational Safety and Health, USA.

CONCLUDING REMARKS

The biomechanical analysis shows that the compressive forces are greater in all operations with "poor" working techniques compared with "correct" working technique. But, related to lifting hazard levels, it seems that even with "correct" working techniques the compressive forces acting on the lower spine could be harmful in some operations. This implies that preventive programs for better technique and engineering and/or administrative controls seeking to reduce the loggers spinal load still are needed.

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