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EVALUATION OF TWO MOTOR-MANUAL DELIMBING TECHNIQUES

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ABSTRACT

A biomechanical model measuring the loading on the lower spine during two different delimbing techniques showed significant reductions in both the compression and shear forces. Using the technique which gave the reduced loading resulted in a 10% reduction in the daily productivity of the faller.

INTRODUCTION

While there have been recent attempts to mechanise the delimbing function in logging operations, the delimbing in clearfelling radiata pine is still carried out motor-manually. The "Transition" crop, in which this study was carried out, is typified as having more green branches than "Old" crop, as a result of having been grown at wider spacing. Growing radiata at such wide spacing has resulted in a very heavy branching habit.

The conventional technique for chainsaw delimbing involves the operator walking along the top of the log removing branches that are immediately obvious. This requires a stooped posture to be adopted by the operator. In an attempt to reduce the amount of bending required, longer than necessary guide bars (18 to 22 inch) are used. Furthermore, chainsaws employed are often 20cc larger than what is required.

These two factors, long bars and large saws, mean the operator carries considerably more weight than is necessary. This technique yields a poor quality of trim which often necessitates recutting of many branch stubs at the landing.

Delimbing using the above technique incurs the largest proportion of accidents reported through the Logging Industry Accident Reporting Scheme. On average during the past three years 30% of all lost time accidents have occurred while the operator has been delimbing (Gaskin, 1988). A recent study of the logging workforce (Gaskin, Smith and Wilson, 1988) found that 45% of all loggers suffered back problems.

In 1980, the industry investigated an alternative technique of delimbing (LIRA and Swedfor, 1980) which involved the operator walking alongside the log where ever possible, supporting the saw on either the log or the thigh. The technique required a shorter bar (15 to 16 inch) and, as a result a smaller chainsaw could be used. The advantages of this method over the conventional method were given as follows:

- The standard of delimbing is higher.
- As the operator is operating the saw much closer to him, he has more control over it.
- By walking alongside the log there would be less likelihood of accidents resulting from falls.
- By adopting a better posture less strain will be placed on the operator's back.

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The alternative technique was first assessed in radiata thinning (Gaskin, 1986). With the recent move to clearfelling transition crop it has become feasible to evaluate the alternative technique in clearfelling.

The two techniques are shown in figures 1 and 2

Figure 1 - Conventional Trimming

Figure 2 - Alternative Method

This report evaluates the biomechanical loading on the operator's lower spine for each of the two techniques, and also investigates productivity implications.

STUDY AREA

The study was conducted in compartment 1003 situated on the Reporoa face of Kaingaroa Forest during January 1988. This stand had been intensively treated (Table 1).

Table 1 - Stand Details

Compartment 1003

Established (regen) 1960

Pruned :

Low	1963	1000 stems
Medium	1966	400 stems
High	1968	300 stems

Thinnings :

1st non-com.	1964	1000 stems
2nd non-com.	1968	600 stems
Prod.(pulp)	1979	210 stems

Mean piece size at clearfell - 2.0m^3

Mean top height (before felling) - 37.8m

Terrain conditions were favourable, nearly flat, while undergrowth was light to moderate. The undergrowth consisted of sparse blackberry, bracken, and low pungas.

STUDY METHOD

The measurement of biomechanical loading and productivity was done separately.

Biomechanical Load on the Logger's Spine

Loadings were calculated using a two-dimensional static, sagittal plane model described by Chaffin and Andersson (1984). Body measurements required for the model were obtained from Chaffin and Andersson (1984) for a person with a height of 186 cm and weight of 88.4 kg. In addition the weight of the headgear used by the operator was 0.75 kg, while the saw weight was 11.5 kg. A stylised representation of the model and inputs is shown in figure 3.

These measurements were combined with the measurements of angles of the trunk, upper arm and lower arm with respect to the horizontal. These posture measurements were obtained by recording on video the operator delimbing three trees using each technique. The video was played back and, at 5 second intervals,

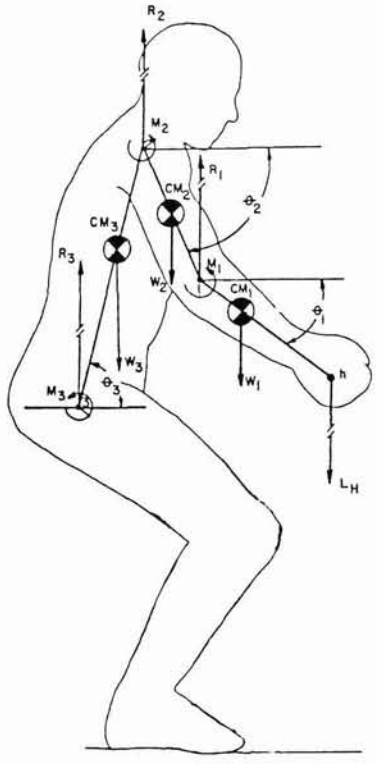

Figure 3 - The model used to calculate forces at the L5/S1 (Chaffin & Andersson, 1984)

body angles were recorded in multiples of 10 degrees. Angles were measured by overlaying a protractor device on the video screen (Slappendel and Gaskin, 1988).

The data were entered into the model which had been developed on a personal computer spreadsheet program. Compression and shear forces were calculated at the spinal disc connecting the 5th lumbar vertebrae with the sacrum. This joint, which will be refered to as L5/S1 is located in the lower back. Research has shown that between 85% and 95% of disc herniations (slipped discs) occur at this area, (Chaffin and Andersson, 1984).

Analysis was carried out for three different delimbing methods:

1. CONV - Conventional, operator on top of the log.

2. ALT1 - Operator alongside the log, log lower than optimum height.

3. ALT2 - Operator alongside the log, log at optimum height.

Saw weight was varied for each of the three techniques.For the CONV technique a Husqvarna 181 equipped with a 20" bar was used (11.5 kg), while a Husqvarna 162 and 16" bar were used (10 kg) for ALT1 and ALT2.

Productivity

Productivity was assessed through continuous time study of the delimbing part of the work only. Sixty two cycles were observed for the conventional method and 105 for the alternatives. As there was no significant productivity difference between the two alternative techniques, they were combined and compared with the conventional.

The length, large end and small end diameters of each tree were also recorded. From this information the stem volume of each log delimbed was calculated.

RESULTS

Biomechanical Loading

Model predictions of compression and shear forces for all three delimbing methods are shown in Figures 4 and 5. The difference in compression forces between CONV and ALT1 is significant, with an even greater difference between CONV and ALT2. Compression forces were also significantly different between ALT1 and ALT2 (at the 99% level).

The same level of significance existed in the shear force calcuations.

The results of the compression and shear forces are summarized in Table 2.

The alternative technique was found to be 27% slower than the conventional (Table 3). It must be noted that the alternative technique results in a higher quality of delimb, therefore the skiddy has less retrimming to do. The operator, by adopting the alternative technique and reducing the loading on the spine, can expect a longer working life than an operator using the conventional technique. Finally, this study was confined to looking at the delimbing function which accounts for approximately 40% of the fallers total work day.

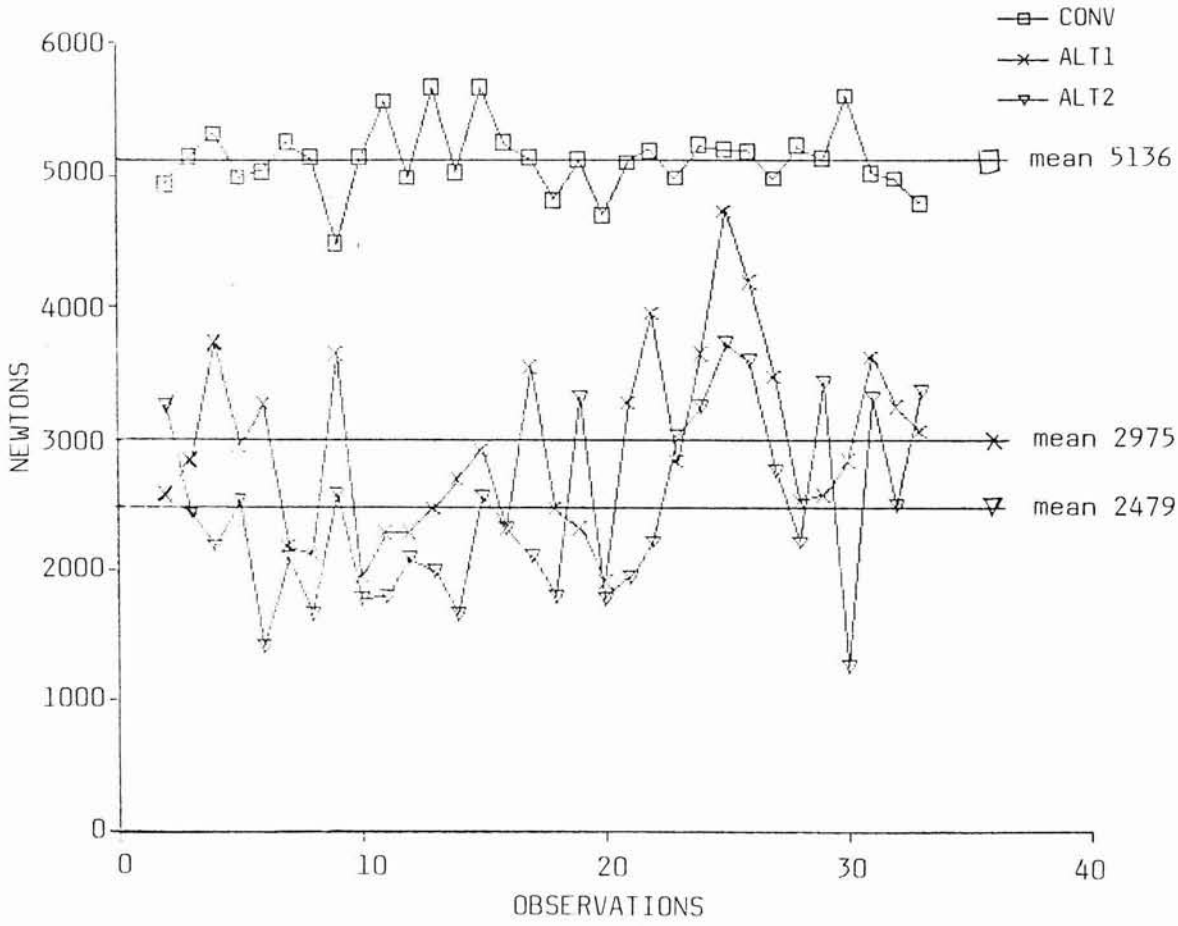

Figure 4 - Compression Forces at L5/S1

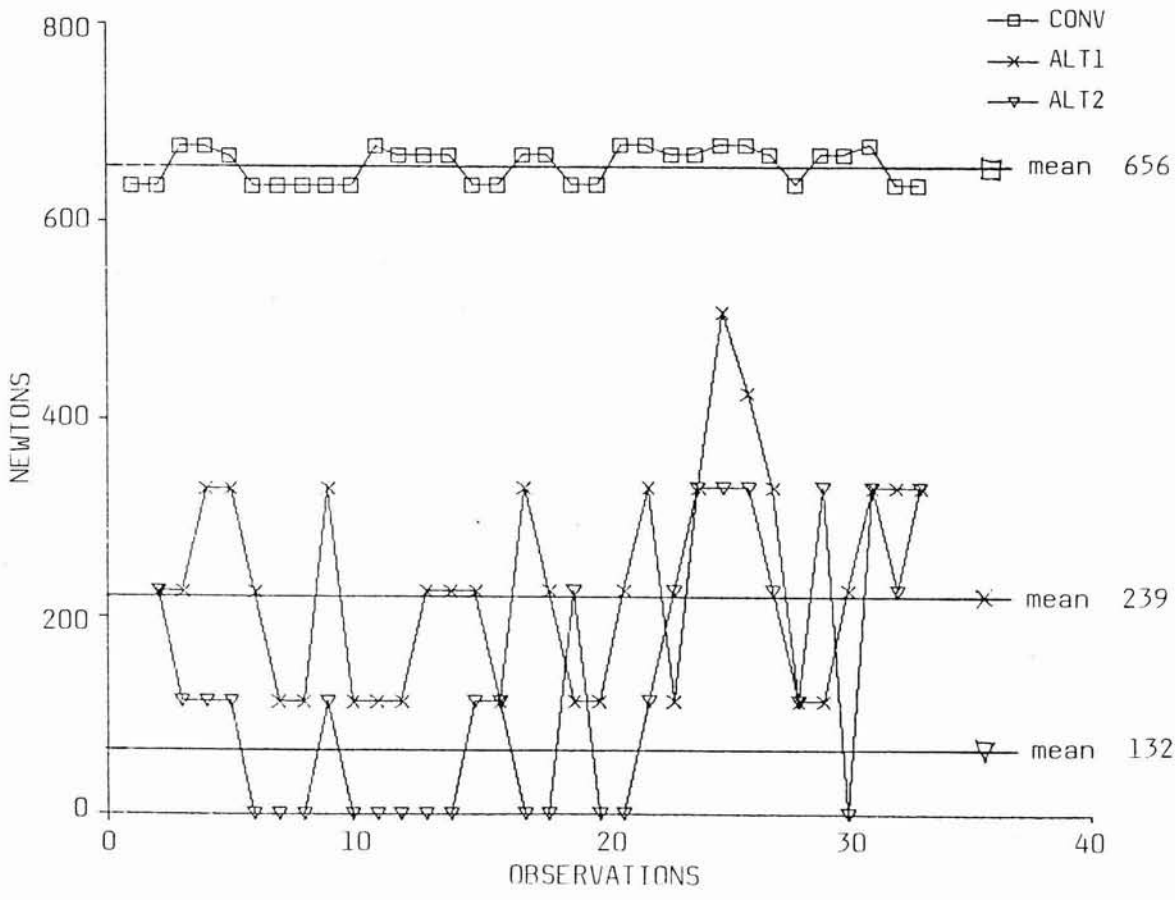

Figure 5 - Shear Forces at L5/S1

Note: Approximately 10 newtons equivalent to one kg

Table 2 - Comparison of forces, all techniques

Technique	Compression Force Newtons (N)			Shear Force Newtons (N)		
	Mean	$S\bar{x}$ *	Number of Observations	Mean	$S\bar{x}$	Number of Observations
Conventional	5136	2.79	33	657	0.74	33
Alternative 1	2975	4.56	33	239	1.81	33
Alternative 2	2479	4.64	33	132	1.99	33

* $S\bar{x}$ = Standard error of mean

Table 3 - Productivity comparison of delimbing techniques

Variable	Technique: Conventional			Alternative		
	Mean	SD*	Number of Observations	Mean	SD	Number of Observations
Time/tree	2.66	0.7	62	3.30	0.9	105
Butt Dia. (cm)	49	7.8	62	49	9.0	105
Length (m)	27.6	3.4	62	27.5	3.9	105
SED (cm)	23.1	6.6	62	21.7	5.9	105
Volume/tree (m^3)	2.4	0.7	62	2.3	0.8	105
Time per m^3	1.1			1.5		
Time per metre	0.10			0.12		

* SD = Standard deviation

Regression analysis on time versus length gave r^2 values of .39 for conventional and .48 for the alternative delimbing technique. Poor relationships were found between time and butt diameter, and time and volume for both techniques. As sampling was carried out in similar conditions, no significant difference was found between butt diameter, length, SED, or volume for either technique.

DISCUSSION

While the model used to compare biomechanical loadings is a simplification of a complex postural task, the results clearly show the advantages of keeping trimmers off the top of the log. The National Institute for Occupational Safety and Health (NIOSH) in the United States has recommended that L5/S1

compression values above 3400 N are considered potentially dangerous to some workers (Chaffin and Andersson, 1984). The Institute noted that if these values exceed 6400 N, the job will be hazardous to most workers. The maximum value recorded for the conventional technique in this study was 5681 N, while the maximum values for ALT1 and ALT2 were 4743 N and 3747 N respectively.

The force values noted in this analysis, especially for the conventional technique, are likely to be understated. The model was unable to include twisted postures and additional forces required when cutting with the top of the bar, ie. cutting from the underside of the branch upwards. Furthermore, no consideration was given to the the effect of shock loadings, ie. controlling the saw during a kickback.

In modelling the alternative techniques it was necessary to assume that the weight of the saw was being carried by the operator. One of the stated advantages of this technique is that the saw is rested on either the log or the operator's thigh. Had this been allowed for it is likely that compression values for this technique would have been even lower.

The productivity difference between the two techniques, taking into account the full working day, was approximately 10% reduction for the alternative technique. This difference is based on the assumption that 40% of the faller's day is spent trimming. It is also assumed that neither technique would have any effect on other parts of the faller's normal work, i.e. felling, saw maintenance, smokos, etc. Given the improved posture and reduced loadings on the spine, a 10% drop in delimbing productivity should be acceptable. Previous research has shown that the alternative technique also results in a higher standard of delimbing.

Further research will follow up this modelling and productivity comparison with an evaluation of physiological workload by monitoring the heart rate of operators using both techniques.

CONCLUSIONS

The alternative technique was slower and about 10% less productive over the whole day. This reduction is felt to be outweighed by an increase in quality of trim and the benefits to the industry in terms of reduced lower back injuries.

The alternative delimbing techniques were found to significantly reduce both compression and shear forces on the L5/S1 disc of chainsaw operators in clearfell transition crop. The reduction was of such a magnitude that adoption of the alternative technique would reduce the risk of low back injury associated with delimbing. The adoption of the alternative technique in motor-manual delimbing would also extend the worker's effective working life.

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