ISSN 0111-6711

LOGGING INDUSTRY RESEARCH ASSOCIATION NEW ZEALAND

REPORT

Vol.14 No.15 1989



# THE WORKLOAD OF MOTOR-MANUAL DELIMBING

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*ABSTRACT*

*Chainsaw felling and delimbing is heavy, physical work. In this study the physiological workload on a chainsaw operator was measured while using two different delimbing techniques. The operator's heartrate was monitored to give an estimate of workload.*

*The operator was chainsaw felling and trimming in clearfell of second crop radiata. For the first technique, the operator delimbed on top of the log, while the second method involved the operator walking beside the log.*

*The study showed that there was no significant difference in the operator's average heart rate between the two methods of delimbing, suggesting the physiological load was similar. The load for both methods was, however, very heavy with the average heart rate during trimming 130 beats per minute.*

## INTRODUCTION

While there have been some attempts to mechanise the delimbing function in logging operations, especially thinning, delimbing in clearfelling radiata pine is still carried out motor-manually. The delimbing part of the work cycle in clearfell operations, based on data collected during this study, accounts for approximately 30% of the work cycle.

*Figure 1 : Delimbing alongside the log*

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** Brent Guild was a third year B. For. Sc. student working at LIRA during the 1988/89 summer vacation.*

The purpose of this study was to assess whether there was a significant difference in the workload of an operator using two different delimbing techniques. In the alongside technique (Figure 1) the operator walks alongside the log, using a lighter 60cc saw with a 36 cm bar. In the on top technique (Figure 2) the operator walked along the top of the log removing branches using an 80cc chainsaw with a 57cm bar.

A recent analysis of accident information collected by the Logging Industry Accident Reporting Scheme (Gaskin, 1989) revealed that one-third of the trimming accidents were caused by operators trimming while walking on top of the log. The biomechanical evaluation indicated that loadings on the lower spinal disc were doubled when operators trimmed by walking on top of the log.

This Report looks at the physiological cost to the operator of motor-manually delimbing in clearfelling of second crop radiata pine. It forms the second part of an ergonomic evaluation of two delimbing techniques, the first part being the biomechanical evaluation of loadings to the lower spine. (Gaskin, Slappendel and O'Leary, 1988).

Typically, when the use of the alongside delimbing technique is suggested the operator's response is "It's **physically much harder** to walk alongside the log than on top of it". Using one operator conversant with both techniques, the physiological workload during delimbing was measured over a period of time to ascertain whether it was in fact physically harder to trim while walking alongside the tree.

There are two ways that the physiological workload can be measured - oxygen consumption or direct heart rate monitoring (Vitalis, Gaskin, and Jeffrey, 1986). Measuring oxygen is not practicable due to the non-availability of the equipment required. Heart rate, by contrast, is easily measured in the work place. Small units have been developed that can monitor heart rate at predetermined intervals and store the information to memory. Such units can easily be worn by loggers during work and the heart rate data can be obtained without the need for the researcher to interfere with the work cycle.

*Figure 2 : Delimbing by walking on top of the log*

Considerable research has been carried out to classify workload in terms of heart rate. Table 2 has been modified from Smith, Wilson and Sirois (1982):

*ACKNOWLEDGEMENTS*

*LIRA acknowledges the co-operation of contractor Blue Parkes, his faller Wes Parkes and NZFP Forests Limited for allowing the trial to be conducted.*

## STUDY METHOD

The study was carried out in a stand of second crop radiata. The stand had been

*Table 1 : Classification of Workload in Terms of Heart Rate*

| Classification of Activity | Heart Rate (Beats per Minute) | |
|---|---|---|
| Light Work | Up to 90 | (1) |
| Moderate Work | 90 to 110 | (1) |
| Heavy Work | 110 to 130 | (1) |
| Very Heavy Work | 130 to 150 | (1) |
| Extremely Heavy Work | 150 to 170 | (1) |
| Maximum average for work of 10 minutes or less | 180 | (2) |
| Maximum average for work of 30 to 40 minutes | 140 to 150 | (2) |
| Maximum average for work of one hour | 120 to 130 | (2) |

(1) Astrand and Rodahl
(2) American Industrial Hygiene Association

established in 1950 and production thinned with only minimal pruning undertaken. Stocking was 236 sph and the mean tree volume was 2.6 $m^3$ .

The heart rate monitor, a Polar Electro SPORT TESTER PE 3000, was attached to the operator for the full work day (Figure 3). His heart rate was recorded at one minute intervals. Wet-bulb globe temperature in degrees celsius was calculated from readings taken at twenty minute intervals as extreme temperature variations can influence a worker's heart rate.

The operator was an experienced faller having been three years in the job, and was considered to be work fit. The basic data, age, weight, height, resting heart rate, and heart rate under known loads was collected first thing in the morning (using a cycle ergometer).

The physical characteristics of the operator are given in Table 2. VO2 maximal was calculated from the nomogram in Astrand and Rodahl (1977). The physical working capacity (PWC) was very high (Astrand's classification).

An activity sample was started at the same time as the heart rate recording. Samples were taken at one minute intervals to tie in with the heart rate information.

*Figure 3 : Heart rate monitor attached to faller*

The operator alternated the trimming technique on a daily basis. For the on top trimming method, he felled and trimmed with a Stihl 064 with a 53cm bar, and for the

*Table 2 : Operator Characteristics*

| Age (yrs) | Weight (kg) | Height (cm) | Months of work as a faller | Heart Rate at rest (beats/min) | Maximal Oxygen Uptake (litres/min) | Physical Working Capacity |
|---|---|---|---|---|---|---|
| 21 | 70 | 179 | 36 | 50 | 5.6 | Very High |

alongside trimming he felled with the Stihl 064, then used a Stihl 034 with a 36 cm bar to trim. Therefore there are two differences between the work methods: he walked alongside the log rather than on top of it, and he used a smaller saw, the 034 with a 36 cm bar, which is 1.9 kg lighter.

## RESULTS

In total, 256 observations were made while the operator was trimming on top of the log and 258 while trimming alongside the log. Variables such as tree characteristics, undergrowth, terrain etc., were kept as similar as possible, which resulted in 258 observations for the alongside and 198 observations for the on top method.

Table 3 summarises the data by day. The percentage of total trimming is the amount of the work time that the operator was observed to be trimming,an average of 30%.

To test if there was a significant difference between the mean heart rate observed for each technique, the trimming data was combined into two categories (Table 4); trimming using the on top technique (198 observations), and trimming using the alongside technique (258 observations).

*Table 3 : Summary of Trimming Activities and Heart Rate by Day*

| Day | Trimming Technique | % of Work Day Trimming | Heart Rate (beats per min) Trimming | |
|---|---|---|---|---|
| | | | Mean | Range |
| 1 | On top | 34 | 133.8 | 91 - 175 |
| 2 | Alongside | 30 | 135.2 | 109 - 161 |
| 3 | On top | 29 | 124 | 88 - 160 |
| 4 | Alongside | 26 | 128 | 89 - 158 |
| 5 | On top | 22 | 124.8 | 106 - 151 |
| 6 | Alongside | 34 | 128.8 | 94 - 155 |

*Table 4 : Comparison of Total Trim Observations for the Two Techniques*

| Technique | Number of Observations | Heart Rate (beats per min) Mean | Range |
|---|---|---|---|
| On top | 198 | 130.1 | 88 - 175 |
| Alongside | 258 | 131.7 | 89 - 161 |

The distribution of heart rate for each technique, at 10 beats per minute intervals, is shown in Figure 4. Figures 4a and 4b show examples of the plotted heart rate against time for both trimming techniques.

No significant difference was found between the methods.

The calculated wet-bulb globe temperature values for the two techniques were 17.35°C for the conventional method and 17.38° for the alternative. The ranges were 12.69 to 21.02° and 13.23 to 20.27° respectively.

With the mean values and ranges so similar, temperature variations were not considered sufficient to influence the average heart rate recordings between the techniques.

Detailed faller productivity using the two delimbing techniques was not assessed during this study. Productivity for the two techniques was assessed during the biomechanical analysis of the lower spine which showed a reduction in productivity of 10% using the alternative method (Gaskin et al, 1988).

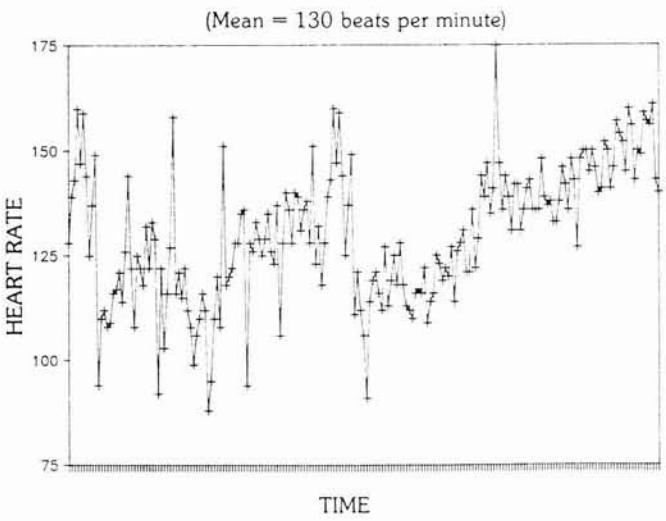


*Figure 4a : Operator's Heart Rate - Trimming on top of the Log*

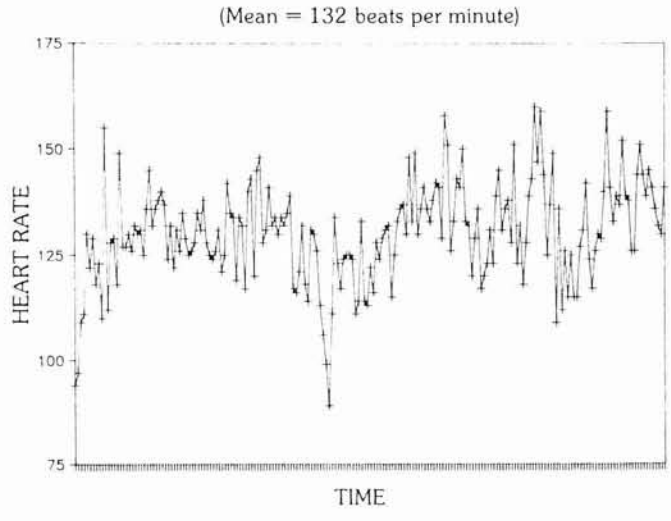


*Figure 4b : Operator's Heart Rate - Trimming beside the Log*

## CONCLUSIONS

Using continuous collection of operator heart rate data and activity sampling, the relative work loadings while using two different motor-manual delimbing techniques was evaluated on one operator. Data analysis showed that there was no difference in the operator's mean heart rate during delimbing using either technique.

The fact that the alongside technique does not induce higher work loadings, coupled with the significant reduction in compression and shear forces on the lower spine, suggests that, wherever practicable, the alongside delimbing technique should be used for motor-manual delimbing in clearfell of second crop radiata.

Furthermore, given the number of accidents occurring during trimming associated with the on top technique, operators should be encouraged to use the alongside method. Use of the alternative technique wherever practical is a requirement for loggers being assessed for the relevant Loggers Certificate.

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