Evaluation of Job Rotation Effects on Chain Saw Operators

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ABSTRACT

This paper analyses the effects of job rotation on physical effort in chain saw operations. This study was conducted in a seven-year old *Eucalyptus grandis* plantation harvested with a short-wood clearcut system. A practical application of ergonomic principles was utilized, considering heart rate as the method to evaluate the heaviness of work. Data were collected in a situation where the chain saw operator and his assistant rotated primary tasks to reduce physiological workload. Piling logs was the most demanding activity for the assistant, while the chain saw operator primarily is exposed to chain saw noise and vibration. Rotating jobs on this situation did not significantly reduce the total physiological workload on saw operators.

Keywords: *chain saw, job rotation, physiological workload.*

INTRODUCTION

The chain saw continues to be used to fell trees and the effects of its use are a concern in terms of worker health, well-being, and efficiency. Lacerda [5] details the occupational risks of chain saw work that must be corrected or attenuated: noise, vibration, weight, work posture, exhaust fumes, and the potential for severe laceration. The International Labor Organization [4] considers felling trees as high intensity physical work, and chain saw manufacturers are striving to make lighter models with reduced vibration and noise levels. Even so, it is a dangerous activity that requires training, personal protective equipment, and continual attention.

Job rotation is an administrative control that could reduce the adverse effect of stressors such as vibration and noise exposure. However, Axelsson and Ponten [3] commented that few job rotation studies have been conducted in forestry. Job rotation is considered something positive, for health (physical and psychological) as well as for long-term productivity. Due to the high intensity physical workload, some kind of activity that could reduce the workload of chain saw operations would be of benefit.

Although job rotation in chain saw operations may be a benefit, it is often impractical because of the organizational structure of most logging crews. Some of the reasons for this are the distance between work sites, the necessity of cross-training, and the refusal of some rural workers to accept chain saw work because of the high physical demands of the task. Some companies have replaced the chain saw operator with feller-bunchers and harvesters, reducing personnel and improving productivity and operational costs. Nevertheless, the high investment cost of these machines limits their applications. So, a large number of chain saw operators will continue working in Brazilian forests for the next several years.

Many logging systems in Brazil use crews composed of one chain saw operator and one assistant to fell, process and pile trees. Some forestry companies have tried to reduce the operator workload and noise and vibration exposure by rotating jobs between both crew members. No studies, however, have been done to determine if job rotation was less physically demanding and hazardous than continuous chain saw use.

OBJECTIVE

This report covers an investigation of the effects of job rotation on chain saw operator physiological workload. Objectives of the study were:

1. Determine if job rotation between felling and delimbing/piling tasks reduced exertion levels of workers, and

2. Document the amount of time spent in each activity when clear felling Eucalyptus plantations in Brazil.

METHOD

This study was conducted in an *Eucalyptus grandis* plantation, located in Sao Paulo State, Brazil (21°57'S and 48°31'W), during July 1992. The stand was seven years old and averaged 13.7 cm D.B.H.; 18.7 m height; and 0.148 m^3/tree. During the study period the average temperature was 17°C, relative humidity was 64%, and there was no rain. The influence of weather was not analysed for this study because of

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the moderate conditions and small day-to-day variation in temperature.

The logging system was a short-wood clearcut, producing 2.4 m logs for pulp (diameter >= 8.0 cm) and energy (diameter < 8.0 cm) to be transported by forwarders. An experienced two-man crew was chosen for this study, representing the company average productivity (13.3 m^3/man-day). Both of the workers on this crew had worked with chain saws for five years and received training in their use for a period of one month. They began work at 7:00 a.m. and finished at 4:00 p.m., with an one hour lunch. The chain saw operator, using a STIHL 034, felled and bucked the trees. His assistant delimbed and piled the logs using an axe. The saw operator sometimes helped the assistant piling and delimbing the logs. Their personal characteristics were:

Person A:
-Age: 34 years
-Rest heart rate: 60 beats per minute (b.p.m.).

Person B:
-Age: 35 years
-Rest heart rate: 58 beats per minute (b.p.m.).

Two different operational systems were compared:

- System (1+1): the chain saw operator used the saw for the entire shift.

- System (2+0): the chain saw operator and his assistant rotated jobs (approximately each hour).

There were two data collection periods: a) morning (7:00 - 11:00 a.m.); and b) afternoon (12:00 - 16:00 p.m.). Each worker was observed during three days in each system, resulting in a total study period of twelve man-days. The activities were divided into seven elements: a) fell; b) buck; c) delimb; d) walk; e) pile; g) personal pause; and h) technical pause (related to the job). For both systems, an observer followed a single chain saw operator throughout the day. For System (1+1), observations were made only on the chain saw operation. Activity was recorded at one minute intervals (see Table 1). At the same instant, the heart rate was recorded using a Polar Electro Sport Tester PE 3000 portable heart rate monitor.

At the end of the day, the heart rate data was recovered and associated with the corresponding activity. The average heart rate of each system, considering data from both operators, was statistically analysed with SAS, utilizing paired mean tests to look for differences between Systems (1+1) and (2+0).

Table 1. Example of form used to collect data.

Time	Activities			Heart Rate (b.p.m.)
	A	B	C	
7:00	x			101
:01		x		110
:02		x		117
:03			x	98
:04	x			103
...				...

While the most direct indicator of physical workload is oxygen consumption, it is a difficult variable to measure under forestry field conditions. To measure oxygen uptake in the field, sophisticated equipment is necessary, as well as highly co-operative subjects. Heart rate, on the other hand, is a simple physiological measurement that correlates well with oxygen uptake, if the relationship between heart rate and oxygen uptake for each individual is established under controlled conditions.

In order to evaluate workload in the field, heart rate was used as the method to establish the heaviness of chain saw work. The study was done during the winter season to avoid as much as possible the confounding effects of environmental temperature on heart rate. The calibration of heart rate with VO_2 was not possible, but one can still have a rough idea of the workload. Overall physical workload for each operator was compared to the 40% cardiovascular capacity limit suggested by Apud [2]:

$$LIMIT = 0.4\ [(220 - AGE) - R.H.R.] + R.H.R$$

where R.H.R. means "Rest Heart Rate" and (220 - AGE) estimated the maximal heart rate, which, of course, is a very rough approximation.

RESULTS AND DISCUSSION

Table 2 summarizes the measured heart rates. There were no statistically significant difference between Systems (1+1) and (2+0), and between the two periods (morning and afternoon) of data collection.

Table 2. Average heart rate of chain saw operators (A + B) working at Systems (1+1) and (2+0).

Activity	System (1+1)		System (2+0)	
	Heart rate (b.p.m.)	Time (%) operation	Heart rate (b.p.m.)	Time (%) operator
Fell	117.6	21.5	115.6	15.3
Buck	117.0	34.6	118.6	16.9
Delimb	119.2	17.6	117.8	20.4
Walk	106.3	5.2	104.3	5.3
Pile	120.6	2.8	120.4	27.9
Pers. pause	99.5	4.6	98.1	6.1
Tec. pause	98.7	13.7	99.8	8.2
Average (b.p.m.)	114.1		115.0	

Piling logs was the most arduous activity, around 120.5 b.p.m. for both systems. Despite the presence of an assistant, the chain saw operator of System (1+1) sometimes had to give some help piling logs, but this activity occupied only 2.8% of his operational time. For System (2+0), the percentage time piling logs reached 27.9 percent, increasing the time doing the heaviest activity.

The global average analysis (Table 2) didn't show any significant differences between systems (1+1) and (2+0). However, there were significant differences between operators within systems. Although the heart rate differences between systems are statistically significant, from a practical perspective the differences are not great enough to have an impact on the overall physical workload of the chain saw operator (see Table 3).

The calculated heart rate limits were 110.4 b.p.m. for operator A and 108.8 b.p.m. for operator B. The System (1+1) represents 41% of cardiovascular workload for operator A and 38% at System (2+0), indicating that it is possible for operator A to maintain those kinds of activities over a full shift. Operator B, on the other hand, reached 46% of cardiovascular workload in System (1+1) and 50% in System (2+0), levels exceeding the recommended limits.

Considering only fell, buck, delimb, and pile activities, which represent 76.5% of System (1+1) and 80.5% of System (2+0) time operation, the average heart rates reached 117.8 b.p.m. and 118.4 b.p.m. respectively, values much higher than the calculated limits. Despite the results predicted by the equation, it is important to remember that pauses must be regularly distributed throughout the shift, making these levels of exertion sustainable.

Felling and bucking accounted for 21.5% and 34.6% of total time in System (1+1). These same activities in System (2+0) consumed 15.3% (felling trees) and 16.9% (bucking trees) of work time, a reduction of 23.9% compared to System (1+1). In System (2+0), however, the saw operator spent 25.1% greater time in piling, the result being no net difference between the two systems in the amount of time spent in the heaviest activities.

The amount of time spent delimbing trees increased by 2.8% in System (2+0), which is reasonable because this is mostly an assistant activity, in spite of the fact that the chain saw operator helped a lot cutting the biggest limbs. Technical pause was reduced by 5.5%, largely because this is related to chain saw maintenance and mechanical problems. The 6.2% reduction in felling trees in System (2+0), not 10% as expected, could be because the operator starts the shift by felling a lot of trees first and then bucking them. This leaves the assistant, now the saw operator, to do most of the bucking.

Tomanic and Majacic [9] conducted similar research in Yugoslavia, with five chain saw operators, ranging from 30 to 50 years old. Their subjects were working in a forest with 44 cm D.B.H., 2.13 m^3/tree, and almost the same ambient environmental conditions. They found these results: a) fell = 118 b.p.m.; b) walk = 106 b.p.m.; c) buck = 130 b.p.m.; d) pause = 92 b.p.m.; and e) technical pause = 108 b.p.m.. The values are quite similar to values observed in the

Table 3. Average heart rate for each operator working at systems (1+1) and (2+0).

System	Operator	
	A (b.p.m.)	**B (b.p.m.)**
1+1	11.8a (*)	116.3c (*)
2+0	108.4b (*)	121.5d (*)

F test 188.42 (**)
C.V. experimental 12.92%
Global average 114.58 b.p.m.

Averages with different Letters are significantly different at:
(*) 95% confidence level

current study, except for bucking. The difference could be due to the larger trees in the Yugoslavian study.

Working with System (1+1) in an eucalyptus plantation, Malinovski [6] found an average heart rate of 105.5 b.p.m. for the chain saw operator and 113.8 b.p.m. for the assistant. Again, in Malinovski's study piling logs was the most arduous activity, reaching 119 b.p.m.. The other values were: fell = 111 b.p.m.; buck = 109 b.p.m.; pause = 92 b.p.m.; walk = 107 b.p.m.; delimb = 119 b.p.m. It is difficult to make comparisons here because there is no information about environmental conditions, but the data are so similar that they reinforce the results of both studies.

Considering the supporting data in the literature, and the data collected in this study, it appears that job rotation offers no advantage in reducing physical workload. However, there was a 43% reduction in the time spent felling and bucking trees for a given operator. Some authors [1,7,8] have noted that job rotation and short frequent rest breaks are good ways to minimize the negative effects of noise and vibration exposure. Since both noise and vibration are cumulative stressors, job rotation would reduce exposure by about 50%. This would significantly reduce the risk of developing vibration white finger disease and permanent hearing damage.

As in chain saw operation, wood piling is also a high intensity physical activity. An option to reduce workload on saw hand assistants would be to eliminate piling of most logs, letting the forwarder accumulate them. This must be evaluated because the reduction in forwarder productivity might be not economically acceptable.

CONCLUSIONS

The principal objective of this research was to give an initial idea of the effects of job rotation on chain saw operators when shifting activities with their assistants. A practical and simple application of ergonomic principles was used, evaluating the workload by heart rate measurements. Despite some drawbacks, the heart rate can give a rough estimate of the heaviness of work with simple and inexpensive instruments.

Confirming the literature, the data in this study found the most stressful activity was piling logs, which is usually done by an assistant. Thus, job rotation will not reduce the workload of the chain saw operator. However, the reduction in noise and vibration exposure is significant, reaching about 50% on alternating shifts. It is recommended to rotate jobs approximately each hour, and not at the middle of the shift, to reduce the cumulative stressors of noise and vibration.

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