Available online www.ejaet.com

European Journal of Advances in Engineering and Technology, 2020, 7(9):34-37

Research Article ISSN: 2394 - 658X

Ergonomic Appearance of Chainsaw Operators in Forest Harvesting

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ABSTRACT
Working and living conditions for forest workers are generally poor in Turkey. Physically heavy work, inadequate working methods, tools and equipment cause occupational accidents, diseases and unnecessary fatigue. Forestry in Turkey appears to be one of the most hazardous occupations with frequent and severe accidents and many diseases. The improvement of safety, health, well-being and efficiency is a basic condition for prosperity, and ergonomics is a very important tool for this. Chainsaw work is both physically arduous and potentially dangerous. A contributing factor to the high injury rate of loggers could be the high physiological and biomechanical load of chainsaw work. This study investigated the comparative cardiovascular load imposed on 50 chainsaw operators and 100 assistant employees when felling and delimbing under normal conditions. A practical application of ergonomic principles was utilized, considering heart rate as the method to evaluate the heaviness of chainsaw work. Also anthropometric dimensions and factors affecting work capacity to carry out physical effort with chainsaw were determined.

Key words: Chainsaw, Heart rate, Forestry

INTRODUCTION

The fact that human body is not appropriate for hard work and human power falls short to do such kind of work requires technological developments. Forest operations differ greatly from industrial works in terms of ergonomics. Mechanization of forest operations has increased productivity since it has accelerated some phases of operations. Although there has been no physical development in human body, there have been lots of technological developments especially in this century. Forestry in Turkey appears to be one of the most hazardous occupations with frequent and severe accidents and many diseases. The improvement of safety, health, well-being and efficiency is a basic condition for prosperity, and ergonomics is a very important tool for this. Chainsaw work is both physically arduous and potentially dangerous. A contributing factor to the high injury rate of loggers could be the high physiological and biomechanical load of chainsaw work.

Forest operations vary (felling, delimbing, logging etc.) and they are performed in different natural conditions (terrain, climate etc.) and with various instruments (chainsaw, axe etc.). Logging activities require considerable physical energy, particularly with motor-manual operations. Harvesting is far more hazardous than any other forest operation [1-2]. Many logging systems in Turkey use crews composed of one chainsaw operator and two assistantemployee to fell and delimb trees.

Forest-labor productivity is perceived to be lower in developing countries than in industrialized nations because of socio-economic, cultural, and environmental factors that influence working and living conditions. Physical work is performed as a result of muscle action [3-4]. A close relationship between heart rate and oxygen consumption, with the rate increasing in proportion to work intensity. Therefore, the physical workload can be estimated by comparing heart rates measured at rest and while working [5]. Thus, the higher the rate, the greater the physiological workload [6]. To efficiency supply oxygen to the body, the average heart rate during work should not exceed 40% of the range between the individual worker's resting rate and its maximum recorded under stress [7]. It is the circulatory system that carries the food which is the energy source of the body to muscles. An increase in the consumption of energy is met by an increase in heart rate. So, there is a strong relation between heart rate and energy consumption. Efforts to measure heart rate (taking the pulse) have proven to be one of the most useful ways to assess cardiovascular load because it can be done so

easily [8-9].Machines that can fell and delimb trees exist, however they are expensive and complex. These machines are used in developed countries. Motor-manual systems continue to be used to felling and delimbing in Turkey. It is therefore desirable to investigate opportunities to reduce the physiological workload of loggers working with chainsaws.
The two most common methods of measuring physiological workload are by oxygen consumption or direct heart rate monitoring [10-11]. The measurement of oxygen consumption in the field presents problems of both practically and validity. To measure oxygen consumption the subject must wear a mask which may be uncomfortable to wear and also impede their performance, and therefore means that true readings may not be obtained. Direct measurement of heart rate on the other hand can be reliably undertaken with little or no interference to the operator or their work cycle. Additionally, heart rate has the ability to measure total strain, unlike oxygen consumption which only measures energy expenditure [12-13]. Accordingly, heart rate data collection techniques were used to estimate the physiological workload of the subjects during the particular study. The purpose of this investigation was to compare the cardiovascular workload imposed by felling and delimbing with chainsaws in the steep terrain. During the operations with chainsaw in the forest, heart rate values of chainsaw operators and assistant employees which are the indicators of workload were measured. Then, factors which have effects on the physical workload in forest operations were evaluated.

MATERIAL AND METHOD

The work should have no negative impacts on workers' health and it should provide them a dignified life in old age. Within this context, the ergonomics as a science and a profession adjusts work to workers so as to reduce difficulty and harmfulness of work by providing adequate work efficiency, which is reflected in a reduced level of illnesses or injuries at work. Physiological workload is a parameter which shows the pressure that the worker encounters during working based on the heartbeat frequency during working. This study was carried out during the phase of felling trees in stand and transporting them near the forest road. During the operations of chainsaw operators and assistant employees (1+2), measurements and examinations were carried out.

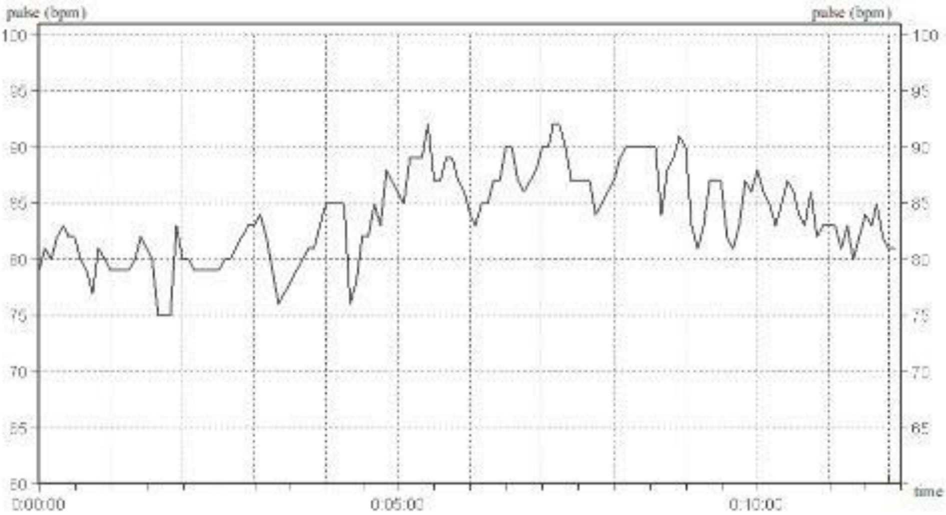

Fig. 1 Heartbeat change during operation of chainsaw operator

In wood production operations, in order to find out the factors that affect workload; working area, social situation, anthropometric etc. characteristics of chainsaw operators and assistant employees working in different regions were determined. Altitude (Al), temperature (Te), relative humidity (Rh), wind velocity (Wv), pressure (Pr), slope (Sl), ground hindrance (Gh=1: high hindrance, 2: hindered, 3: low), light (Li), noise (Ns), daily working time (Dw), duration of lunch break (Lb), duration of total breaks (Db), total years worked (Tw), age of the worker (Ag), educational status (Es=1: literate, 2: primary school, 3: secondary school, 4: high school, 5: university), number of persons in the family (Fp), working time within the year (Wm), smoking status (Sm=1: smoking, 2: not smoking), alcohol consumption (Ac=1: drinking, 2: not drinking), stature (St), eye height (Eh), shoulder height (Sh), waist height (Wh), knee height (Kh), shoulder breadth (Sb), shoulder-elbow length (Se), elbow-fingertip length (Ef), upper limb length (Ul), chest depth (Cd), body weight (Bw), heart rate while working (Hr) and heart rate while resting (beats/min) were all measured. With the help of the data obtained, workload of chainsaw operators and assistant employees were shown comparatively.

Fig. 2 Felling and delimbing

Apparently healthy males from the logging industry were experienced chainsaw operators who had worked under normal logging conditions in Turkey forests. Heart rates which indicate the physical workload of workers were measured both at rest and while working. Heart rates were measured at one-minute intervals for workers both at rest and while working continuously in normal operations. A Polar S610i heart rate monitoring system was used. The chainsaw operator rested for 10 minutes to obtain a pre-work heart rate. Working heart rate was determined as the chainsaw started felling and delimbing. Heart rate was recorded throughout the study period. These heart rate responses have been expressed as a proportion of heart rate range (%ΔHRratio-Physiological load) [14-15].

$$\%\Delta \mathrm{HR}_{\mathrm{ratio}} = \frac{\mathrm{HR}_{\mathrm{work}} - \mathrm{HR}_{\mathrm{pre\text{-}work}}}{\mathrm{HR}_{\mathrm{maximum}} - HR_{pre-work}} \times 100$$

HR_{work} : Heart rate while working
$HR_{pre\text{-}work}$: Heart rate before working, while resting
$HR_{maximum}$: 220 - age (year), maximum heart rate adjusted for age

Table -1 Severity of Work in terms of VO_2, Heart rate, and Energy expenditure*

Work severity	VO_2 (L/min)	Heart rate (Beats/min)	Energy expenditure (kcal/min)
Light work	< 0.5	< 90	< 2.5
Moderate work	0.5-1.0	90-110	2.5-5.0
Heavy work	1.0-1.5	110-130	5.0-7.5
Very heavy work	1.5-2.0	130-150	7.5-10.0
Extremely heavy work	> 2.0	150-170	> 10.0

*Adapted from Astrand et al. (2003) [3]

RESULTS

The table 2 shows the workload of chainsaw operators and assistant employees. In the table, heart rates while working, change limits, %ΔHRratio, average age of workers and heart rates at rest are all displayed.

Table -2 Average and Range of Heart Rates for Forest Workers

	Chainsaw operator	**Assistant employee**
Heart rate $\pm$ SD	115±7	91±8
Range	103-130	75-106
%ΔHRratio	42	17
Age	46	38
Resting Heart rate	73	72

Heart rates at rest were found to be 72-73 per minute. In general, heart rates at rest ranges from 60 to 75 [14]. As can be understood from the table, the work of chainsaw operators is involved in the heavy workload (heart rate:115) group. Also, the work of assistant employees is involved in moderate workload (heart rate: 91) group. %ΔHRratio of chainsaw operators was found to be over 40%, which is the limit for chainsaw operations [12-16]. Shemwetta et al. (2002) found the average heart rate 118 beats/min during chainsaw operations, Seixas (1995) found the average heart rate 117 and %ΔHRratio 41 while working with an operator and an assistant employee for chainsaw operations [5-17]. The findings obtained in this study are similar to those of other studies in the world.

The highest positive correlations among variables which affect the operator and the assistant employee in terms of ergonomics in chainsaw operations are between anthropometric dimensions (stature and eye height (r=0.969), stature and shoulder height (r=0.894), shoulder height and eye height (r=0.890), heart rate and noise (r=0.841)). This is a natural case. These anthropometric values concerning length have a close relation with each other. That heart rate correlates high to noise results from chainsaw operations. Heart rates are high because operators are exposed to much noise, they are affected by vibration and the weight of the chainsaw and they don't wear protective equipment. Physical and mental workload depends on factors such as age, sex, body size, health, nutritional status and training.

CONCLUSION

Felling trees is a high intensity physical work and a dangerous activity that requires training, personal protective equipment, and continual attention. Many factors can influence a worker's capacity to carry out physical work. Some of the more common personal factors are stature, body weight, age, alcohol consumption, tobacco smoking and training. In this study, it was determined that the operations of chainsaw operators were classified as heavy work, and the operations of assistant employees as moderate work in terms of physiological workload. The most important factors that have influence on physiological workload are stature, terrain conditions, daily working time, body weight, age, noise, humidity and harmful habits. Negative impacts can be witnessed on the health of forest workers due to abnormal changes in values which can take place in the heartbeat values of workers from time to time. Considering that heartbeat values are affected by such factors as age, height and weight, it must be ensured that workers use tools and machines which are suitable for themselves; thus, possible workload pressure on workers can be prevented.

During harvesting, accidents most often occur when felling trees, the main reason being an interaction with parts of trees. To reduce the risk of accidents during harvesting, fellers must be properly trained, and the contents and emphasis of trainings must be different for professional and non-professional fellers, beginners and experienced workers. The level of harvesting mechanization and control must be increased and employee turnover reduced. Fellers must be physically and mentally fit to adapt to changing working conditions, because even experienced workers cannot anticipate all dangers. Immediately before the harvesting starts, a felling plan must be prepared in compliance with working conditions hazards. Efforts to improve the safety during felling are also made by developing new methods and auxiliary tools for directional tree felling, since the studies show that the positioning of workers in the danger zone is one of the major factors causing lethal accidents. It is possible to reduce the risk of a kickback during cross-cutting with chainsaw by applying caution according to types and state of tree, right selection of chainsaw power and the length of the plate, the selection and maintenance of chain and its tension, and with efficient chain brake.

Acknowledgement

This study, was presented as oral presentation in the 3rd International GAP Mathematics- Engineering and Health Sciences Congress which was regulated in November 29-30, 2019 in Şanlıurfa.

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