MENTAL STRESS ON HARVESTER OPERATORS

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Abstract: *High tech operations in Austrian forestry are persistently increasing. Although mechanization relieves men from heavy physical work some new forms of stress become apparent. Very long working days (up to 15 hours), short and bad organized brakes as well as financial responsibility for expensive machines are the most important stress-causing factors. Furthermore harvester operators have to deal with a flood of information during work and additional knowledge of technology and silviculture is often required. In contrast to these demands most harvester operators are insufficiently prepared for their job: average training lessons last only for 4.2 days resulting in a very high drop out rate.*
This study gives a description of the physiological processes in the human body associated with stress situations and the resulting health problems. Heart rate variability, derived from EKG measurements, and psychological tests are used to determine single stress factors and to analyse the existence of a special combination of different stress factors that influences the stress situation in an extremely unfavourable way. To reduce the drop out rate the qualification of persons for harvester operators has to be determined prior to the start of the employment. This can be done by aptitude tests, such as already used for pilots. In the following work some primary results are presented.

1. Introduction

A technological change is currently taking place in Austrian Forestry. Motor manual harvesting is more and more replaced by high tech forest operations. Harvester technology was first introduced in Austria in the 80ies. At present about 200 harvesters are in operation (Pröll, 2002). Due to the permanent further development of the machines slope areas up to 60% can be harvested. As a result the annual wood cut by harvesters is steadily increasing: In the year 2000 7.83% of the felling was carried out by harvesters, in 2001 it increased to 10.14% and 2002 the percentage was at 11.45% (BMLFUW, 2003).

Mechanization relieves men of heavy physical work, but new forms of stress and strain appear. In particular mental stress is increasing.

2. Objective

72% of all harvester operators are working 50 to 60 hours a week. 18% of operators even reach 70 –80 hours a week. Only 9% of the operators have a 40 hours week (Sporer, 2002).

Usually harvester operators take only short lunch breaks where they eat cold food. Commonly they take their lunch alone (Berger, 2001). According to an investigation of Berger (2001) operators are socially isolated not only during day but also in the evenings. 68% of harvester operators work so far away from their home (Berger, 2001) that renting a room is necessary.

About 70% of all Austrian operators are individual entrepreneurs (Pröll, 2002), which means that they have to do the organisation and charge work in addition to the work on the harvesters. Besides this, individual entrepreneurs are also financially responsible.

In most cases (85%) forest thinnings are not properly signed (Berger, 2001). Besides technical, mechanical and negotiation skills a harvester operator should have knowledge in silviculture, especially stand thinning, ecology and ecomomy. A knowledge of human nature is very helpful for personnel recruiting.

Most operators are insufficiently prepared for their jobs, because their training lessons are on average 4.2 days (Berger, 2001). According to operators` statements, 81% classify their jobs as "stressful jobs" (Berger, 2001). Many operators can not stand this burden and drop out of their jobs. Only 55% of all participants of the harvester operators course in FAST Ort/Gmunden are still in their jobs (Jirikowski, 2003).

Next to tourism agriculture and forestry are on the second place in Austrians foreign-trade balance. But only little has been done in health provision on this sector.

3. Aim

To reduce the operators stress, singular stress factors associated with harvester work are determined. It was examined how intensive the singular factors contribute to the stress situation and if a special combination of different factors exists, which influences the stress situation of the harvester operator in an extremely unfavourable way.

Another goal of the study was to develop an instrument for the decision if a person is qualified for the job "harvester operator" or not prior to the start of his career. The output should be a kind of aptitude test as it is already used for some professions like pilots etc.

4. State of the art

4.1 Stress – reason – effect – measurement

A stress situation can be described as follows: A threat is perceived by our sense organs. The organism reacts immediately by pouring out stress hormones - Adrenalin and Noradrenalin. Hormone production is initiated by the hypothalamus via the sympathetic nerve system. The sympathetic nerve system activates the adrenal cortex to release the stress-hormones. Glucose and fat are mobilised by these hormones and transported to the muscles as an energy donor by the blood. The sympathetic nervous system is also responsible for raising blood pressure and heart rate, for reducing heart rate variability and for speeding up respiration. Other functions like immune defence, digestion or sexual functions are reduced.

The sympathetic nerve system is, besides the parasympathetic nerve system, part of the vegetative nerve system, which can not be influenced deliberately. It regulates the function of the inside organs and the circular course. In general the sympathetic system is working when performance is needed; the parasympathetic system is working when the body recovers.

If the released energy is burnt by physical activity (e.g. flight or fight) the stress situation can be managed easily and fast. Because of lack of physical body exercise on sitting working places the released energy is not used and stress- illnesses appear:

- The risk for Diabetes increases due to an increasing blood-sugar-level.
- Chronically raised blood pressure destroys arteries and veins.
- Fat and sugar plug the bloodstream, which causes arteriosclerosis, cardiac infarction, lung or cerebral infarction.
- The immune system is weakened.
- Digestion organs are not well supplied with blood, therefore pathogens of gastritis can grow easily.
- Mental stress causes permanent activated neck muscles, this causes bracing.
- Mental stress is also the reason for social retreat, depressions may follow.
- Less efficiency, a higher risk for accidents as well as a lot of days absent from work is due to mental stress.
- Too much stress during the working day and too less possibilities for recovering cause a state of exhaustion, which results finally in a physical and psychical break down. This phenomenon is designated as Burn-out.

Stress should not automatically represent negative effects; stress can be also associated with positive effects. As neither muscles nor endurance are developed without physical effort, mental stress is necessary to adopt our behaviour to a constantly changing environment. In this way we learn all new things.

If the mental stress is too much, or if the stress level reaches a steady state, it can be the reason for many diseases. Mental stress has been declared to the biggest health hazard of the 21st century by the WHO (World Health Organisation). Worldwide more working days get lost by psychological than by physical diseases.

Concentration and relation of the stress hormones Adrenalin and Noradrenalin can be measured by blood tests. Identification of mental stress by spittle is uncomplicated but has anyhow to be analysed in a laboratory. A further method is to measure muscle tension with the help of an Elektromyogram (EMG) at the brow or upper back. These points are known to react exceptionally intensely to mental stress.

Skin-temperature decrease, irregular respiration and sweating palms indicate mental stress. These parameters can be easily evaluated by temperature sensors, electrodes or respiration straps. The most reliably parameter to determine mental stress is heart rate, more precisely, heart rate variability. Heart rate variability is a barely noticeable anomaly between two heart beats.

Personal inquiry about subjective stress feelings with the aid of different psychological tests is another possibility to acquire the stress situation during work.

4.1 Stress – in Forestry

Sullmann and Kirk (1998) have investigated the mental stress situation of one grip harvesters with the aid of the NASA Task Load Index (TLX). Pressure of time and the mental components were found to be most exhausting. The results of this study can be compared with the stress situation of simulated start- and landing- Situations of F-16 pilots.

Byers´ (1997) inquiry provides an insight into the stress level and the most stressful parameters during the work with a harvester. 53% of all questioned operators stated to be "sometimes isolated". 65% ranged their job "to trigger sometimes stress". 9% of them claim to suffer the whole working day from stress. The most serious problems are to rehearse a new harvester, to be permanent concentrated, to come to a decision numberless times a day and the failures of the harvester. All studies mentioned above are based on subjective testing.

The authors Böltz and Schmidt-Vielgut (1989), Schmidt-Vielgut (1986) and Stampfer (1996) could not supply evidence of mental stress in high tech forestry operations nether by Adrenalin and Noradrenalin analyses nor by blood pressure and lactate concentration.

Imatomi (1997) simulated harvester's, haulers' and processors' work in a laboratory. He related mental stress on these operators to heart rate variability measurements. Field studies of the same author didn't verify these findings (Imatomi, 1997).

Gellerstedt (1997) took the first attempt to collect data on mental stress using heart rate variability in a field study. He divided the operator's working day in 3 shifts (10-12am, 13-14pm and 14-18pm). Mental stress was highest during the shift 14-18pm. Subjective tests confirmed these results.

5. Study design

5.1 Contribution of single stress factors to the general stress situation

Table 1 gives the study layout for finding the contribution of single stress factors to the general stress.

Table 1: Study layout

Difference in mental stress between…..	**Probationers**	**repetitions**
....weekend commute or sleeping at home	6 operators commuters 6 operators sleeping at home	2 2
.... with or without training	6 operators with training 6 operators without training	2 2
....with or without financial and organisation responsibility	6 with financial and organisation responsibility 6 without financial and organisation responsibility	2 2
….flat and steep terrain	6 operators 1 day steep 1 day flat	2

During each day (24 hours) of investigation the following measurements were taken:

- 24h EKG-Measurement (12h – 13h)
- exact recording of all activities
- fatigue - monotony - psychical satiation – stress BMS (before the working day + after the working day)

Measures for the different comparisons were taken under comparable boundary conditions (e.g. comparable weather conditions, comparable age of operators etc). For harvester types this was not possible. Therefore harvesters were grouped according to Holzwieser and Stampfer (1994) (
Table 2).

For studying the difference between steep and flat terrain only Neuson 1102 Harvesters were considered.

Table 2: Groups of harvester types according to Holzwieser and Stampfer (1994)

	Small harvesters	Intermediate harvesters	Large harvesters
Net weight [t]	≤ 6,0	6,1 – 13,0	≥ 13,1
Engine output [kW]	≤ 70	71 - 95	≥ 96

All participants in the study volunteered for no money.

5.2 Aptitude test

After fixing the dates of the separate meetings by telephone 6 harvester operators and one trainee of FAST Ort were interviewed "problemzentriert" (problem based). "Problemzentriert" (problem based) means that the entire interview is focused on a particular problem. Interviews were either taken at the home of the operators or directly at the place they were working. All interviews were recorded on tape. Duration was between 60 and 90 minutes. Again, all participants volunteered for no money.

6 Method

6.1 EKG-Measurement

The EKG was recorded with a small micro-data-logger. A modified commercial software package was used to analyse the data. In a continuous electrocardiography record each QRS complex was detected and the so called normal-to-normal (NN) intervals were determined. The oscillation in the interval between consecutive heart beats is called heart rate variability and is used as a parameter for non physical stress (Rodahl, 1989; Luczak, 1987; Rohmert and Luczak, 1973; Laurig, et al., 1971; Manzey, 1986).

Heart rate is sensitive to many other physiological rhythms and factors like inspiration and expiration, blood pressure rhythms, variations peripheral blood flow, thermoregulation, as well as excitement and exercise (Hildebrandt et al 1998, Moser et al. 1994). All of them influence the inter-beat interval and hence the hear rate variability (HRV). Frequency analysis of the HRV makes it possible to distinguish between the different systems involved. Respiratory sinus arrhythmia (RSA) reflects cardiac vagal tone and is therefore of special interest for stress analyses (Moser et al., 1994). RSA is the high frequency (HF) variability in heart rate mediated by respiration. Low frequency (LF) variability is influenced by the sympathetic as well as by the parasympathetic nerve system. The quotient of LF and HF is called vegetative quotient (VQ) and is at status quo the best measure to show the autonomic balance of the body. High rates indicate stress.

6.2 Fatigue - monotony – psychical satiation – stress BMS

Short-term stress like psychical fatigue, monotony or psychical satiation was registered by BMS II/B (Plath and Richter, 1984) prior and after the working day.

The test consists of 40 module components and was first developed for industrial working places, where controlling or supervise and steering activities dominate. The single module components about the actual feelings have to be answered with either "correct" or "incorrect".

6.3 Aptitude test

Problem based interviews were carried out to analyse the job "harvester operator" under considering task, behaviour and characteristic patterns. This means the interview is centred on a special problem which the interviewer takes up again and again (Mayring, 2002). The dialog was carried on as open as possible.

A very economical method to lead the interview partner again to the main problem is the Critical Incident Technique after Flanagan (1954). He tries to separate success relevant partial tasks from tasks which are sensed as a failure. A Critical Incident is an event or a human activity, where purpose, intention and consequence are obvious.
Afterwards the recorded interviews have to be transcribed. Because mainly the content and the thematic level was of interest , the technique "translation into written German" was chosen, as it is suggested by Mayring (2001) for such cases. Thereby the dialect was adjusted, syntax errors were eliminated and the style was smoothed. This is the basis for further evaluation.

The transcript is presented in form of a table, where you can find both, the interview rough draft as well as the edited version. All parts which are not important for the content are eliminated, such as decorative, repeating or explaining phrases. The rest was presented in a grammatical short version.

7. First results and further investigations

7.1 Heart Rate

First checking and analysis of heart rate variability data has already been done. The vegetative quotient shows the actual vegetative activity level of the organism. On average harvester operators (Figure 1, left side) are on a very high level during the whole working day. Additionally VQ values during night are similar to those during work. This means that stress during the working day is not followed by recovering in the night, where the organism could regenerate. Figure 1 (right side) shows optimal recovering during night (negative VQ values).

In previous studies (Moser et al., 2001) it was shown, that such a vegetative balance-course during night is due to chronic overload during day.

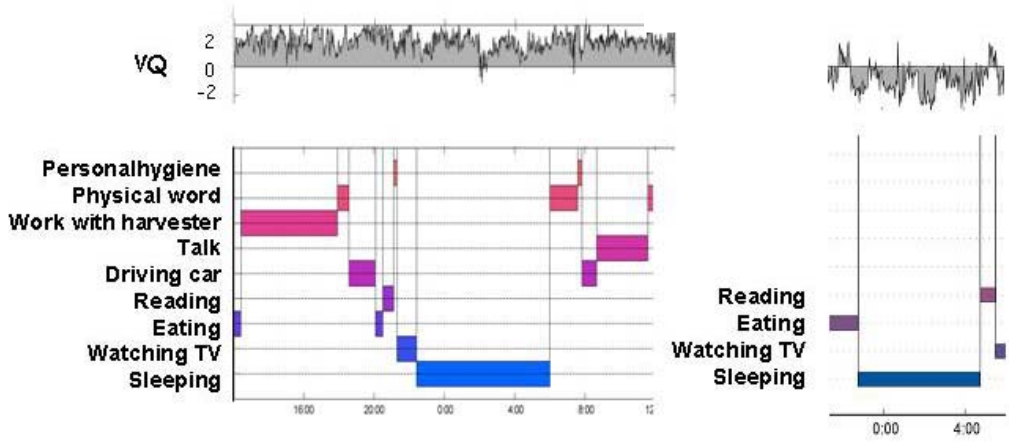

Figure 1: Autonomous picture of 24 h EKG Measuring (left side: harvester operator with bad recovering; right side excellent recovering)

In a further step the autonomous pictures of all investigated operators have to be analysed and the difference between steep and flat terrain, with or without training, etc. have to be evaluated.

7.2 BMS Tests

A pre-study (Berger, 2001) shows significant differences between morning and evening measurement concerning psychical fatigue (Figure 2).

The proponents felt exhausted, had slow reactions and it was difficult for them to concentrate. Plath und Richter (1984) as well as Richter und Hacker (1998) give a possible explanation for a constant high level of psychical fatigue. Working under time pressure causes psychical fatigue. Besides the long working days, weather and surface conditions influence psychical fatigue. Dangerous working conditions (steep and/or slippery terrain) represent additional cognitive requirements.

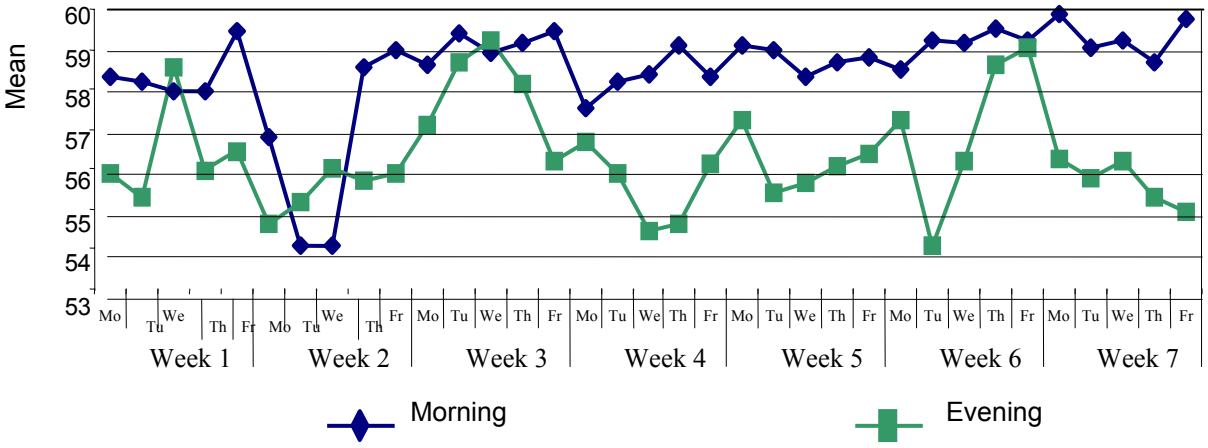

Figure 2: Difference in psychical fatigue between morning and evening measurements

Psychical satiation is also in the evenings higher than in the mornings (see Figure 3). During the working day the operators loose motivation, the will to bring performance and therefore they don't enjoy their work. As a result they work without any enthusiasm and interest.

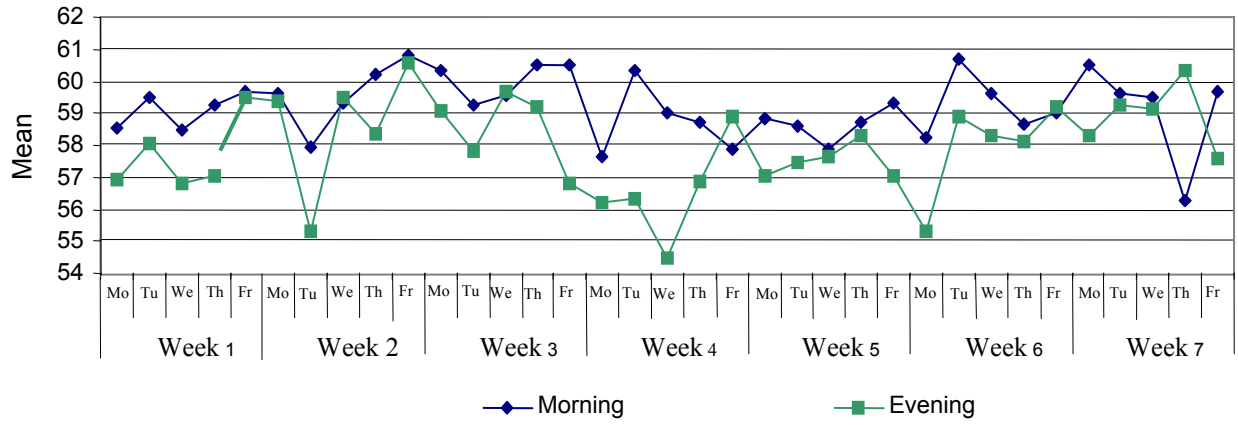

Figure 3: Difference in psychical satiation between morning and evening measurements

A week indication of different monotony feelings between morning and evening measurements could also be pointed out. At the end of the working days the operators felt limp and week. It seems that time pasts very slowly, and the work is monotone and not eventful.

Further investigation include to find the difference in monotony, psychical fatigue and satiation between steep and flat terrain, with or without training, etc. On checking the data it became clear, that operators with financial and organisational responsibility feel less monotony than the operators employed by a company etc.

7.3 Aptitude test

The shortened transcript is the basis for further work. The operators´ concise statements (Critical Incidents) were put in order and classified by topics to filter partial activities which are relevant for success.

Following categories of different activities stated, which are relevant to drive an harvester were found out:

Table 3: Categories which are relevant for the job "harvester operator"

Organisation Form	Basis Criteria	Tasks		
		Planning	Main task	Technical domain
Position in the enterprise (employee-entrepreneur	Careful harvesting	Organisation of one task	Strategy (Cooperation with forwarder, trace lines, have enough spare parts)	Service and maintenance of machines
Shift work (Night and/or weekends	Satisfaction of customers	Organization over a year	Drive with a harvester	Mechanical equipment (purchase, stock-keeping
Cooperation forms and communication	Profit ability		Felling trees	
	Security		Following work (cleaning roads, etc.)	

With the help of qualitative content analysis the category system (see Table 3) is analysed, worked on and classified. Besides sorting into categories each item must be assigned to a certain level of requirement. Three levels of requirement were built.

Activity requirement (describes the requirement of the work itself)
Personal requirement (describes any requirement concerning the person, such as physical requirement, abilities skills or motivation))
Requirement of circumstances (describes the circumstances e.g.: critical forest owners, controlling, weather or terrain)

The next step is to create a list of different activity categories – subdivided in greater detail into three levels of requirement – will be discussed by a group of experts (forester, Psychologists and harvester operators). They should find out necessary abilities, skills and knowledge to drive a harvester as well for each item as well for each category. Abilities and skills can be found with the taxonomy of Human Abilities (Fleishman, 1992). The amount of knowledge which is necessary to be a harvester operator is known by experts.

Then questionnaires are sent to harvester operators to quantify the different abilities, skills and previous knowledge. Respectively to estimate the relation of abilities, skills and previous knowledge.

The result of the study is at least a list of the most important characteristics, which a harvester operator has to possess to be a successful harvester operator. A psychologist will arrange suitable psychological tests for testing these characteristics. This instrument enables man to decide if a person is qualified for the job "harvester operator" or not before he has started the profession

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