

Czech University of Life Sciences Prague

Faculty of Forestry and Wood Sciences



**Assessment of Selected Biometric Data of Students in Practicing on the
Simulator of Multioperational Logging-Transport Machines**

Bachelor theses

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BACHELOR THESIS ASSIGNMENT

Jan Němeček

Forestry

Thesis title

Assessment of Selected Biometric Data of Students in Practicing on the Simulator of Multioperational Logging-Transport Machines

Objectives of thesis

The aim is use the device Biofeedback 2000 XPert for measuring and consider chosen biometric data of students participating in training on simulator of harvester technology.

The aim is primarily to assess students reaction to various forms of training and setting up a training program and working environment.

It also aims to propose methods of training leading to higher work efficiency on harvester simulator.

Methodology

Measurements will be preceded by a literature review.

Measurements will be made on device Biofeedback 2000 XPert that allows to record biometric data (BMP, EMG, temperature, perspiration etc.) And at work practicing on a simulator harvesting technology.

Comparing the measurement results in various forms of training, program settings and changes of the working environment, it should be possible to design steps to optimize the training.

The proposed extent of the thesis

30 pages

Keywords

Biofeedback, simulator, harvester technology, training,

Recommended information sources

- KLOUDA, M.: Normování práce. Praha: MZLVH ČR, 1988, 208 s.
- NERUDA, J. a kol.: Harvesterové technologie lesní těžby. 1. vyd. Brno: Mendelova zemědělská a lesnická univerzita v Brně, 2008, 149 s. ISBN 978-80-7375-146-3 (brož.).
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-

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Affirmation:

Hereby I declare that I have written Bachelor thesis "Assessment of selected biometric data of students while practicing on the simulator of multioperation logging-transport machines" on my own under supervision of Ing. Jan Macků, Ph.D. and I have used only the sources which are marked in the bibliography.

I am aware that by releasing of this bachelor thesis I agree with its publication according to the law number 111/1998 Sb. about universities as amended regardless of the result of its defend. Have been complied with all guidelines for experiments with humans.

In Prague, April 15.2017

Abstract

Bachelor's thesis describes the use of a harvester simulators for a training of operators. The paper presents the possibility of a use and its benefits and possibilities of various kinds of simulators as is needed. Part of this work is how to measure an activity of muscles of the forearm and evaluation of their activities on a simulator of John Deere. Also, part of this evaluation is a comparison between muscles during exercise and relax time and comparing the strain of left handers and right handers during a training on the simulator. For this work has been used more than 655 000 data, which were recorded with an equipment Biofeedback and evaluated by program Biofeedback X-pert2000 and after that further elaborated in the program Statistica. In this study was demonstrated that there is a clear distinction between exercises and relax on forearm, but not so big differences between left-handers and right-hander, or any other conjunction. This is probably cause by no inexperience of operators. This issue is more urgent for the reasons of safety at the workplace. This studies gives us a better understanding of this issue, and we will be able to create better conditions for operators during work and their safety during work. These changes can bring us many opportunity to improve skills and speed of the operators and reduce personal injury.

Keywords: Harvester, harvester technology, simulator, Biofeedback, arm muscle

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1 Introduction

From ages, wood is an integral part of human development. As humanity develops and evolves as its processing and purpose. Beginning use of wood had origins in the use of simple tools as well as a heat source. Over time, the man started to use wood as building material. Increasing need for wood use, also rise logging. Increasing demand for wood products is also rising demand for timber extraction and logging. The first easement comes in the form of a simple hand tools such as axes, handsaws. These tools have been able to facilitate and streamline mining. However, they are not able to replace human labor. The gradual development of these tools, also comes the development of tools that will be able to relieve or in part replace human manual labor. But forest logging is not just about cutting but also, for the transport of the material to a collection point or directly to the consumer. Transportation of the material started again just moving material by human power. Later, man began to use animals for work, which largely facilitated transportation. Increasing demand for a wood products, the demand for more efficient means of transport than the animals. So, the man began to use mechanization in this area. Since the beginning of the use of simple machines until today using sophisticated motor machines.

Technology evolution also brings significant part of the responsibility. Whether we are talking about the improvement of working tools, processes, also increases the responsibility for the people who work with a modern tool and implements new procedures. This responsibility is meant as a safety at work and safety in the workplace and associated with hygienic on workplaces. These things lead us to research how to eliminate workplace hazards or at least reduce it. However, it is not just about security but also facilitate the work itself. Harvester operator's work is quite demanding. The operator performs several operations at one time, and therefore it is in our interest to simplify and simultaneously to use his abilities on maximum. Therefore, it is necessary to pursue research that will bring new solutions and streamline processes in forestry.

2 Goals of the thesis

Aim of this paper is to work out a literature search, to gather evidence on the issue of control elements of harvesters and verification of knowledge on the case study. In literature search is processed problems around simulator, simulator for forestry and special forestry simulator by John Deere and Mevea company. Also, the search is focused on topics around muscles of forearm and technology of biofeedback. The practical part of thesis is focused on the issue of control elements of harvester. For the measurement is used special equipment's for collecting a data and after this the data has been evaluated. The main aim of the thesis is compered activity of muscles on left and right forearm during exercise and relax time and compere left-hander with right-hander.

3 Literary review

In the following chapter will be discussed a type of a harvester simulator and advantage of them, EMG measuring tools and the features, muscles of a forearm and they function.

3.1 *Harvester simulators*

Nowadays, when the emphasis is on time and economical utilization are these factor also necessary in forestry. Because a time, main affect productivity and revenues. That is main reason why we want to optimize productivity of operators of harvester. If we look on the modern harvester is complex, expensive, and difficult to operate productively without previous experiences or training. Learning-by-doing is a common way to learn how to use harvesters but this can be dangerous, lead to ineffective work methods, financially demanding and thereafter to low productivity (OVASKAINEN, 2005). This assertion is confirmed by studies. (GELLERSTEDT, 2002). In this case is necessary to professionally and effectively train the operator in short time and minimalize costs and damages on harvester. For this purpose, is the best way to use harvester simulator. "The use of simulators has been introduced to support and develop harvester operator training programs. Simulators enable the student to gain practice in forest machine management, control and measurement systems, timber harvesting process planning, working methods, cooperation between felling machine and forwarder, and timber harvesting on diverse types of felling site. The simulator-based training is an important part of a broad comprehensive training development programme. "(RANATA, 2009). In studies (OVASKAINEN, 2005) is shown that sufficient preparation on harvester simulator increase skill of respondents in first week up to 15% than the respondents without previous skill exercise. The practice on simulator allow to increase a production, otherwise it reduced repair costs, a non-negligible part of operation costs. A comparison of repair and maintenance costs decrease of 26% of the costs. Those savings are mainly due to a reduction of frequent breaks to the chainsaws, blades, as well as many hydraulic components such as hoses. Finally, there was also less hydraulic

oil usage, since the reduction of breaks also reduced the volume of oil spillage. (LAPOINTE, 2000)

The harvester simulator is becoming an integral part of training the operators. To achieve the best results in training, is necessary to create an identical copy of the cockpit of the machine on which the operator will trains. Thanks, of the identical cockpit, the operator can adjust to future work environment and transfer their experiences into reality.

The simulator is not only used for training of the operators. It can be used for research as to calculate a time of work and effectivity of work of the operator, cost. (PURFÜRST, 2006)

Advantages in summary:

- safe for operators
- without fuel costs
- zero production of CO²
- without damage machinery and Nature
- possibility of multiple repetitions
- creating a different models situation for operators and machines
- simulation and development of new components of harvesters

3.2 The most commonly used types of simulator

In the Czech Republic is used manly two type of harvester simulator, John Deere simulator and simulator by Mevea.

3.2.1 John Deere Simulator

The John Deere E-Series simulator is an excellent tool for training the best working methods virtually before working in a real forest. The simulator can simulate two machines, namely: forwarder and harvester. This simulator is equipped with E-Series harvester control system TimberMatic H-

09, FlexController control modules and TimberLink™. These programs are the same as in a John Deere E-Series forestry machine. The equipment of the harvester simulator like the keypads and the seat are also same as in the John Deere E-Series. Every E-Series simulator includes one pre-programmed training terrain. Create customized exercises with Terrain Editor by creating terrains and stands, various types of trees, rocks, terrain types, driving tracks etc. The simulator monitors a variety of functions, and can produce a machine-specific real-time feedback report on all exercises. The exercise can even be scored; choose the assessment criteria to be monitored in Score Editor and compete for points. Repeating the same exercise several times helps to polish operating skills and ultimately leads to an increase in productivity. (URL 1.)

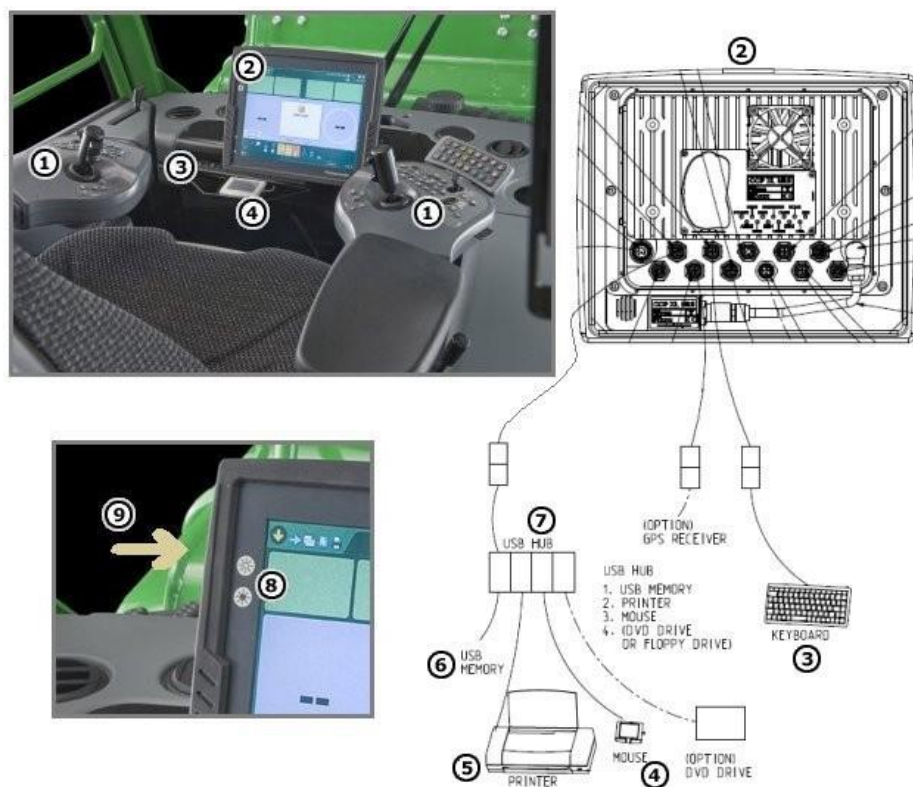


Fig. 1 Equipment inside the cabin of simulator (URL 11, 2015)

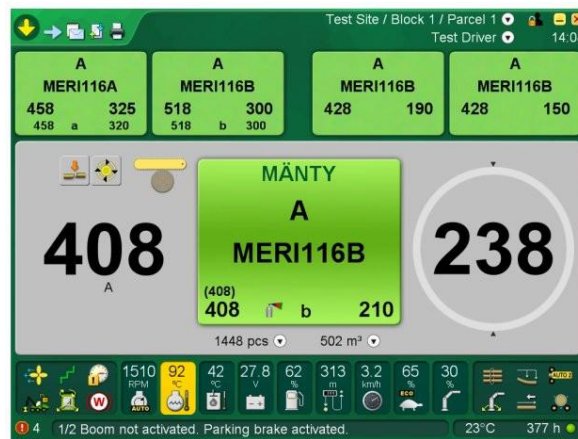
Part of the program is a cockpit. The cockpit is the same as the real machine as showed in a picture 1, and it is equipped with the following components:

Keypad on the armrest

1. Second HPC07 / FPC07, display and CPU
2. Keyboard

3. Touchpad
4. Color Printer
5. USB Flash Drive
6. USB Hub
7. Display Brightness (+ /)
8. Slot for removable hard disk

The system TimberMatic has two operating modes which can be switched the main page of this program is shown in a picture 2:



Pic. 2 demonstration of display in operating mode (URL 2, 2017)

- Setup mode
- Operating mode: the system is always running in the working mode. Display in operating mode shows all the data that the operator needs to know about machine, and the processing of the felling.

We can save the data from system TimberMatic. These data include information about production, labor, and the machine. All this data is recorded to a local disk, or can be stored in external storage via the USB drive. Data can be divided into the following groups:

- Manufacture of wood stands
 - categorized by classes of length and diameter
 - information about the production, including types of price clustering tree trunks
- Date of manufacture
- Manufacture

- Labor statistics
- Information about trunk
- Price list
- The machine settings
 - It includes all the settings, such as controller parameters, internal PC settings, calibration values
- Alarms and Events
- Repairs and maintenance

This device is available to students of University of Agriculture, Faculty of Forestry to familiarize yourself with the machine's programs and properties. Students after graduation are familiar with the machine and their features and facilitate them entry into employment. In practice, these machines become an integral part of the training of operators and reduce cost and faults. All information and detail description is written in manual (URL 11, 2015).

3.2.2 Mevea harvester simulator

Mevea is a company focusing on development and production of training simulator for various type of miming, crane, construction and forestry. Mevea can bring these benefits:

- Efficient training
- No human or machine damage
- Better fuel economy
- Real machines in productive work
- More experienced operators

Mevea has developed a forestry simulator in cooperation with Finnish forest machine professionals. Thanks to their experience of a real environment helped to create the most accurate simulator. The forestry simulators excellency lies in the simulation of dynamics, which no other company can do as accurately as Mevea. The behavior of the logs is as realistic as it gets, and the machine behavior has been polished to perfection utilizing the deep knowledge of the Kesla professionals. The Harvester Simulator's training program allows to make

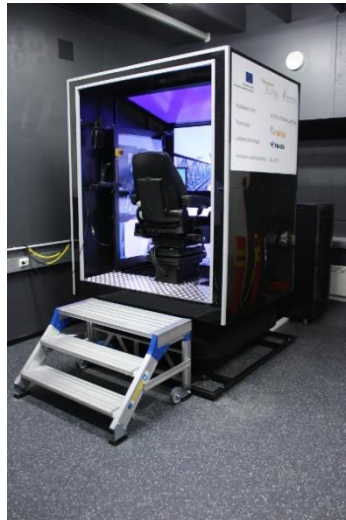
own exercises where the forest parameters, such as forest type, tree type and density, tree thickness and weather conditions can be varied according to the skills of each trainee. The user can set up the number of logs of each tree species to be harvested during the exercise. These features give the opportunity to make countless different exercises which develop also the experienced drivers. The harvester simulator can offer these features:

- Real controls and machine control system
- Game-like graphics and 3D-vizualisation
- The best dynamic engine in the world
- Real machine behavior
- Realistic machine-tree –interaction
- Adjustable pruning forces
- The accurate simulation of hydraulic components (valves, pumps etc.)
- Various trees and forest environments

The Mevea has four type of harvester simulator. These simulators are different cab design, position the TV, the possibilities for mobility of the all simulator for easy transport. Active moving parts to simulate realistic movements cabins etc. Mevea company can offer these types of the simulators. They are describing on the brochure or web pages (URL 6, 2017):

- **Cabin**
 - The Cabin Simulator is the high-end model of Mevea simulators. Equipped with up to six large Full HD screens or projector screens, a motion platform, a head tracking system, surround sound and a real cabin with original machine controls it generates the most accurate operating feedback. The instructor's station is used for managing and supervising the ongoing simulation exercise. This Cabin can be used for various type of simulation from crane to wheel machine. This simulator is shown in the picture 3.
 - Properties
 - Mevea 6DOF or 3DOF Motion Platform
 - 3-6 Large Full HD Screens
 - Original controls and Head Tracking System

- Instructor's station



Pic. 3 Cabin simulator of Mevea (URL 3, 2017)

- **ACS 2DOF**

- This simulator is optimal for users that want the best possible operating feedback without losing the ability to move the simulator from one training site to another. This simulator's 2DOF motion platform generates realistic movements and gives the driver the feeling of sitting in the real machine. The ACS 2DOF can be equipped with a head tracking system, where the operators head position alters the view seen on the screen. This gives the operator the possibility to peek around objects as in a real machine. The simulator can also be equipped with three vertically positioned screens. The ACS simulators have also a 3D option, where the simulators can be turned into 3D mode which provides a stereoscopic sight and thereby better depth perception. All ACS simulators are provided with a real working machine seat and real controls. This simulator is shown in the picture 4.

- Properties

- Mevea 2DOF Motion Platform
- Large 3D Full HD screen (Optional: 3 large screens)
- Head Tracking System for altering the drivers view
- Original controls



Pic. 4 ACS 2DOF simulator of Mevea (URL 4, 2017)

- **ACS**
 - ACS acronym stands Arm Chair Simulator, equipped with a working machine seat, working machine controls and a large 3D Full HD screen. This hardware option is easy to take from one place to another and it's thereby suitable for customer's whose training sites change regularly. This simulator is shown in the picture 5.



Pic. 5 ACS simulator of Mevea (URL 5, 2017)

3.4 Muscles of the forearm

The muscles attach to a bone and their shrinking causes movement. So, bones act as levers and muscle as driving force, which lever moves. Because the muscles attached to the bones are considered a kind of connective tissue. Tapering muscles convert into tendons and through tendons are clamped to the bone and cartilage. So, tendons connect muscles and bones. Fascia (means

bandage) are stringy fibers which are connect and the skin beneath it positioned the structure and create cases for muscles uniting their fibers into a single bundle. Fascia are also a form connective tissue, and can be found throughout the body (DIMON, 2009).

Truncation is induced by nerve impulses, the process allows myofibrils that are contained in all types of muscle tissue. These basic units are composed of two proteins actin and myosin, which contract together and thereby leads to contraction. We distinguish three types of muscle tissue. First are smooth muscle or "involuntary muscle". We can found within the walls of organs and structures such as stomach, blood vessels, etc. Second types are Cardiac muscle, (myocardium), is also an involuntary muscle. We can found only in the heart. And last type skeletal muscle. (HANUŠOVÁ, 2014);

To better understand the function of the muscles of the hand is needed to define the movements that are performed. There are two basic movements, supination (palm facing up) and pronation (palms facing down). Pronation and supination are specific for the movement of the forearm. Pronation and supination are carried out thanks to the contraction of the muscles which rotate radius bone (os. Radius) around relatively stable ulna, wherein the upper and lower joints act as pivots. (ABRAHAMS, 2016)

For this experiment are important, these muscles shown in picture 6: musculus flexor carpi radialis, musculus extensor carpi radialis longus, musculus extensor digitorum, musculus abductor pollicis longus. These muscles are describe in book Anatomy written by ms. Čihák. (ČIHÁK, 2016) or in book written by (MERKUNOVÁ, 2008).

- **Musculus flexor carpi radialis**

Is external wrist flexor, proceeds from a common beginning obliquely to the radial side of the lower end of the forearm. on the border of the middle and lower third of the forearm passes into lean sinew and continues through the canalis carpi.

- Function: flexion and radial duction wrist by interplay with other muscles acting on the wrist. auxiliary flexion of the elbow

- **Musculus extensor carpi radialis longus**

Is long outer wrist extensor, passes along the outer side of the radius and passes on its dorsal side.

- Function: dorsiflexion and radial duction of wrist

- **Musculus extensor digitorum**

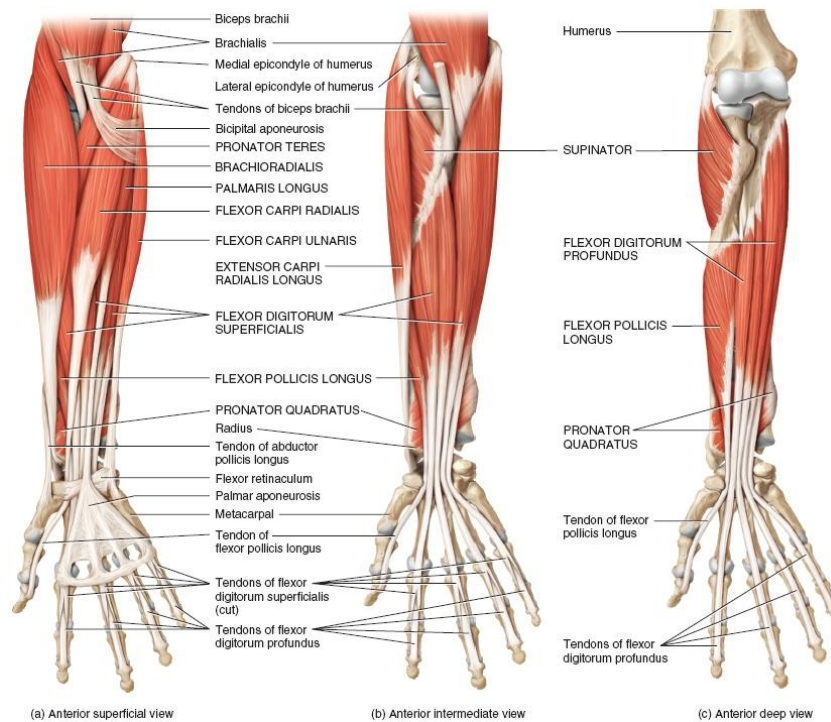
Is fingers extensor, going down by forearm and passes to the back of hand under a reinforced lateral fascial band, transmits through four tendons that are at the back of the hand flattens and diverge on the backs of 2nd to 5th finger.

- Function: stretch fingers, auxiliary dorsal flexion

- **Musculus abductor pollicis longus**

Descends in depth forearm diagonally latero-distally along the radius and membrane interossei. Its tendon sweeps the bottom of both forearms mm. extensores carpi radiales then proceeds retinacula musculorum extensorum and headed to the thumb

- Function: abduction of thumb



Pic. 6 Forearm muscle (URL 10, 2017)

3.5 Biofeedback

We can use definition which may suggest that biofeedback is a technique which enables the individual to readily determine the activity levels of a physiological process, and with an appropriate training, learn to manipulate the same process by an internalized mechanism. The practice of biofeedback has developed markedly over the last few years, and many different forms of feedback are currently employed in the clinical setting. Biofeedback cover wide range of inputs like EMG, pressure, movement, pulse, blood pressure. Generally, there are three types of data which are collecting by method biofeedback:

- Physiological: heart rate, blood pressure, temperature, EMG
- Neurological: EEG (brain wave)
- Biomechanical: joint angle and force applied

All these data are collecting by specific kind of sensors apply on human body. (WANG YE, 2016)

EMG Biofeedback

The main part of biofeedback machine are electrodes which detect small voltage changes which arise from the working muscles. The electrodes can be made by Silver/Silver Chloride construction which are efficient at detecting small biological electrical signals from the body surface. For better transport of electrical signal can be used electrode gel which helps in converting the biological (ionic) signals to electrical signals needed by the machine. The use of surface electrodes results in a broadly sourced signal which will not be specific to a motor unit or even a specific muscle. The signals reaching the electrodes need to be processed before they are of any real value to the patient. The signal is amplified, and usually filtered and then processed. Transform from analogue to a digital form. (URL 7, 2017) The result of these actions is to produce a time varying electrical voltage which can be displayed to the patient by means of a series of lights, varying tones, numbers on the LED display or through a computer link once it has been converted.

3.5.1 Biofeedback 2000 x-pert

This equipment is detailly describe on web page (URL 8, 2017). Biofeedback 2000 x-pert is a system consisting of 4 different measuring devices, different sensors, the basic software and additional programs for special therapy applications. The measuring instruments are small and easy to attach to the patient's body. The measured values are transmitted by radio (Bluetooth) to the computer. The sensors can be combined with all commercially available electrode types. This equipment is shown in picture 7.

Measuring instruments and the sensors

1. Measuring instrument MULTI

- Measurement parameters: Skin conductivity (EDA); Pulse amplitude, pulse rate (PULS); Temperature (TEMP); Movement (MOT)
- Sensors: skin conductance sensor (EDA sensor); Pulse sensor; Temperature sensor; Combined sensor for pulse, temperature and skin conductance

2. Measuring device RESP

- Measurement parameters: Breathing
- Sensors: Atemensensor

3. Measuring device EMG

- Measuring parameters: muscle tension
- Sensors: standard EMG sensors; Rectal and vaginal electrodes

4. Measuring instrument EEG

- Sensors: standard sensors
- Measurement parameters: electroencephalography

The software

The basic software provides all the essential functions and can be used in several therapeutic applications. There are additional programs for specific

requirements. The basic software offers besides various administrative and basic functions:

- RESP relaxation training
- Threshold Training
- Audio feedback
- Line feedback
- Volume feedback
- Programs for special therapies:
- Respiratory Training (BFRESP)
- EDA Relaxation Training (BFEDA)
- Confrontation Training (BFKON, BFVID)
- Neuromuscular Rehabilitation (BFMUSK)
- Blood flow (BFVASO)
- Load test (BFBEL)
- Voice recorder (BFREC)
- Statistics module (BFSTAT) among others



Pic. 7 Biofeedback device (URL 9, 2016)

4 Practical part

The main goal was to measure the muscle activity of the forearm and compare the data. Measurements were made on respondents who had no experience with the operation of the harvester simulator or real harvester. For measuring was used a biofeedback device on simulator John Deere. Thanks to use the school simulator we could simulate real condition in harvester machine. Subsequently, the data were evaluated and compared with each other. Comparing was focus between the muscles of the forearm, which was calm and forearm muscles at work, then these data was compared between the left and right hand.

4.1 *Measurement methodology*

Data acquisition can be divided as follows:

- Selection of respondents
- Description of the simulator control elements to respondents
- Attaching of measuring tools
- Paired with a PC and setting measurement instruments
- Activity measurement
- Evaluation of the collected data

4.1.1 *Selection of respondents*

Selection of respondents was the main criteria of experiment. Was determined several criteria for respondents. These criteria were:

- No experience whit harvester simulator
- spatial imagination
- two or three right-handers and two or three left-hander's respondents
- age range 18-50 years

For this experiment, have been selected three right-handers and two left-hander's respondents. Detail description of them is describe in a table 1 below.

Table 1 Table of respondents (source: Author)

Name of respondent	left/right-hander	age	education	experience with simulator/games
Ary	Rigt	26	High school	yes
Michal	Rigt	23	High school	yes
Kryštof	Left	18	Primary school	yes
Pepa	Rigt	21	High school	yes
Petr	Left	40	College	yes

4.1.2 Description of the simulator control elements to respondents

For the experiment was necessary to explain the basic control elements of simulator to each respondent separately. The time for explaining of the control elements was around 5-7 minutes. The main control elements were: left joystick and right joystick (used for moving of crane and opening and closing of harvester head, button for cutting, button for moving of log forward or backward in the head of harvester, button to select the assortment, accelerator, shift lever. After the explanation of the control elements the respondents had the opportunity to ask for detail information or if they were something unclear in controlling of the simulator. It is necessary to mention that the respondents were not able to try the simulator before. The explanation was just theoretical not practical. The John Deere simulator has more control elements, than there is mentioned, but for the experiment and not so deep knowledge of the respondents about harvester was use sufficient quantity control elements for maintaining the most frequently used controls of operators.

4.1.3 *Attaching of measuring tools*

After the explanation of control elements of harvester simulator, the respondents were asked to be only a T-shirt order to attach measuring instruments. It was necessary because the electrodes of the measuring instrument must be in direct contact with the skin of the respondents. Always first was chosen left hand to attach the electrodes. First of all was essential to lay out, where the electrode will be placed. Place for the attaching were left and after right forearm. For this experiment were used two type of electrode because the measurement was going in bipolar way. It means that was used two electrodes (light green) for EMG 1, two electrodes (dark green) for EMG 2 and on black electrode for ground. Each electrode is provided with an adhesive sensor (after each measuring was necessary to change the adhesive sensor for compliance with the principles of hygiene). The attaching of electrode is described step by step in this order:

1. Connect the data collector with electrodes: dark green electrode with dark green plug and light green electrode with light green plug and black electrode with black plug
2. Place the adhesive sensor to the forearm: the position is very important for experiment so it is necessary to try place the sensors to the same position on the forearm on all respondents
 - Try to determine on the forearm beginning and the end of: musculus flexor carpi radialis, musculus extensor carpi radialis longus, musculus extensor digitorum, musculus abductor pollicis longus
 - On the beginning and the end place one adhesive sensors
3. Between these four sensors place fifth one
4. After placed the sensor connect the electrodes to the adhesive sensor
 - EMG1 dark green to the site of little finger
 - EMG 2 light green to the thumb site of the forearm
5. Ensure the data collector to the clothes

A picture 8 below shows the wiring electrodes on the forearm



Pic. 8 Attached measuring sensor on forearm of respondent (source: Author)

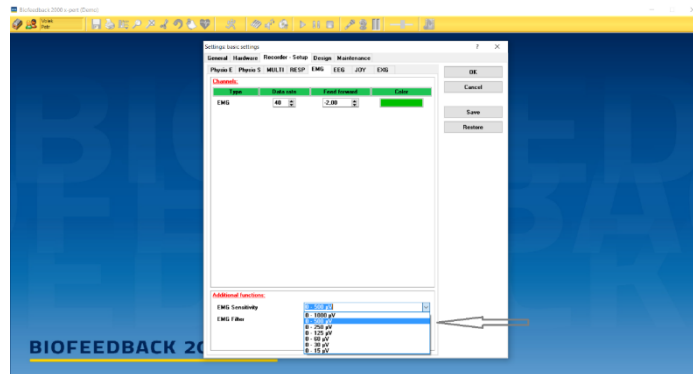
4.1.4 Paired with a PC and setting measurement instruments

After connecting the sensors on the respondents is needed to pair the collector with the PC. For this propose is used the special Bluetooth adapter.

1. Plugged the adapter into a USB port of the PC
2. Run the program Biofeedback 2000x-pert
3. After the run are the sensors automatically connected with the data collector and data collector relates to Bluetooth adapter (all equipment must have been connected)

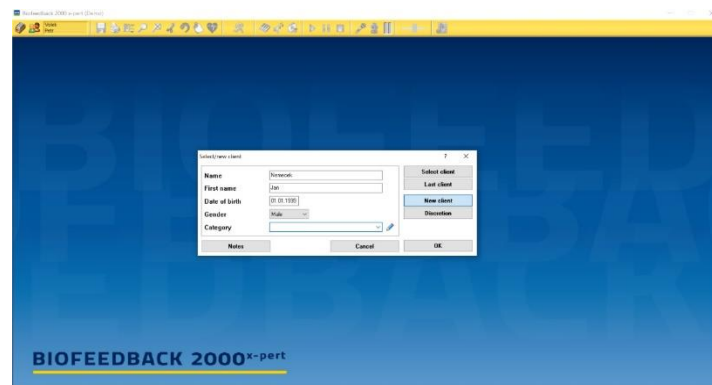
After these steps, followed setting of program Biofeedback 2000x-pert.

4. In program control chose setting→basic setting→Recorder-Setup→EMG sensitivity on 0 - 500 μ V as in picture 9.



Pic. 9 Biofeedback setting sensitivity in program (source: Author)

5. Close the Setting Basic-setting
6. Open Database→Select/ new client→chose New client→fill the information for all of respondents do the same as in picture 10



Pic. 10 Filling information in too program (source: Author)

7. In database, open→Open diagram/ Database→choose respondents for the actual measuring→press start measure→Start

4.1.5 *Activiti measurement*

Measurement has two types. First is during exercise (when the operator/ respondent is active). This activity phase of measurements is going around 15 minutes. Respondents has been driving the harvester and trying to cut some tree during 15 minutes. After 15 minutes' respondent finish this active part.

Second part of measurement is relaxing time. The respondents can stay on simulator, but without any activity. No moving of forearms or hands. This part is going around 6-7 minutes. After each measurement save the date. After active and relaxing part, must be change the forearm for right. Measurement is going

on both hand Left and Right/ relax and active phase. In a picture 11 is the operator during exercise on the simulator John Deere.



Pic. 11 Respondent during operating time on harvester simulator (source: Author)

4.1.6 Evaluation of the collected data

The data has been exported to the excel by function export data: Database→Open diagram/ database→choose the data of respondents→press export→export to excel file for more evaluation of the collected data.

After evaluation of the data was chosen few parameters: mean, minimal value, maximum value and these parameters were putted to the table for each EMG and each respondent. The second part of the evaluation was done by program Statistica. Where was taken all collected data from excel. In program statistica was chosen Basic statistic→T-test- independently by Variables + Leven test→put the data to the program→chose the comparison data→start test

T- test is the difference between the two data sets. Level of significance of the test was at 0.05. In these tests were confirmed, that in 95 % could demonstrate the difference.

4.1.7 Comparison data

Table 2 Ary data of EMG measurement and comparison of activity (source: Author)

ARY	EMG 1	EMG 2	EMG 1	EMG 2	EMG 1	EMG 2
	Mean		Minimal value		Maximum value	
Left hand ex.	21,75	21,00	4,60	5,37	93,17	81,29
Left hand rel.	2,06	2,06	0,00	0,00	10,74	7,67
Difference ex.X rel.	91%	90%	100%	100%	88%	91%
Right hand ex.	32,75	8,32	11,12	2,30	161,04	44,10
Right hand rel.	0,32	0,09	0,00	0,00	17,25	3,45
Difference ex.X rel.	99%	99%	100%	100%	89%	92%

In the Table 2 is clearly done that the difference between exercise and relax time in case left and right is nearly 100%. This respondent is right hander and we can see that higher numbers (activity of muscle) is on right hand over the left and in the comparison, of difference ex. X rel. is higher difference in case of right hand. In this case is clear that it is burdened right hand even though the respondent is right hander. For better understanding, there is box diagram 1.

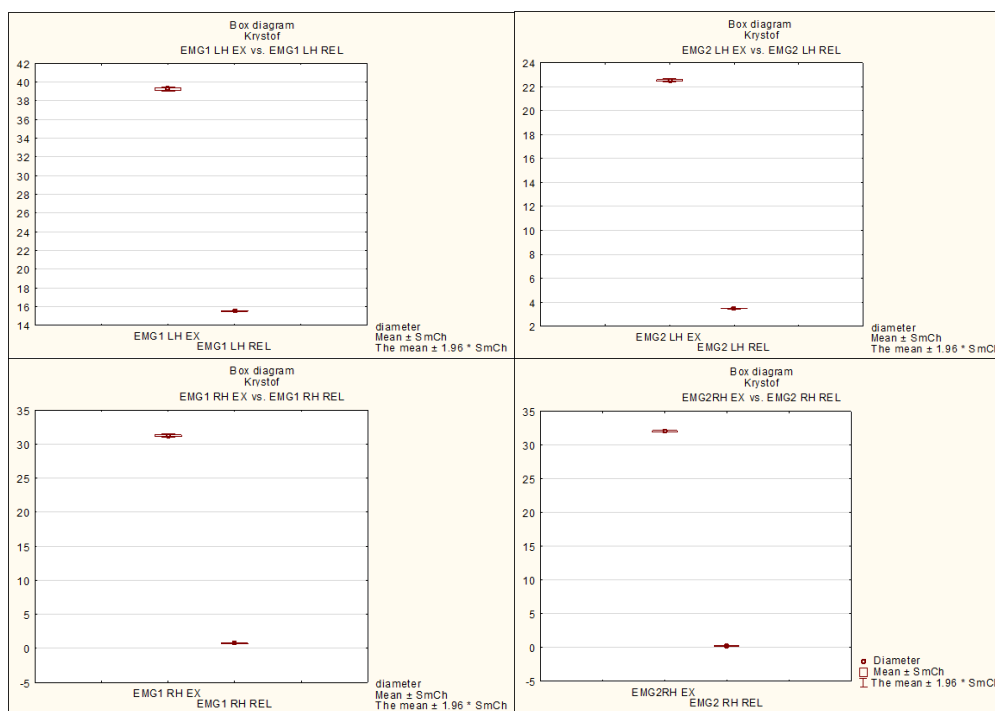


Box diagram 1 Ary (source: Author)

Table 3 Kryštof data of EMG measurmant and comparison of activity (source: Author)

KRYŠTOF	EMG 1	EMG 2	EMG 1	EMG 2	EMG 1	EMG 2
	Mean		Minimal value		Maximum value	
Left hand ex.	39,26	22,52	9,20	8,82	232,75	97,01
Left hand rel.	15,52	3,47	1,53	0,00	79,37	37,19
Difference ex.X rel.	60%	85%	83%	100%	66%	62%
Right hand ex.	31,23	32,04	1,15	4,60	161,43	100,46
Right hand rel.	0,74	0,24	0,00	0,00	66,72	44,86
Difference ex.X rel.	98%	99%	100%	100%	59%	55%

In the Table 3 is clearly done that the difference between exercise and relax time in a case left and right is nearly 100%. This respondent is left hander and we can see how it is burdened with the right hand over the left. But in the comparison, of difference ex. X rel. is higher difference also in case of right hand. In maximal value are bigger difference for left hand, this can be cause by higher activity thanks that the respondent is left-hander. For better understanding, there is box diagram 2.

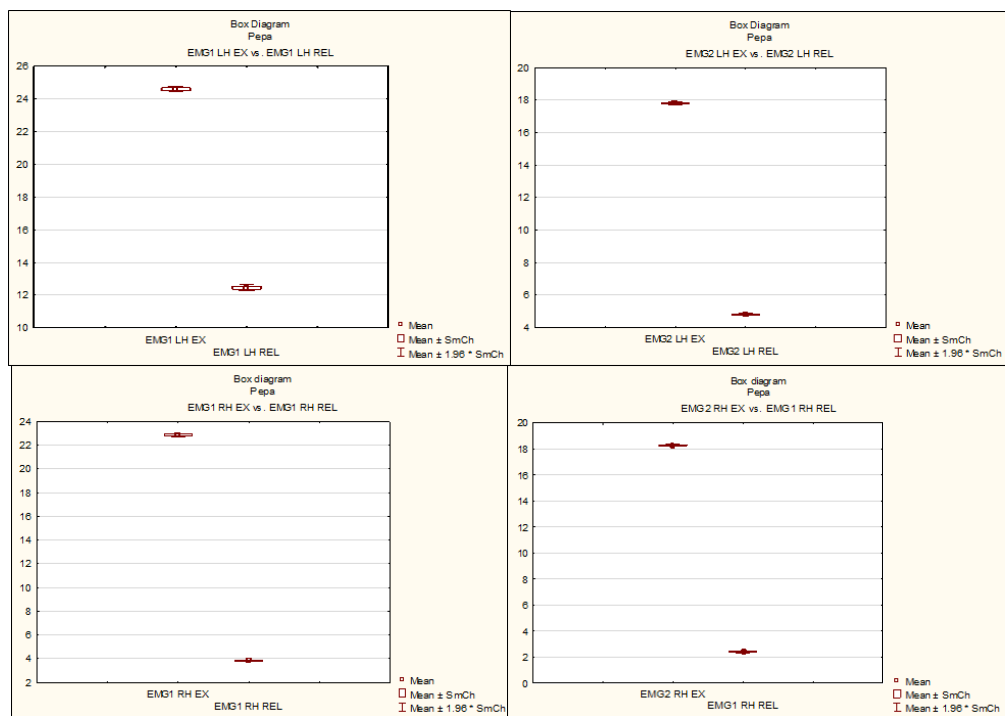


Box diagram 2 Kryštof (source: Author)

Table 4 Pepa data of EMG measurement and comparison of activity (source: Author)

PEPA	EMG 1	EMG 2	EMG 1	EMG 2	EMG 1	EMG 2
	Mean		Minimal value		Maximum value	
Left hand ex.	24,59	17,78	1,53	6,13	101,61	58,67
Left hand rel.	12,46	4,79	0,00	0,00	65,95	19,17
Difference ex.X rel.	49%	73%	100%	100%	35%	67%
Right hand ex.	22,85	18,25	3,07	3,07	79,75	67,10
Right hand rel.	3,83	2,38	0,00	0,00	50,23	52,53
Difference ex.X rel.	83%	87%	100%	100%	37%	22%

In the Table 4 is significant difference between right hand in relax and exercise and exercise and left hand in relax and exercise. But higher mean value is in case of left hand for EMG 1 than EMG 2 this is cause by the preferences of muscles. In this case, we can say that higher burdened is on left hand even though the respondent is right hander. For better understanding, there is box diagram 3.

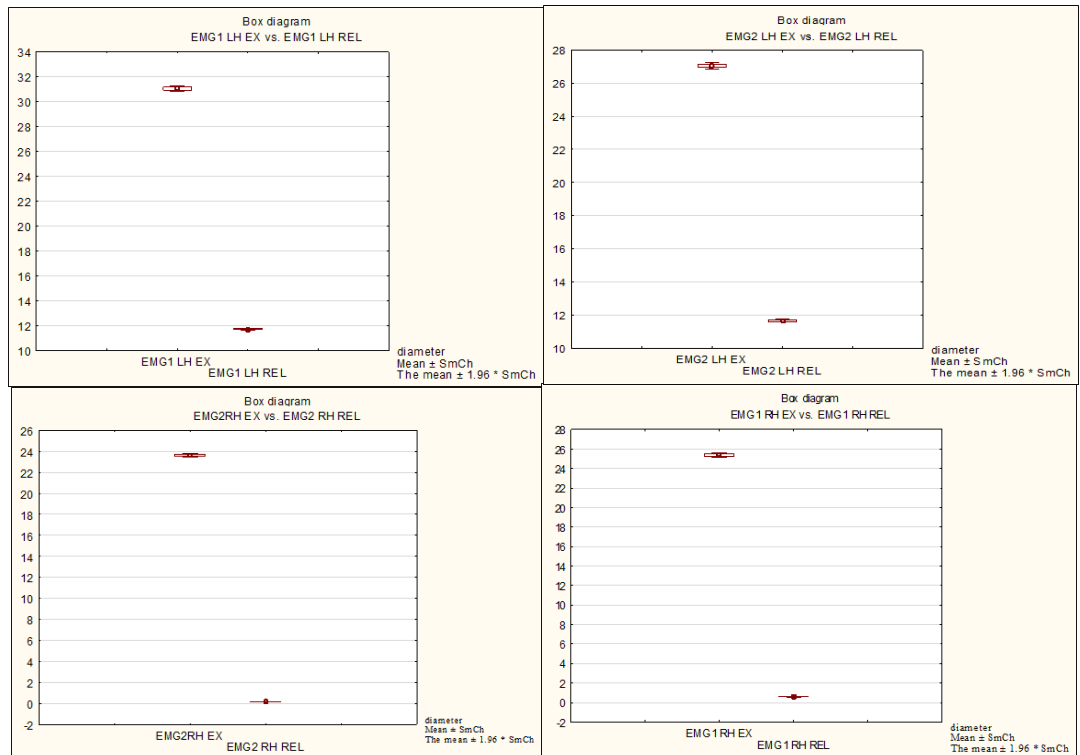


Box diagram 3 Pepa (source: Author)

Table 5 Michal data of EMG measurement and comparison of activity (source: Author)

MICHAL	EMG 1	EMG 2	EMG 1	EMG 2	EMG 1	EMG 2
	Mean		Minimal value		Maximum value	
Left hand ex.	30,98	27,00	0,00	0,00	161,43	130,37
Left hand rel.	11,72	11,66	0,00	0,00	26,84	35,28
Difference ex.X rel.	62%	57%	0%	0%	83%	73%
Right hand ex.	25,38	23,63	0,00	0,00	120,40	167,94
Right hand rel.	0,57	0,18	0,00	0,00	21,86	10,74
Difference ex.X rel.	98%	99%	0%	0%	82%	94%

In the Table 5 is significant difference between right hand in relax and exercise and left hand in relax and exercise. But higher mean value is in case of left hand for EMG 1 and EMG 2. Also, maximal value is significantly for left hand. In this case, we can say that higher burdened is on left hand even though the respondent is right hander. For better understanding, there is box diagram 4.

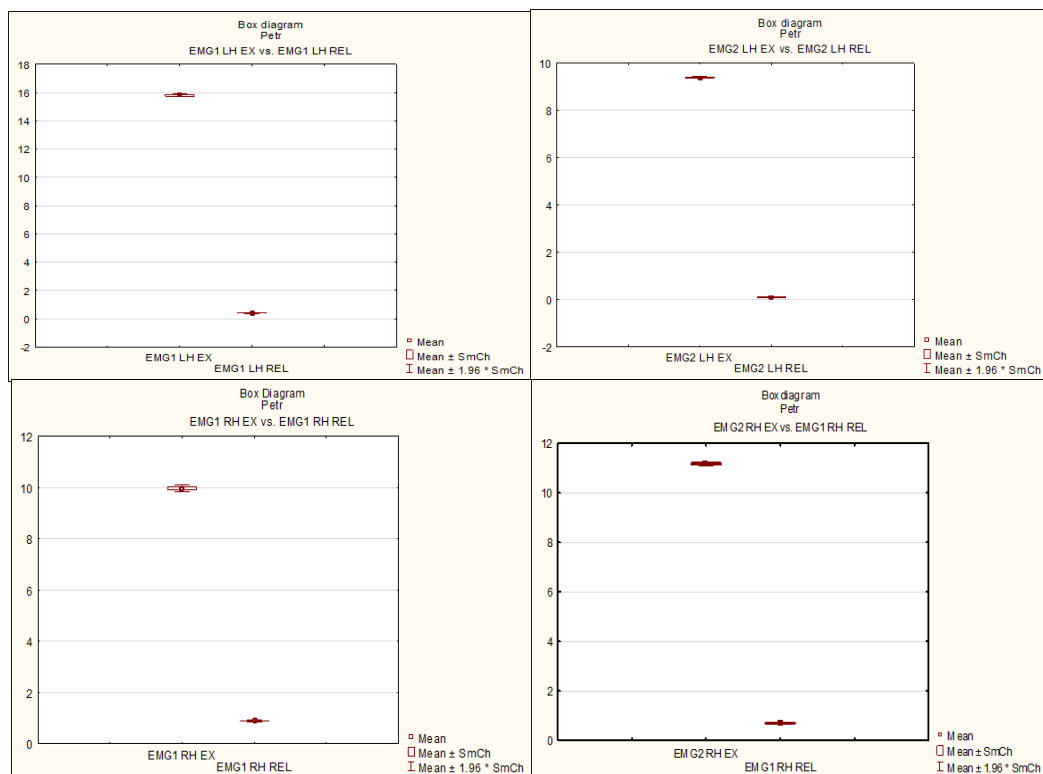


Box diagram 4 Michal (source: Author)

Table 6 Petr data of EMG measurement and comparison of activity (source: Author)

PETR	EMG 1	EMG 2	EMG 1	EMG 2	EMG 1	EMG 2
	Mean		Minimal value		Maximum value	
Left hand ex.	15,79	9,38	1,53	0,00	66,72	29,91
Left hand rel.	0,42	0,10	0,00	0,00	39,49	17,25
Difference ex.X rel.	97%	99%	100%	0%	41%	42%
Right hand ex.	9,96	11,17	0,00	0,00	79,37	52,15
Right hand rel.	1,65	1,03	0,00	0,00	309,43	200,54
Difference ex.X rel.	83%	91%	0%	0%	-290%	-285%

In the Table 6 is significant difference between right hand in relax and exercise and left hand in relax and exercise. But higher mean value is in case of left hand for EMG 1 than EMG 2, this is caused by the preferences of muscles. But maximal value is significantly for right hand. The maximal value for right hand in relax was caused by accidental squeezes of muscles during measurement. In this case, we can say that higher burdened is on left hand even though the respondent is left hander. For better understanding, there is box diagram 5.



Box diagram 5 Petr (source: Author)

Table 7 T-test and Leven test (source: Author)

Sloupec1	arithmeti c mean	Parameter- T	degree of freedom	error probabilit y	Leven F(1, sv)	sv Levene	p Levene
MICHAL LEFT HANDER							
EMG1 LH EX vs. EMG1 LH REL	31,0	115,4	43600,0	0,0	11019,5	43600,0	0,0
EMG2 LH EX vs. EMG2 LH REL	27,0	116,6	43600,0	0,0	5940,1	43600,0	0,0
EMG1 RH EX vs. EMG1 RH REL	25,4	178,8	43647,0	0,0	26063,6	43647,0	0,0
EMG2RH EX vs. EMG2 RH REL	23,6	204,5	43647,0	0,0	17815,7	43647,0	0,0
KRYŠTOF							
EMG1 LH EX vs. EMG1 LH REL	39,3	159,4	43384,0	0,0	8673,8	43384,0	0,0
EMG2 LH EX vs. EMG2 LH REL	22,5	218,3	43384,0	0,0	13115,3	43384,0	0,0
EMG1 RH EX vs. EMG1 RH REL	31,2	188,3	44209,0	0,0	14298,7	44209,0	0,0
EMG2RH EX vs. EMG2 RH REL	32,0	285,3	44209,0	0,0	22711,0	44209,0	0,0
ARY							
EMG1 LH EX vs. EMG1 LH REL	21,7	262,8	44303,0	0,0	18412,3	44303,0	0,0
EMG2 LH EX vs. EMG2 LH REL	21,0	257,9	44303,0	0,0	16380,4	44303,0	0,0
EMG1 RH EX vs. EMG1 RH REL	32,8	322,8	46036,0	0,0	16853,0	46036,0	0,0
EMG2RH EX vs. EMG2 RH REL	8,3	276,9	46036,0	0,0	13636,8	46036,0	0,0
PEPA							
EMG1 LH EX vs. EMG1 LH REL	24,6	99,2	48051,0	0,0	2,1	48051,0	0,1
EMG2 LH EX vs. EMG2 LH REL	17,8	229,8	48051,0	0,0	1418,9	48051,0	0,0
EMG1 RH EX vs. EMG1 RH REL	22,8	194,5	48880,0	0,0	13357,0	48880,0	0,0
EMG2 RH EX vs. EMG1 RH REL	18,3	254,6	48880,0	0,0	3835,2	48880,0	0,0
PETR							
EMG1 LH EX vs. EMG1 LH REL	15,8	241,3	48209,0	0,0	18566,6	48209,0	0,0
EMG2 LH EX vs. EMG2 LH REL	9,4	323,5	48209,0	0,0	21225,5	48209,0	0,0
EMG1 RH EX vs. EMG1 RH REL	3,0	405,7	48209,0	0,0	23884,3	48209,0	0,0
EMG2 RH EX vs. EMG1 RH REL	-3,4	487,9	48209,0	0,0	26543,2	48209,0	0,0

The data in Table 7 were tested, it displays significant differences. These differences were confirmed during static analyze by T- test. Hypothesis H0: Between the tested files are not statistically significant difference, managed to disprove in all cases. Hypothesis H1: Between the tested files are statistically significant difference which was confirmed. All data was tested at a significance level of 0.05. Before used the T-test were the data tested by Leven method that pruded conformity of scattering. The Leven test confirmed the possibility of using t-test.

4.1.8 Evaluation of results

Measured data match the quality of the measurement. In this case the data cannot be used for accurate results. These data are only approximate. This inaccuracy is due to measurement technology, to get more accurate data, will be necessary to place the sensor immediately to muscles and get a direct contact with the muscle mass.

We can certainly confirm that measurements show differences, which confirm that the respondent raises several times muscle tension of forearm during work against standstill. In the cases of the zero activity of the muscles is caused by inaccurate measurements as is mentioned before. On the contrary, very high values, which were measured arose the rash conduct of hand. These phenomena can assign to the fact that the respondents had no experience with this type of operation. In some cases, the differences during exercise and during relax were high like in case of Ary and in some cases, the differences were lower like in case of Pepa. This phenomenon can also be assigned to inaccurate measurements and the experience with the operation of the simulator. To compare the activity of the left hand and right hand, and their preference must be approached with detachment. For better understanding, there is a Table 8 that indicates a greater use of the given area of the hand during measurement EMG1 and EMG2. Only the left-handed people show a similarity in loading of the same parts on the same forearm. While the right-handed show no similarities. Only Ary has similarity with left-handed gays, although he is right-hander. In cases of Pepa and Michal are not the similarity with any cases of this study. They create new

group of possibilities to comper.

Table 8 Preference of using Left or right hand by EMG1 and EMG2 (source: Author)

Right- hander		
Name	EMG1	EMG2
Ary	Right	Left
Pepa	Left	Right
Michal	Left	Left
Left-hander		
Kryštof	Left	Right
Petr	Left	Right

5 Discussion

All the data unambiguously show differences. This means, that all operators showed difference. But these results are not conclusive. In work of Mr. Ranata (RANATA, 2009) is mentioned, that the process of a training and educations on the simulators depends on time and ability to learn. In conjunction with this work is meant that we cannot say, that the operators use more some of the part on the forearm than on the other forearm. Because the operators are still developing, (learning and getting more experiences) these ability witch they got from the training can transform to the reality. Thanks, of these training the operator can learn an ability to reduce a utilization on the forearm. The difference between left and right are clear. I think, that it depend on a personality of the respondents and their experiences.

In studies, of Mr. Ovaskainen (OVASKAINEN, 2005) has been showed interesting result about difference of the operators' witch trained on the simulator and without the simulator. Higher skills got the operators with has trained on simulator.

I think that this study bring new perspective on this issue and can help us to develop new possibilities for the operators in their development and ability to get more skills thanks of the simulators.

6 Conclusion

Elaborated problems of this work is a plan view of the complexity of control of the simulator and therefore the machine itself. In Bachelor work is presented an outline summary of harvester simulator, the most used muscles during control of the harvester and how these things can be measured.

Modern technology of harvesting and processing of wood harvester is based on the technology. These technologies are perspective, because they provide a high degree of mechanization and convenience of controlling of the operation. But they are demanding for learning curve for operators. Therefore, establishing a training on the harvester simulator. This possibility brings many opportunity and advantage for the future. This approach has two main benefits: first is low cost and second is, that it is safe and without limits on training repeating. For most companies, however, it is impermissible to own the simulator. However, there are companies that focus on this issue and training. For the future is necessary to develop new systems and devices for the harvesting and the training of the operators.

In this case study, we can certainly confirm that measurements show differences, which confirm that the respondent raises several times muscle tension of forearm during work against standstill. In the cases of the zero activity of the muscles is caused by inaccurate measurements as is mentioned before. On the contrary, very high values, which were measured arose the rash conduct of hand. These phenomena can assign to the fact that the respondents had no experience with this type of operation. This phenomenon can also be assigned to inaccurate measurements and the experience with the operation of the simulator. To compare the activity of the left hand and right hand, and their preference must be approached with detachment. Only the left-handed people show a similarity in loading of the same parts on the same forearm. While the right-handed show no similarities. Only Ary has similarity with left-handed gays, although he is right-hander. In cases of Pepa and Michal are not the similarity with any cases of this study. They create new group of possibilities to compeer.

This gives you a better understanding of this issue, and we will be able to create better conditions for operators during work and their safety during work. These changes can bring many opportunity to improve skills and speed of the operators and reduce personal injury.

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