Czech University of Life Sciences Prague

Faculty of Forestry and Wood Sciences

Evaluation of the Influence of a Special Orthopedic Aid on the Trapezium Muscles Load of the Harvester Technology Operator

DIPLOMA THESIS

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DIPLOMA THESIS ASSIGNMENT

Bc. Jan Němeček

Forestry, Water and Landscape Management

Thesis title

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Objectives of thesis

The main aim of the thesis is to evaluate the influence of special orthopedic aid on the ergonomics and hygiene of harvester technology operator.

The partial objective of the work is to evaluate the selected biometric data (EMG, temperature, BVP, respiratory rate) of the operator during training on the harvester simulator.

The partial aim is to propose measures that could improve the operator's well-being during training and work, especially the use of special orthopedic aids.

Methodology

Measurements will be preceded by literary research.

The basis of the experimental part of the thesis is the measurement using the Biofeedback 2000xpert device, which aims to record specific biometric data during training on the harvester simulator.

The measurement will be focused on:

EMG (electromyogram) of trapezoid muscles

BVP (blood volume pulse)

breathing frequency

body temperature

Measurements will take place on the simulator to avoid disturbing environmental influences.

The results of the measurements will then be subjected to statistical analysis, especially the Leven test, the T-test and other basic statistics.

The proposed extent of the thesis

40 pages

Keywords

harvester simulator, biofeedback, orthopedic aid, operator

Recommended information sources

Dvořák, J. Využití harvestorových technologií v hospodářských lesích = The use of harvester technology in production forests. Kostelec nad Černými lesy: Lesnická práce, 2012. ISBN 978-80-7458-028-4

Neruda, J. a kol.: Harvestorové technologie lesní těžby. 1. vyd. Brno: Mendelova zemědělská a lesnická univerzita v Brně, 2008, 149 s. ISBN 978-80-7375-146-3 (brož.).

Sellgren, U. a kol.: Model-Based Development of machines for sustainable forestry. In 12th European Conference of the ISTVS, 2012.

Ulrichová, M.: Člověk, stres a osobnostní předpoklady : souvislost osobnostních rysů a odolnosti vůči stresu. Ústí nad Orlicí: Oftis ve spolupráci s Pedagogickou fakultou Univerzity Hradec Králové, 2012. ISBN 978-80-7405-186-9.

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The Diploma Thesis Supervisor

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Prague on 22. 03. 2019

Affirmation:

Hereby I declare that I have written Diploma thesis “Evaluation of the Influence of a Special Orthopedic Aid on the Trapezium Muscles Load of the Harvester Technology Operator” 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 it defend. Have been complied with all guidelines for experiments with humans.

In Prague, April 15.2019

Abstract

Diploma thesis describes use of a harvester simulators and operator sitting position during a training by using an orthopedic aid call backrest Authoterapia and without that. The paper describes the possibility of a use and its benefits and possibilities of various kinds of simulators as is needed not only in forestry. Part of this work is devoted how to measure an activity of muscles of the trapezoid, hearth rate, blood pressure respiration, temperature and evaluation of their activities on a harvester simulator of John Deere. This thesis is focused on evaluation and comparison between trapezoids muscles activity during exercise and relax time and comparing trapezoids muscles activity with using of orthopedic aid and without used of it. For this research has been used more than 10 million data. Those data were collected with a unique equipment and technique call Biofeedback and transform and evaluated by program Biofeedback X-pert2000 and after that, further elaborated in the program Statisctica. In this research was demonstrated that there is a clear distinction between exercises and relax of trapezoids muscles and some difference of other measured parameters, out of blood volume pressure. But a more significant difference has been demonstrated using backrest Authoterapia. This add-on has been shown to affect operator work and performance. Within the focus on trapezoidal muscles, it has been shown that in some cases it may affect the operator, but provided that the operator has followed the procedure to set up the orthopedic backrest. More significant finding was that the orthopedic device had an impact on 11 of 14 respondents to abdominal breathing. Which can positively affect operator efficiency and vitality.

Keywords: Harvester simulator, Biofeedback, operator, orthopedic aid

Content

List of Figures, Tables and Graphs

1 Introduction

Utilization of natural resources by human as well as their desire to dominate is present from the very beginning of mankind. Whether lifeless Natural Resources and Life Natural Resources, it has always been and still is the essence of human being. Therefore, it is necessary to realize that without these resources it would not be possible to achieve today's results. Especially when we talk about resources like wood. If we want to get a product like wood, it is necessary to realize the importance of sustainability of individual sources. Living and inanimate nature turns a united organism that is still disturbed and degraded by human activity.

Humanity has always used wood-based resources, whether we are talking about primitive instruments or as a source of heat or as a building material. In the early days of humanity, use resources without interfering. They only used what they found. Over time, humanity understood that resources from forests, especially wood, can be channeled so that resources are for the benefit of man. Thanks to this knowledge, the demand for wood rises. With growing demands, it was necessary to optimize forest cultivation for the greatest benefit. Hence, greater demands were placed on tools and later machines. From the first tools like hand axes and saws. Mankind has moved from the nineteenth century to the period of mechanical machines. It started with primitive machines but still with great use of human and animal work in the form of material transport, harvesting or silviculture. Over time, mechanical machines have improved to today's almost perfect machines. From hand saws to harvesters full of gauges and various sensors. With the advent of modern technology, there is also many demands, both for safety and efficiency. These demands are put on both machines and, of course, humans. As a result, great demands are placed on both machines and man. That is why it is necessary to pay more attention to research on how to make work more efficient and to minimize damages and / or addictions.

2 Goals of the thesis

Goals of the thesis is compared activity of trapezoids muscles and other physiological function with used an orthopedic back aid. To understand this issue, it is necessary to understand other aspects that describe the literature search

In a literature researcher of this thesis is describe a problematic of harvester simulator of different companies and their use for the training and possibilities of used. An integral part of this issue is the operator's position in the harvester. This is described in part operator sitting ergonometric and hygiene of the working environment. Then there is a description and part of the back muscles and their purpose. Which is associated with orthopedic aids, specifically AutoTherapia. This aid should influence effectivity and load of Trapezoid muscles. To evaluate a data is used a device called Biofeedback. Goal is to collect a data from different sensors of Biofeedback and evaluate if the orthopedic aid specifically AuthoTherapia influent mainly trapezoids muscles activity and other physiological activity.

3 Literary review

In the literary review will be discussed a type of a harvester simulator and theirs advantage, EMG measuring tools and the features, muscles of a trapezoids and they function and the possibility of improving the seat of the harvester operator by using an orthopedic aid.

3.1 Harvester simulators

Nowadays, when the emphasis is on time and economical utilization are these factors 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 programmer. "(RANATA, 2009). In studies (OVASKAINEN, 2005) is shown that enough 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 of harvester simulators in summary:

- Safety for operators
- no fuel costs
- zero production of CO^2
- no damages on Machinery and Nature
- possibility of multiple repetitions
- different model's situation
- testing and developing of new technology and approaches

3.2 Harvester simulators commonly used for training

For the training and practicing on simulators of harvesters or forwarders are used simulators from famous company whit long history. One of them is John Deere or Mevea. John Deere is a company focused on production of machinery, like harvesters, forwarders, tractors, trailer mechanical equipment in forestry and agriculture. While the Mevea is only focused on the production of simulators of various types like, cranes and harvesters.

3.2.1 Mevea harvester simulator

Mevea is leader on a market with a production of simulators and software used for simulators and simulation. They are developing they own software and hardware which gives them some market advantage in the form of cooperation with several company producing agriculture, building and forestry machinery. Those machines can be, tractors, construction cranes and harvesters. Also, they are developing software and hardware for virtual reality.

In a cooperation with Finnish specialist in forestry machine has developed unique simulator, used for a training of harvesters and forwarders operators. Their experience brings a new view on the problematics of simulators. Thanks to knowledge of a real environment, it helped to create the most accurate and realistic simulator. The simulators from Mevea company excellency lies in the simulation of dynamics, so it makes more realistic feelings, which no other company can do as accurately as Mevea. The behavior of environment is realistic as it gets, and the machine behavior has been polished to perfection utilizing the deep knowledge of the Kesla professionals. In the training programs of harvester simulators can a trainer change a condition and parameters like machine and condition of machine (can simulate different situations and states), weather, terrain, forest types, distribution and count of trees on a plot. All those parameters are set on skill of the operator and trainer can optimize settings for more effectivity. All those features can give the opportunity to make countless different exercises which develop and rise experience of operators. The harvester simulator can offer these features:

- Real and machine control system
- 3D visualization
- Dynamic engine
- Real machine behavior
- Adjustable pruning forces
- Simulation of hydraulic components (valves, pumps etc.)
- Various trees, forest environments and terrain

Mevea has many types of simulators, which can have different cab design, position and number of screens and different possibilities for mobility of all simulator. Possibilities of use is described on web pages of Mevea company (URL 1, 2018). Mevea simulators can obtain active moving parts to simulate a realistic movement of cabins etc. All those simulators can by sell with many kinds of software represents different machinery. All simulators and possibilities are describing on the brochure or web pages (URL 2, 2018) and in a work of Němeček: (NĚMEČEK, 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

Figure 1 CABIN SIMULATOR OF MEVEA (URL 3, 2019)

- **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

Figure 2 ACS 2DOF SIMULATOR OF MEVEA (URL 4, 2019)

3.2.2 John Deere Simulator

John Deere represent very famous company on a market of agriculture machinery. In his own interest, therefore, is the development of tools for practicing the operator to achieve the highest quality and with the aim of increasing the machine and operator effectivity. One of the factors is also the intention to minimize workplace hazards. For this purpose, the company has developed an exact copy of operator cockpit of John Deere E-Series forestry machine.

The John Deere E-Series simulator represent excellent tool for training the skill. This simulator can simulate two machines, namely: forwarder and harvester. John Deere E-Series simulator is equipped with E-Series harvester control system call TimberMatic H-09, FlexController control modules and TimberLinkTM. It is not just software but also hardware which is used in a real machine. Every E-Series simulator includes one pre-programmed training terrain. E-Series simulator has its own terrain tool call Terrain Editor where trainer can create their own terrains and stands, various types of trees, rocks, terrain types, driving tracks etc. The simulator obtain computer, this computer has variety of function and can produce a machine-specific and real-time feedback report on all exercises. Those exercise can be monitored and scored in Score Editor and compete for points. (URL 5, 2019)

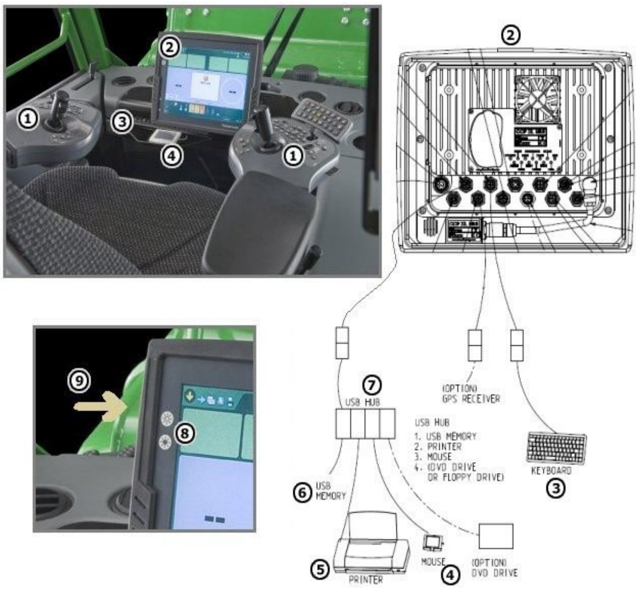


Figure 3 EQUIPMENT INSIDE THE CABIN OF SIMULATOR (URL 11, 2015)

In the picture 3 is described and show a control element. This cockpit of simulator is almost the same as in a real harvester.

1. Keypad on the armrest
2. Second HPC07 / FPC07, display and CPU
3. Keyboard
4. Touchpad
5. Color Printer
6. USB Flash Drive
7. USB Hub
8. Display Brightness (+ /)
9. Slot for removable hard disk

TimberMatic software has two operating modes: Setup mode and Operating mode which is SHOWN IN A PICTURE 4:

Figure 4 DISPLAY IN OPERATING MODE OF TIMBERMATIC (URL 7, 2019)

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.

The data from system TimberMatic can be used for more detail analysis. These data can inform the operator about production, labor, and the condition of machine. All data are recorded on local disk or can be saved in external storage via the USB drive. All those Data are 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 are written in user manual.

3.3 Muscles

If human body change a position and from a relax position want to make a move, he needs to use set of muscles, tendons and nerves. (ČIHÁK, 2016) Muscles are attached to the bones and to each muscle goes nerves. Process call truncation is when nerve give an impulse witch cause truncation of muscles. Muscles are compound of myofibrils contained in all types of muscle tissue. These myofibrils are composed by two proteins, actin and myosin. So those proteins are basic units of muscles and main goal for motion (NIGG, 2007). In human body can be distinguish three types of muscle tissue. As is describe in book (HANUŠOVÁ, 2014);

- **smooth muscle** or "involuntary muscle": found within the walls of organs and structures such as stomach, blood vessels, etc.
- **cardiac muscle**: also, an involuntary muscle can be found only in the heart
- **skeletal muscle**

For this observation are important skeletal muscles. Movement of skeletal muscle can be easily described as: bones are as levers and muscle are as driving force (JANURA, 2003). With these basic physical knowledges, we can imagine the work of skeletal muscles. Tapering muscles convert into tendons which are connecting muscles and through tendons are clamped to the bone and cartilage (DIMON, 2009). Muscles can be divided by their movement function. Those function are described in book human anatomy (AMILL, 2009).

- **Agonist:** movement performing a movement in a specific direction
- **Antagonist:** muscle performing contrary exercise as an agonist
- **Synergist:** muscle that participates in the same movement as an agonist

The agonist and antagonist form a pair of muscles or muscle groups that work together to ensure the accuracy of the movements.

- **Fixation muscles:** allow for hardening a part of body where motion is based. These muscles do not directly participate on the movement but keep the movement segment in the most favorable position for movement
- **Neutralizing muscles**: eliminates movements that move through the movement apparatuses of the main and auxiliary muscles

3.4.1 Trapezoids muscles

Trapezoid muscle (*musculus trapezius*) is included in the group of back muscles and his main function is fixation. It is a large and superficial muscle extending from the cervical to thoracic region on the posterior aspect of the neck and trunk. Above all, it controls the movement of the blade, which at the same time, when contracting all the muscular components, presses and fixes the chest wall. Simultaneous contraction of the ascending and descending part of the muscle, rotating the shoulder of the shoulder joint and allowing the limb to buckle. When the muscle action is bilateral, the chest is tight. If the ascending sheaf contract with the fixed limb, the muscle pulls the entire torso upward. Functional failure of trapezoidal muscles greatly influences the holding and position of the head and the whole upper half of the body (DYELSKÝ, 2009). Position and fixation of the muscle is shown on picture 5 below.

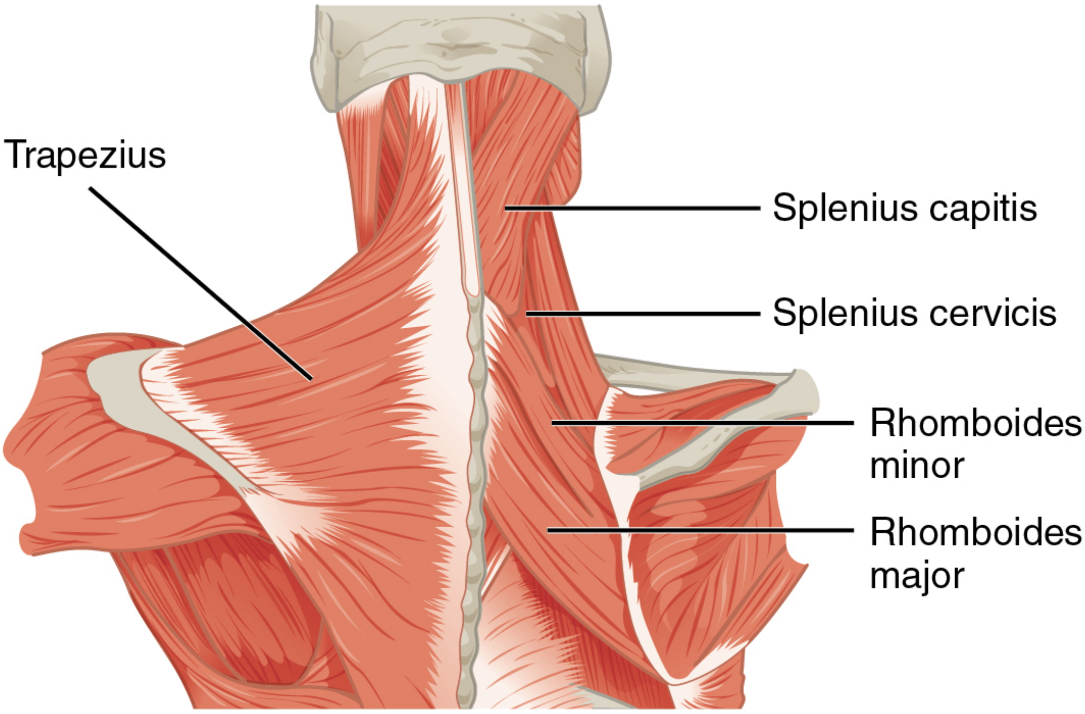


Figure 5 TRAPEZOID MUSCLE (M. TRAPEZIUS), (URL 7, 2019)

3.4 Operator seating ergonometric and workplace hygiene

Ergonomics deals with the issue of optimizing human activity according to Mrs Gilbert's work (GILBERTOVÁ, 2002). The seated working position is still considered as advantageous compared to the stand working position. It is characterized by lower energy expenditure, lower fatigue, lower load on the lower limbs, placing less demands on the circulatory system and especially on the heart. Unfortunately, it also has its drawbacks, because several health problems are associated with the long and wrong seating, such as coronary heart disease, obesity, diabetes, hemorrhoids, lower limb vascular disease such as varicose veins, and last but not least back pain and related diseases. Load on the musculoskeletal and spinal system, long-term sitting has several negative consequences, both in the case of posture, overloading of the muscular and ligament systems, affecting the pressure on the intervertebral discs, and the resulting various back problems. It is already proven that people whom work for more than half time their working hours for five years are far more prone to prolapse of the intervertebral disc, than people who diversify their working positions during the day (CHUNDELA, 2007).

Possibility of Right Sitting

In the picture 5 are describe basic types of seating position, especially about the activity: sitting in the front position, sitting in the middle position and sitting in the back position.

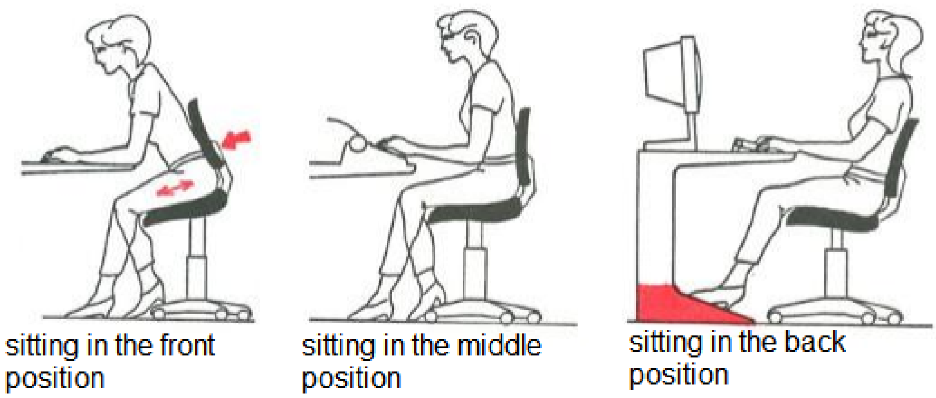


Figure 6 TYPES OF SEATING POSITION (GILBERTOVÁ, 2002)

Front seat

- In the front seat, the torso is tilted forward, the load of torso on the seat surface is transferred forward in front of the bones and on the back of the thighs

- Middle position
  - In a middle seating position, the torso is located on a square formed by the bones and the posterior surface of the thights This type of seating allows both upright posture and round seating. If a hold of back upright without proper support, it may increased static strain on the back muscles
- Back position
  - Back position in a proper support of the spine and pelvis is least tiring position. In the rear seat position, the torso is tilted backwards at an angle greater than 95 ° from the vertical. It is considered as a relaxing position with the lowest pressure on the lumbar spine discs. At this position, the back is best supported by the back of chair and thus allows the back muscles to relax, thereby reducing the compression of the abdominal organs. However, if the pelvis is incorrectly supported, the lumbar lordosis is flattened

Possibility of inappropriate sitting

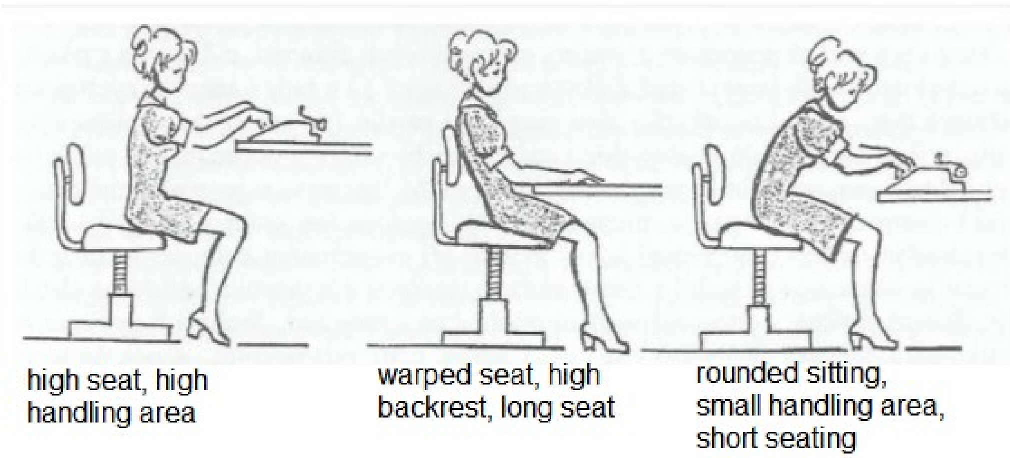


Figure 7 TYPES OF INAPPROPRIATE SITTING (GILBERTOVÁ, 2002)

Inappropriate sitting is primarily characterized by, relaxed, posture is further and typicaly show protruding and holding arms and overload muscular system, as well as restricted breathing and compressing the abdominal organs. Due to a lack of activity during prolonged session generally occurs weakening muscle groups and the ensuing reduction of physical fitness. Detail description of ergonomy is describe in book Ergonomie (GILBERTOVÁ, 2002).

The most common health problems associated with sitting:

- Osteoporosis
- Varicose veins
- Cervicobrachial syndrom
- Cervicocranial syndrome
- Headaches, migraines
- Weakening of the deep stabilization system
- Prolapse of intervertebral discs of the spine (especially in professional drivers)
- Shortening of the breast and weakening of the bladder muscle – hyperkyphosis

Proper working seat is a basic requirement for every good work place. Seating design should respect the anthropometric parameters of our population, as well as anatomical, physiological and biomechanical aspects of the musculoskeletal system. This was described a observed aslo in a work of Mr's Lusted, when they also used EMG to observed this problematic (LUSTED, 1994). The basic general requirements are stability and appropriate positioning of the driver settings to achieve maximum comfort and appropriate features. The importance of a well-designed seating area is that it reduces the static load, helps to hold the pelvis and spine correctly, ensures proper stability and allows for body position changes (GILBERTOVÁ, 2002).

Another problem which affects the hygiene of the working environment is a strees. Its very often discutable topic. Stress can be a driving factor that determines the quality of the working environment and the performance of the operator itself. We distinguish two types of stress: Eustres - a positive burden when an individual is driven by stress to achieve better work performance and can be considered as a stimulant and Distres - Excessive stress, where an individual does not manage the situation, which can lead to depression, reduced work performance, collapse, and even death (BEDRNOVÁ, 2002)

Another problem of hygiene and comfort of the operatar are a vibration and unexpected shoks. This problems cause movemnt of a cabine and shock cause by digign or movemnt of crane (TANELI, 2015). But the vibration are cause minly by the engine while is going (SMITH, 2015). Those microvibration should be minimalize by the anti-vibration components witch are mounted on engine holders or appropriate on chair of the operator. (REHN, 2009). Solutions for these problems can be better adjusted seats and used of better material for seats. One of the problem could be lack of operator awareness of the right posture and posture during work.

3.5 Orthopedic aid

Orthopedic aids are intended to compensate and facilitate the possibility of movement. Or even replace a part of the human body. Some compensation aids can be used to facilitate seating and ensure proper positioning and the optimum position of musculoskeletal. These include lumbar support, foot pads, seat wedges, slanted pad under the keyboard, document holder, movable forearm support, and the like. The seats Is the most importanat part of harvester cabine and is partly equipped with compensation aids in the form of armrests and their individualization options for each operator (LIN, 2011)

3.5.1 AUTOTHERAPIA backrest

Therapia backrest is made by a purely Czech company that develops and manufactures orthopedic chairs for the office and ergonomic chair accessories. (URL 9, 2018). Ergonomic backrest AutoTherapia is designed to attach to almost any type of car seat or other machine. The aim is to improve the seat ergonometry or replace the missing back support for old and unsatisfactory chairs. The Main purpose of the AutoTherapia pad is to optimize operator seat ergonomics. With two independent inflatable zones, ergonomic seating can be adjusted, and can reduce the cause of fatigue and promote good posture. The first horizontal part supports the lumbar portion of the back while the second vertical part supports the thoracic portion of the back. reducing the pressure on the musculoskeletal system, reducing the tension of the thoracic and upper back muscles. With the Air pump, can be independently inflate the chest vertical section and the horizontal lumbar section as needed. With the push-button, the air can be easily drained, and the seat returned to its original shape. An unquestionable advantage is precise optimization and simple handling (URL 10, 2019). The appearance and attachment options are shown in the figure 7.

Figure 8 AUTHOTHERAPIA AID (URL 10, 2019)

3.6 Biofeedback

Biofeedback is the name of a behavioral-medicine treatment method, which makes it possible to observe unconsciously occuring physiological functions, and to learn to willingly influence them so that physiological (muscular or vegetative) misregulations can be corrected. The term biofeedback originally comes from regulation technology or cybernetics. This conceives of organisms and machines as systems, in which the individual elements communicate with each other, and control and influence each other. The roots of modern biofeedback treatment lie in the animal experiments of N.E. Miller, DiCara and their colleagues. They could show that physiological functions can be changed, not only by classical conditioning, in the way of Pavlov, but also by operational conditioning, namely a systematic manipulation of contingencies. In this early phase of biofeedback research this served to indicate that especially those physiological functions controlled by the autonomous nervous system can be directly and immediately conditioned over motor processes. For example, the skeletal musculature of rats was paralyzed by the nerve poison Curare through blockage of the stimulation ducts around the periphery. It was thus possible to refute the objection that the rats did not experience vegetative alterations directly by the conditioning of a somatic reaction, but merely indirectly. Biofeedback has several data collection options and is broken down by type

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

EMG Biofeedback

EMG biofeedback is devices that measure electromagnetic pulses. It is equipped by electrodes which detect small voltage changes. Those impulses arise from the muscles during they activity. Sensors of electrodes are made by Silver or SilverChloride construction. This is very efficient at detecting small biological electrical signals from the body surface cause by move. (WANG, 2016) For better data transfer of electrical signal can be used special electrode gel. This gel should help in converting the biological (ionic) signals to the electrical signals

(URL 11, 2018). The result of collected data is to produce a time variety of electrical sygnals. Those data can be displayed by series of lights on LED display or through a computer and display as a data set or graph.

3.6.1 Biofeedback 2000 x-pert

This equipment is detailly describe in user manual Biofeedback 2000 x-pert. This is a devices compound by four different measuring devices with many possibilities of sensors. Included with this device is a software and additional manuals and programs for special therapy applications. The data measured by sensors are transform to data collectors and they are transmitted by Bluetooth technology to the computer. Deices is shown in a picture 8.

Figure 9 BIOFEEDBACK DEVICE (URL 12, 2016)

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

4 Practical part

The main goal was to measure physiological parameters by used Biofeedback 2000 x-pert. Measured parameters are described in table 1. Measurements were made on 14 respondents. For that study was used the simulator John Deere Department which has faculty of Forestry of the Czech University of Live Science. Thanks to use the school simulator we could simulate ergonometric condition in harvester John Deere machine. Subsequently, the data were evaluated and compared with each other. Comparing was focus between the practicing on a simulator with the backrest Athoterapy and without that and it was also necessary to compare with the relax position on a regular chair.

Table 1 Measured parameters and description (Author, 2019)

Module	Impute	Brief description
EMG	EMG1	Electromyography, recorded from surface electrodes
	EMG2	as for EMG1
MULTI	TEMP	Skin temperature
	PVA	Blood volume amplitude
	BVP	Blood volume puls
	PULS	Changes in blood flow just below the skin surface
	MOT	Motility (increase of rate of movement)
RESP	RESPA1	Abdominal respiration- change in abdominal circumference
	RESP1	Thoracic respiration- change in chest circumference
	RespirationF1	Respiration frequency

4.1 Measurement methodology

- Preparation
  - Selection of respondents and short questionnaire
- Practical part
  - Description of the simulator control elements to respondents
  - Attaching sensors and measuring tools
  - Paired with a PC and setting measurement instruments
  - Measurement activity with after without orthopedic backrest and relax measurement
- Evaluation of collected data

4.1.1 Selection of respondents

Selection of respondents was not based on a special requirement. The basic requirements were if the respondent is familiar with the computer technology and to be able to control the harvester simulator. For this research 14 respondents were addressed, mostly university students. Age range is between 20 and 32 years old. These respondents were advised not to do any more physical exercise at least two days before the measurement to optimize the conditions for all respondents and for data accuracy. In a table 2 are described all respondents and their basic information, how often they do sports and how much time they spend by sitting.

Table 2 List of respondents and basic information (Author, 2019)

Name	Age	Sex	Activity before measurment	Sport Frequency per week	time seating (hours)	Left/right hand
Tomáš B.	21	M	No sport activity	3	1	R
Jakub K.	20	M	No sport activity	1	2	R
Věra K.	28	W	No sport activity	6	6	R
Josef P.	21	M	No sport activity	1	4	R
Vašek Š.	21	M	No sport activity	1	4	R
Martin M,	20	M	No sport activity	1	4	R
Jan M.	22	M	No sport activity	2	4	R
Jan K.	21	M	No sport activity	2	2	L
Jaroslav H.	21	M	No sport activity	1	2	R
Marco A.	26	M	No sport activity	2	4	R
Michal A.	26	M	No sport activity	1	7	R
Tomáš A.	32	M	No sport activity	3	7	R
Lucka W.	28	W	No sport activity	5	6	R
David G.	26	M	No sport activity	3	4	R

4.1.2 Description of the simulator control elements to respondents

To get the date and be sure that the data are accurate was necessary to set the same condition for all respondents. In the first step was necessary to explain how the harvester technology work and how to control and used all main control elements of the harvester simulator properly. Explanation was done for all respondents same and separately to each other. Explanation time take around 5 minutes. During this time was explain basic control elements: right and left joystick and the elements on its: (moving of crane, opening and closing of harvester head, cutting, moving of logs) and control elements like button for choosing of assortments, gear shift, gas pedal. After that they have an opportunity to try a simulator and get familiar. Respondents could ask if they were not clear with the simulator. For this work was not necessary to explain all possibilities of simulator and all control elements. It was use sufficient quantity of control elements for maintaining the most frequently used operation with the simulator.

4.1.3 Attaching of measuring tools

After the explanation to the respondents was necessary to attach tree modules for measuring. of control elements of harvester simulator, the respondents were asked to be only a T-shirt order to attach measuring instruments. This is necessary to divided in to tree steps according to the tree modules:

EMG: this green module and their sensors had been attached on a skin on trapezoid's muscles. As is shown in picture 9. In this measurement was used a bipolar method of measurement. It means that was used two groups of sensors in one measurement EMG1 and EMG2. EMG1 represent dark green sensors on left trapezoids muscles and EMG2 represent light green sensor on right trapezoids muscles. Black sensor is used as a ground. For attaching was necessary to keep the same procedure for each respondent and always try to place the sensors at the same locations, preferably to the end of trapezoids muscle nodes as is shown on picture 9. All sensors are connected according to the user manual and a module is fixed on the respondent clothes. Each electrode is equipped with an adhesive part and special gel for better signal transmission, (after each measuring was necessary to change the adhesive sensor for compliance with the principles of hygiene).

1. Connect the EMG module with electrodes: dark green connector with dark green plug and light green connector with light green plug and black electrode with black plug
2. Place the adhesive sensor to trapezoids muscles: the position is very important for experiment was necessary to replay on all respondents as its shown in picture 9
3. Between these four sensors place fifth one
4. After placed the sensor connect the electrodes to the adhesive sensor
    - EMG1 dark green on the left trapezoids muscle
    - EMG 2 light green to the right trapezoids muscle
5. Fix EMG module on clothes

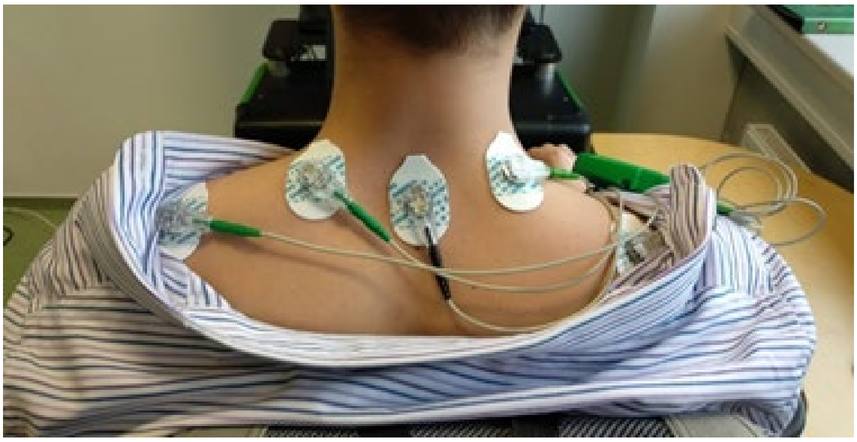


Figure 10 ATTACHED MEASURING SENSORS EMG ON TRAPEZOIDS MUSCLES (SOURCE: AUTHOR)

MULTI: this yellow module and their sensors had been attached on a skin on a head. Sensors are attached to the head using a headband and the sensors are located on both temporals' bones. Position of module is shown in picture 10.

1. Connect the MULTI module with electrodes: red connector to red plug and purple connector to purple plug
2. Sensors connect to the special headband with Velcro
3. Put the headband on head of respondent and place sensors on temporals bones (there must not be hair between the skin and the sensor)

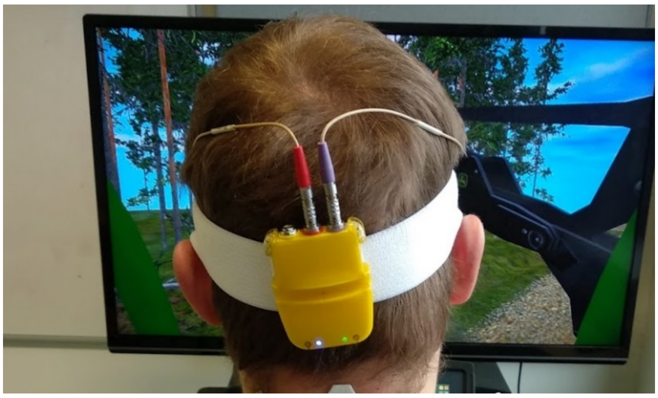


Figure 11 ATTACHED MEASURING SENSORS MULTI ON HEAD AND TEMPORAL BONES (SOURCE: AUTHOR)

RESP: respiration module is consisting of two parts, measuring module and a tube that measures the expansion and frequency of breaths. This module is placed around the chest circumference when the blue sensor module is placed on the lower part of the sternum and the tube runs around the entire chest in the bar just below the breast. Connection a position is shown in picture 11.

1. Connect the pipe ends to the module
2. Place a module around a chest of respondent and starch a tube tightly tighten the module to hold it tight

Figure 12 ATTACHED MEASURING SENSORS RESP ON CHEST (SOURCE: AUTHOR)

4.1.4 Paired with a PC and setting measurement instruments

After wiring and placement sensors on the respondents is needed to pair the modules via Bluetooth with the PC. For this propose is used special Bluetooth adapter. This adapter is connected all the time without dependence of different respondents. Pairing and sating is described below. Only EMG module is setting other modules are automatically set on default values.

1. Plugged the Bluetooth adapter into a USB port of the PC
2. Run the program Biofeedback 2000x-pert
3. After the software run, sensors are automatically connected with all modules
4. After these steps, followed setting of program Biofeedback 2000x-pert.
5. In program control chose setting →basic setting →Recorder-Setup →EMG sensitivity on 0 - 500 μV as in picture 12.

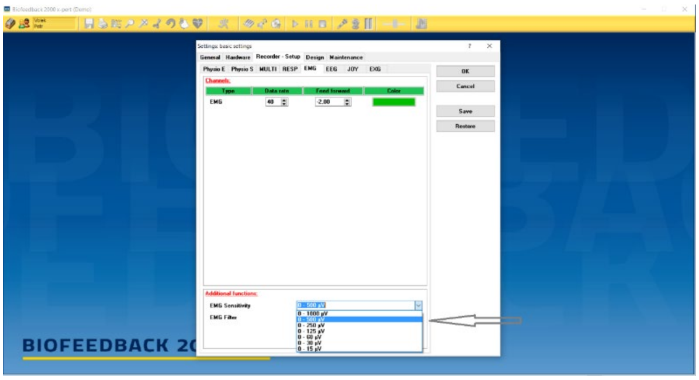


Figure 13 BIOFEEDBACK SETTING SENSITIVITY IN PROGRAM (SOURCE: AUTHOR)

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 13

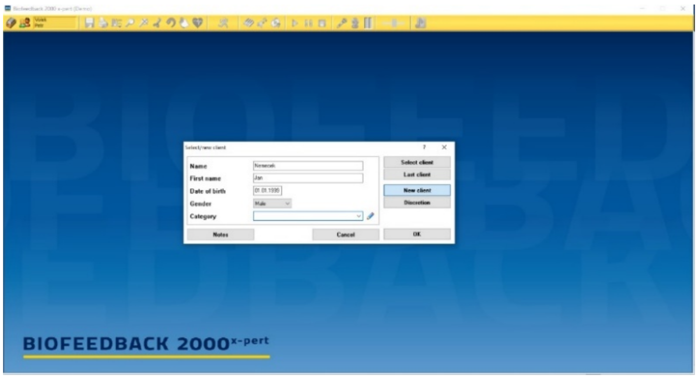


Figure 14 FILLING INFORMATION IN TOO PROGRAM (SOURCE: AUTHOR)

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

4.1.5 Activiti measurement

Measurement was divided in to tree stages. Where the first two stages ware measured during activity of operator and third one in a relax. The first stage was measuring parameters during practicing on simulator with used of orthopedic aid, backrest Authoterapia. Second stage was measuring parameter during practicing on simulator but without orthopedic aid, backrest Authoterapia. And third stage was measuring in a standstill on a regular chair. From the reason to see if there are differences between work and relax time. **Activiti with used of backrest Authoterapia:** Respondents were asked to sit in to the simulator and set up their chairs to suit them best and then set up Authoterapia beck rest using two pumps as is described in chapter Authoterapia. The aim was to keep the respondent sitting upright with a gentle curl of the back turned off the rib cage and without forwarding the cervical spine and an upright head. This correct seating position is shown in picture 14.

Figure 15 RESPONDENT SITTING WITH AUTHOTERAPIA BACKREST (SOURCE: AUTHOR)

Activiti without used of backrest Authoterapia: in the second stage of measurement respondents should stay seated and only deflate both bellows on a minimum backrest Authoterapia. In that step all respondents confirmed a significant change in sitting position and higher discomfort of seating. All that information was necessary to recorded in the questionnaire, all records are mentioned in table 3. The process of measuring was the same as in the case of measurement activity with used of backrest Authoterapia. Seating position of respondents had dramatically change. Loins was round and fell backward, holding the shoulders and trapezoidal muscle position changed. The cervical spine was leaned forward, and the shoulder plait moved forward. Change of seating position is visible in the picture 15.

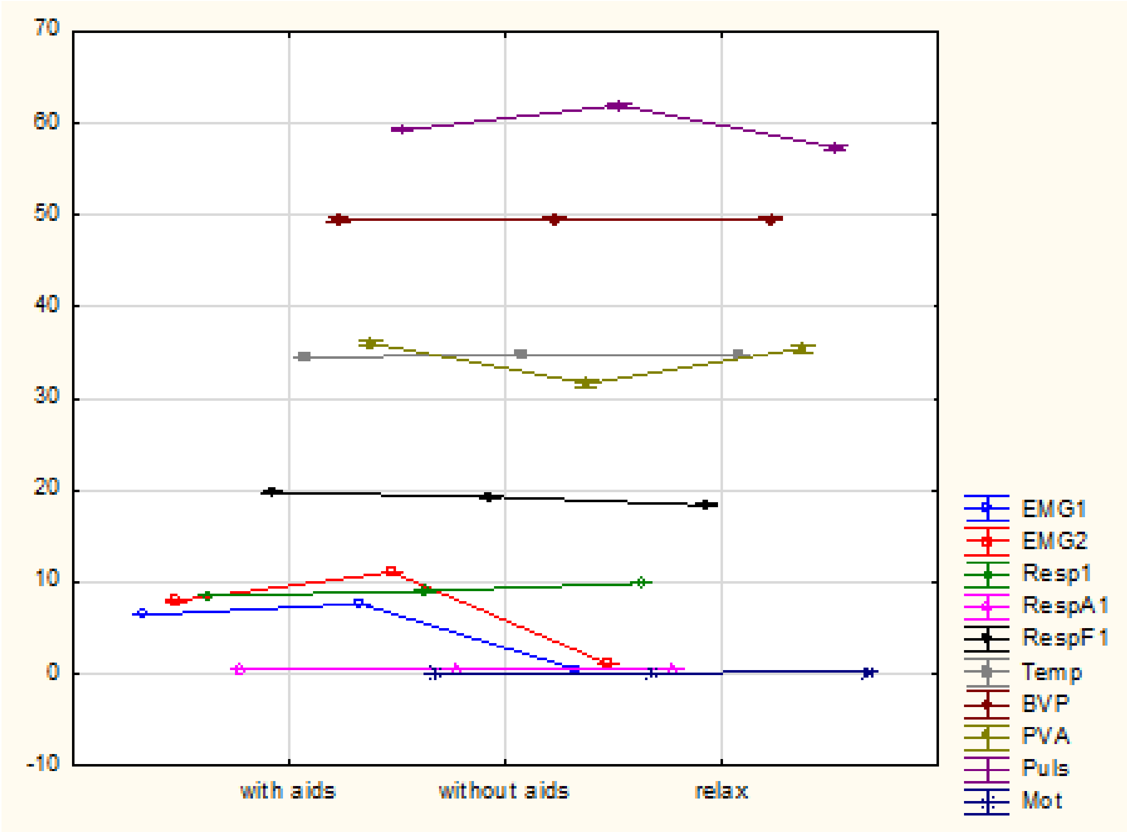
Figure 16 RESPONDENT SITTING WITHOUT AUTHOTERAPIA BACKREST (SOURCE: AUTHOR)

Measurement in relax position on chair: This measurement was necessary to do because was needed to compare if there is some difference between activity on a simulator and in a standstill. This measurement takes around 5 minutes. This step was done at the end of the measuring session on a regular chair. Respondents were asked to stay in relax without unnecessary movements.

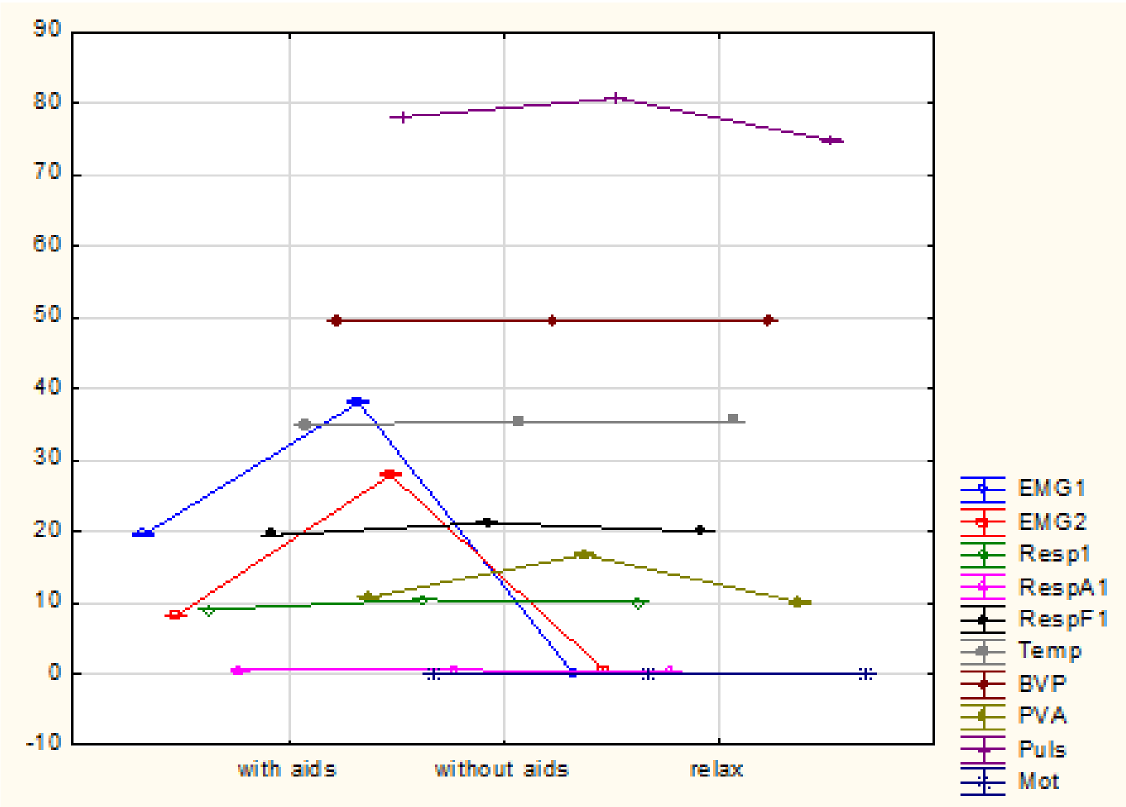
4.1.6 Evaluation of the collected data

All data has been exported to the excel, separately each measurement and divided by the respondents to a folder. Export was done by function export data in software Biofeedback 2000 x-pert: Database →Open diagram/ database →choose the data of respondents →press export →export to excel file for more detail evaluation of the collected data.

All exported data for each respondent was necessary to get in to one excels file. To evaluate the data, was used the Statistica program. In program Statistica was chosen data normality test. According to the test the data were in normal distribution, so was not choose a non-parametric test, but parametric test. From that reason was chosen one factor analysis call Anova. And for more detailed testing was chosen Scheffe's test. This test show that there were statistically significant differences between the individual measured values. So, whether the measurement was done with the orthopedic backrest Authoterapia, without the orthopedic backrest Authoterapia or during relaxing on the chairs and whether values were affected under these conditions. This test showed that the only value that was not affected was BVP. The difference between the individual measured parameters is graphically represented by the Scheffe’s test in graphs 3 and 4. Graph 3 represent measured data from respondent Marco. In that case are noticeable changes between individual parameters due to the influence of orthopedic backrest Authoterapia. Graph 4 represent measured data from respondent Tomas A. In that case are significant difference between individual parameter.



Graph 1 Respondent MARCO Graphical difference Scheffe's test (Author, 2019)



Graph 2 Respondent TOMAS A. Graphical difference Scheffe's test (Author, 2019)

More detailed data represent table 3 below. In the Table 3 is described all parameters in average value during measurement. Almost all data showed a statistical difference between individual measurement positions with, without orthopedic backrest Authoterapia and relax on regular chair. In some cases, has been shown that there is no statistically significant difference between data representing measured position, these values are marked by yellow color in the Table 3. In this case it is evident that there was no statistically demonstrated difference for BVP parameter between individual measurements for all respondents. In the table 3 is mentioned coefficient 1 and 0. Coefficient 1 represent positive difference between= (Type of siting) with aids – (type of siting) without aids. It means that orthopedic backrest Authoterapia has a positive influence on measured parameter. On the other side, Coefficient 0 represent negative difference between = (Type of siting) with aids – (type of siting) without aids. It means that orthopedic backrest Authoterapia has a negative influence on measured parameter.

Thanks to the coefficient, it is possible to determine the number and effect of the orthopedic backrest Authoterapia. It should be noted that the effect of the orthopedic backrest Authoterapia was reflected in all respondents, at least for two measured parameters. Below is a downward described effect of orthopedic backrest Authoterapia on respondents independently on measured parameters. All those results come from the Table 3. Eleven respondents showed the most frequent influence in parameter Resp1 (Abdominal respiration). Abdominal respiration is more typical for men than for women, which also confirms the results when the difference was not demonstrated in either woman. Also, eleven respondents showed the most frequent influence in parameter Temperature. This parameter is not so interesting from point of physical and medicinal view, because of the very slight increase and it may be due to different ambient temperatures during measurement. In the case of the nine respondents were shown the difference on measured parameter EMG2. This sensor measured right trapezoids muscles. The reason may be the fact that everyone with a positive difference is right-handed. The same number where the influence has been shown is the Pulse and MOT parameters in the number eight. Seven respondents were influence in a case of EMG1 (left Trapezius muscle) and Respiration1. And lowest positive influence was on RESPF1 and PVA.

Influence of Trapezius muscles: it is clear from the overview that the orthopedic backrest Authoterapia had influence in a total on ten respondents and in seven cases on the left trapezoid muscle and in nine cases on right trapezoid muscle. For six cases was affected function of both trapezius muscle, (left and right). Level of influence of positive difference was quite bigger. Difference was measured in order of units. As far as the level of influence is concerned, the differences were in the order of units and in some isolated cases the difference was greater. It is also evident that the effect was also negative, when there was an increase in muscle activity using the orthopedic backrest Authoterapia. In total, the negative effect of the orthopedic backrest Authoterapia on both muscles was observed in a total of four respondents. If we compare the positive and negative effects of both trapezoidal muscles, which were also affected by one respondent, it is clear that the positive difference is much higher than the negative. This can be attributed to poor settings orthopedic backrest Authoterapia during a measurement.

At the end of the evaluation, it should be noted that the effect of the orthopedic backrest Authoterapia was proven in all respondents, at least in two measured parameters. The average number of parameters affected due to the orthopedic backrest Authoterapia was calculated on five parameters. In total seventy-five measured parameters were affected in case of all respondents. Therefore, it can be clearly demonstrated from the statistical point of view that the orthopedic backrest Authoterapia had an effect on the individual parameters and therefore there is a high probability that it may affect the operator's work.

Table 3 the data evaluated, and the influence determined by the coefficient (Author, 2019)

Responde	Type of Sitting	EMG1	EMG2	RespA1	Resp1	RespF1	TEMP	BVP	PVA	Puls	MOT	Sum
Tomáš B.	with aids	8,94	6,34	8,91	0,55	18,37	35,61	49,57	38,85	80,19	0,17	
	without aids	13,47	2,57	9,62	0,45	17,70	35,31	49,57	21,99	73,90	0,16	
	relax	1,53	0,15	8,53	0,48	21,08	35,68	49,59	23,62	75,76	0,07	
change coe.		1	0	1	0	0	0	0	0	0	0	2
Josef P.	with aids	5,85	4,29	9,65	0,43	21,67	35,41	49,53	32,22	77,59	0,07	
	without aids	5,80	4,85	9,83	0,41	22,63	35,62	49,54	29,05	76,45	0,07	
	relax	1,04	5,00	9,46	0,42	16,22	35,65	49,56	26,21	78,53	0,03	
change coe.		0	1	1	0	1	1	0	0	0	0	5
David G.	with aids	13,56	16,36	8,16	0,73	19,85	35,23	49,53	24,20	96,64	0,08	
	without aids	9,00	15,07	9,89	0,70	21,28	35,63	49,56	26,27	98,05	0,09	
	relax	0,99	1,44	10,06	0,55	16,42	35,48	49,57	34,98	86,10	0,03	
change coe.		0	0	1	0	1	1	0	1	1	1	7
Jaroslav H.	with aids	22,14	27,42	9,78	0,37	22,51	35,60	48,22	94,22	80,53	0,15	
	without aids	18,35	27,31	9,92	0,40	22,99	35,69	49,55	30,79	81,72	0,18	
	relax	4,31	5,00	10,12	0,50	22,69	35,65	49,58	31,83	76,86	0,09	
change coe.		0	0	1	1	1	1	0	0	1	1	7
Jakub K.	with aids	3,63	0,82	10,02	0,39	23,47	35,49	49,52	39,14	83,95	0,06	
	without aids	14,62	8,83	9,60	0,38	24,79	35,33	49,56	38,33	84,09	0,08	
	relax	0,46	0,51	9,40	0,38	24,37	35,52	49,57	38,02	82,67	0,07	
change coe.		1	1	0	0	1	0	0	0	1	1	5
Věra K.	with aids	2,60	0,80	9,82	0,62	24,29	36,02	49,55	31,65	72,06	0,10	
	without aids	9,43	4,38	9,67	0,66	23,49	35,82	49,56	34,68	69,92	0,11	
	relax	0,83	1,10	9,83	0,56	23,68	36,03	49,55	32,52	65,06	0,15	
change coe.		1	1	0	1	0	0	0	1	0	1	5
Lucka W.	with aids	9,63	2,07	8,32	0,49	31,45	35,61	49,54	42,60	98,25	0,07	
	without aids	8,48	3,01	10,53	0,48	27,54	35,71	49,57	14,79	93,46	0,06	
	relax	0,24	0,36	7,85	0,71	19,79	35,68	49,57	16,77	85,32	0,11	
change coe.		0	1	1	0	0	1	0	0	0	0	3
Tomáš M.	with aids	1,44	4,65	9,44	0,40	30,24	34,90	49,55	31,72	95,96	0,13	
	without aids	0,74	1,80	9,92	0,34	29,26	35,23	49,55	29,56	98,45	0,09	
	relax	0,13	1,84	9,75	0,33	25,26	35,40	49,57	31,47	93,42	0,16	
change coe.		0	0	1	0	0	1	0	0	1	0	3
Marco A.	with aids	6,38	7,98	8,50	0,43	19,72	34,50	49,46	36,04	59,25	0,10	
	without aids	7,61	11,06	9,02	0,44	19,32	34,74	49,61	31,65	61,94	0,12	
	relax	0,50	1,07	9,86	0,42	18,36	34,75	49,60	35,47	57,34	0,19	
change coe.		1	1	1	1	0	1	0	0	1	1	7
Jan M	with aids	8,55	3,30	9,42	0,81	23,68	35,78	49,54	25,92	74,56	0,16	
	without aids	11,42	5,84	9,99	0,86	24,16	35,96	49,54	36,86	77,44	0,15	
	relax	0,77	2,25	9,99	0,64	25,02	35,89	49,56	40,95	72,90	0,10	
change coe.		1	1	1	1	1	1	0	1	1	0	8
Michal A.	with aids	2,59	2,22	9,78	0,41	22,03	35,46	49,55	16,99	92,62	0,07	
	without aids	3,44	3,26	9,59	0,45	20,55	35,64	49,55	39,19	90,99	0,10	
	relax	0,16	0,02	9,71	0,39	21,30	35,68	49,56	40,74	85,64	0,02	
change coe.		1	1	0	1	0	1	0	1	0	1	6
Vašek Š.	with aids	7,54	10,80	9,80	0,43	24,13	35,50	49,53	29,84	67,25	0,12	
	without aids	6,14	8,89	10,51	0,56	22,89	35,59	49,53	27,38	70,09	0,16	
	relax	4,04	4,78	10,03	0,45	26,01	35,60	49,30	65,65	67,99	0,23	
change coe.		0	0	1	1	0	1	0	0	1	1	5
Tomáš A.	with aids	19,50	8,12	9,07	0,52	19,47	35,01	49,58	10,76	78,16	0,12	
	without aids	38,12	27,92	10,40	0,55	21,19	35,37	49,57	16,71	80,78	0,17	
	relax	0,03	0,34	10,10	0,38	20,00	35,41	49,58	10,07	74,87	0,03	
change coe.		1	1	1	1	1	1	0	1	1	1	9
Jan K.	with aids	27,28	40,42	9,66	0,31	21,87	36,08	49,55	29,83	83,92	0,13	
	without aids	27,21	47,35	10,06	0,27	19,81	36,11	49,57	27,66	81,88	0,10	
	relax	3,27	3,03	8,99	0,35	19,80	35,98	49,56	15,71	79,09	0,13	
change coe.		0	1	1	0	0	1	0	0	0	0	3
change coe.	sum	7	9	11	7	6	11	0	5	8	8	75
		average number of parameters affected per respondent										5,4

Table 4 subjective evaluation of influence of orthopaedical backrest Authotherapia (Author, 2019)

Sloupec1	Fatique	Fatique2	Comfort	Comfort2	Beneffit
	With	without	With	without	conclusion
Tomáš B.	2	2	2	2	3
Jakub K.	2	3	1	3	1
Věra K.	2	2	2	3	2
Josef P.	2	2	1	3	1
Vašek Š.	2	2	1	4	2
Martin M,	1	1	2	2	1
Jan M.	1	2	1	3	1
Jan K.	2	2	1	4	2
Jaroslav H.	2	2	1	3	1
Marco A.	2	2	1	4	1
Michal A.	1	2	2	3	1
Tomáš A.	2	2	1	3	1
Lucka W.	2	3	2	4	1
David G.	2	2	1	2	2

In the table 4 is described a subjective evaluation of respondents. Most respondents agree that the chair is not comfortable enough. Thus, when using a backrest, respondents have a subjective improvement in sitting sensation, and it was therefore much more comfortable for them to sit in a simulator with the orthopedic backrest Authoterapia.

5 Discussion

Based on the measurement of all parameters and subjected to statistical tests to demonstrate the difference between positions and with using the orthopedic backrest Authoterapia. It has been unequivocally demonstrated that the orthopedic backrest Authoterapia affects the operator while working on the simulator. This has been shown to have a positive effect on the measured parameters, always to at least two parameters during one measurement and also negative coefficient of influence. Therefore, we can say with certainty that the influence of the orthopedic backrest Authoterapia on the operator's work is more than provable.

If the operator sits down in a machine with a non-straight sitting and so-called loose seat, his skeletal apparatus is improperly loaded, and the force acts differently than they should. Whereas the operator of the harvester is sitting in the machine for several hours the consequences may be noticeable. This is also confirmed by studies of Mr's Wasin (WASIN, 2003) and it is confirmed also by study Mr's Mansfield focusing also on a problem of vibration (MANSIELD, 2006).

After consultation with Mgr. Bártlová we agreed that the backrest has a positive effect on trapezial muscles. Especially if the backrest is properly inflated, the back is straightened and the back of the lumbar part is slightly deflected, thereby relieving the breast muscles and reducing the trapezoidal muscles. This was also confirmed in the study of Mr's Bendix (BENDIX,1985). Another indisputable advantage is the reduction of the load on the trapezoid muscles and thus prevent fatigue, inattention by the pain of the cervical spine. It may also result in a reduction in stress and thus in the improvement of the operator's personal comfort, which in turn leads to higher production and more attention. Thanks to the optimum position, operator is able to breathe better and thus also oxygenate the brain and retain attention. This has the consequence that the harvester operator is more attentive therefore, it is able to increase production and prevent possible losses or reduce the risk of injury of himself or another person. Based on the responses of respondents can be expected that the influence of the backrest should be demonstrable and beneficial even in the field.

6 Conclusion

This thesis fulfilled all the parameters that were in the assignment. As a result, it has been found that the orthopedic backers Authoterapia had an influence on the measured parameters of the individual operators and thus in some cases has a positive effect on the work. In conclusion, it should be noted that the options for setting and optimizing the harvester seat are good especially in the area of ergonomics of the upper limbs. Otherwise, when there is insufficient optimization of the seat is in the lumbar area. Another cause may be the lack of awareness and education about the right position of seating and posture. The solution may be a better seat that will have better support in the lumbar part of the spine, and greater optimization setting option. And raising awareness of the right sitting and hygiene of the working environment, this information should be a part of training of Occupational safety and health. Every harvester operator has to go through this course and that's a great opportunity

In my opinion is that the orthopedic backers Authoterapia is perfect supplement with low purchase costs and high appreciation in operator performance and comfort.

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