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Ergonomic evaluation in a development workshop

A case study at Volvo Group

Master's thesis in Product Development and Quality and Management Operations

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Abstract

Social status, health status, economic relations, development and self-fulfillment are often directly linked to the individual's work and work situation. Good working conditions is the basis for a productive and healthy work life and avoiding heavy loads, or harmful postures and movements is of great importance. Today, work containing repetitive movements and postures are usually very well monitored and is reduced as much as possible since the risks are known. However, smaller loads can also affect the body and put it at risk (Hägg et al., 2015) and due to this the project group found it important and relevant to study cases where tasks not necessarily are repeated frequently, but where harmful postures and movements exist and may impose a risk for injuries.

The purpose of this master thesis was to investigate and improve the ergonomics in a development workshop at Volvo Group, focusing on heavy lifting, hand vibrations and, noise and light. This was done by identifying the present ergonomic state in the development workshop by using ergonomic evaluation methods and then evaluating the method's applicability in this context. The study has had a more deductive approach (Bryman and Bell, 2015) since the project group used known ergonomic theories and methods and deduced research questions that needed to be verified through empirical data. However, the study also had an inductive approach since the project group presented theory as an outcome of the research.

From the results the project group saw that many tasks in the development workshop involved postures that needed further investigation and change according to the evaluation methods. This points towards the direction that many of the postures today can be harmful or cause injuries in the long run. Vibrations is a problem that already has resulted in injuries, e.g. white fingers and numbness and is something that should be followed up. The study also showed that the evaluation methods did not always suit the context of a development workshop since the methods many times seem to be adapted to contexts like productions line where repetitive work is performed. The project group learned that measuring handheld vibrations is hard and the evaluation methods contained little on vibrations.

The thesis concludes that further improvements in the GB workshop is needed and that the evaluation methods should be adapted to better fit contexts without repetitive work and that ways to measure or estimate the vibration exposure should be further developed.

Keywords: Development workshop, Production line, Postures, Ergonomic evaluation methods, Handheld vibrations.

English - Swedish

Air spring	Luftfjäder
Anti-roll bar	Krängare
Bending machine	Bockmaskin
Certified Europe ergonomist	Certifierad Europa ergonom utfärdat av Nordiska Ergonomisällskapet, NES, på uppdrag av CREE (Centre for Registration of European Ergonomists).
Impact wrench	Mutterknackare. Mekaniskt slående kraft.
Pneumatic nutrunner	Segdragare. En mutterdragare som använder mothållande moment istället för mekaniskt slående kraft.
Plate cutting machine	Plåtsax
Swedish Work Environment Authority	Arbetsmiljöverket
Torque wrench	Momentnyckel. De kritiska bultarna dras åt för att säkerställer rätt/tillräckligt moment. Den har ett långt skaft vilket gör att mindre kraft måste appliceras.
Visual ergonomics	Ljusergonomi
Water cutter	Vattenskärare

Abbreviation/Nomenclature

CTD	Cumulative Trauma Disorders
CTS	Carpal Tunnel Syndrome
GTO	Group Trucks Operations
GTT	Group Trucks Technology
HARM	Hand Arm Risk-assessment Method
HAWS	Hand-Arm Vibration Syndrome
IEA	International Ergonomics Association
KIM	Key Item Method
MSD	Musculoskeletal diseases
OSHA	Occupational Safety and Health Administration (The United States Department of Labor)
REBA	Rapid Entire Body Assessment
RULA	Rapid Upper Limb Assessment
VPS	Volvo Production System
WRMD	Work Related Musculoskeletal Disorders

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1 Introduction

Work is a central part of our society. Social status, health status, economical relations, development and self-fulfilment are often directly linked to the individual's work and work situation. Good working conditions are the basis for a productive and healthy work life. Many factors affect the work environment but techniques and technical configurations often have the largest impact on the work environment. By creating material products, the designer already decides what type of work environment is possible to achieve. Thereafter, the configuration of the manufacturing process, the way the work is organised and how the workplace is configured, determines how the work environment will be like (Bohgard et al., 2015). In 2006 the International Ergonomics Association (IEA) formulated the following:

“Ergonomics (or Human Factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory principles, data and methods to design in order to optimise human well-being and overall system performance”.

Ergonomics can be evaluated from three perspectives: organisational ergonomics, cognitive ergonomics or physical ergonomics (International Ergonomics Association, 2017).

If repeated frequently a load that is harmful to the body can impose injuries and create similar injuries caused by sudden and powerful load strikes (Linton, 1990). Hägg, Ericson and Odenrick (2015) describe how smaller loads can affect the body and put it at risk. Since the way of performance also affects it is important to not look only at work where tasks are repeated frequently but also work including tasks that are not performed in an ergonomic way. This may be because of the lack of knowledge and education since it is commonly known that by repeating the same movements during a longer period of time is harmful. Due to this the project group find it important and relevant to study cases where tasks not necessarily are repeated frequently, but where harmful postures and movements may exist and may impose a risk for injuries.

1.1 Background Volvo Group

This thesis has been performed at Volvo Group since they have a wide range of departments ranging from production lines to development workshops. One of Volvo Group's divisions is Group Trucks Operations (GTO) that encompasses all the production, e.g. production lines. Another division is Group Trucks Technology (GTT) that is responsible for all the product development activities, e.g. development workshops. A production line typically contains work that is repetitive and a development workshop typically contains more varied work tasks. GTO wants to provide a stimulating and healthy work environment for their employees and has manuals and standards for working with ergonomics in the daily work (Ergonomiska riktlinjer Volvo Group, 2015; see Appendix I). These are developed for Volvo Group's production lines and are more suited for evaluating workstations, logistics and packaging. However, there is no equivalent declared statement or manuals for GTT and the development workshops. The focus of the thesis will be on the ergonomics in one development workshop at GTT, called GB workshop, where the work is not necessarily repeated frequently but where harmful postures and movements may exist.

The ergonomic aspect is also an important aspect within Volvo Production System (VPS), a “Lean” thinking within the whole Volvo Group, since it ensures the safety and health for the employees and contributes to higher efficiency and productivity.

1.2 Purpose

The purpose of this master thesis was to investigate the ergonomics in the GB workshop and the focus included two ergonomic areas: heavy lifting and hand vibrations. The aim was to lay a foundation for ergonomic improvements in the workshop.

1.2.1 Research Questions

Volvo Group wanted to improve the ergonomics in their development workshops and a good starting point is to identify the present state. This leads to the first research question.

1. What is the present state from an ergonomic perspective using existing evaluation methods?

The project group found it of interest to evaluate the method's applicability in the development workshop since much focus usually is directed on environments with more repetitive work. This leads to the second research question.

2. How well do the evaluation methods suit a development workshop?

In order to answer research question two the project group needed to understand the differences of how Volvo Group works with ergonomics in a production line compared to a development workshop. The project group thought it was important to not assume that problems and risks only exist in production lines but also can be found in a development workshop.

1.2.2 Delimitations

The thesis will only cover physical ergonomics and not discuss from an organizational ergonomic or cognitive ergonomic point of view (International Ergonomics Association, 2017).

Since there are many methods for evaluating work from an ergonomic point of view the project group will due to the time frame only be able to use some and present these in the report. These methods will be chosen based on knowledge gained from recommendations and literature studies and therefore limit our scope.

Due to the narrow time frame the master thesis will only have time to understand the differences between one of Volvo Group's production lines (Tuve) and one development workshop (GB).

2 Methodology

This chapter presents how the project was conducted, describe the different methods used within the project, why they were chosen and performed, and with what purpose they served for the project.

2.1 Research Strategy

Bryman and Bell (2015) mention that many researchers describe their research strategy as being either qualitative or quantitative. The distinction between them are although somewhat ambiguous since they are regarded by some as a fundamental contrast and by others as no longer useful. However, there is strong evidence of its use and growing currency and no signs of decreasing.

The study taken place in this thesis project is regarded as both a quantitative and qualitative research strategy. The study has had a more deductive approach since the project group used known theories and deduced research questions that needed to be verified through empirical data. The project group used known theories of ergonomics and ergonomic evaluation methods to understand and evaluate the work in the development workshop, and to collect data. However, the study also had an inductive approach since the project group presented theory as an outcome of the research. Bryman and Bell (2015) describes that deductive studies often entails induction, and vice versa. We see the study as having tendencies within both deduction and induction. The study takes an epistemological position known as positivism (Bryman and Bell, 2015). Positivism advocates the application of methods of the natural sciences to the study of social reality. The study used proven and well known ergonomic evaluation methods to study the mechanics in their everyday work environment. The purpose of the theory was to generate hypotheses that could be tested and explained, e.g. "how well does the evaluation methods suit the development workshop environment?". The study only focused on physical ergonomics, and not on cognitive and organisational which most certainly would involve interpretivism as well, and not only positivism. The project group can see that the study has taken the ontological position of being objective (Bryman and Bell, 2015). The project group noticed that they could affect the environment of the mechanics and what the mechanics' thoughts of the project group and the study yet ahead. The project group also saw how the mechanics were not necessarily formed by hierarchical structures, but by themselves. Both the organisation and culture were in continuous motion, but more so the organisation than the culture. However, this did not affect the actual study since the project group evaluated the mechanics from an ergonomic perspective.

The study even neglected the cognitive and organisational factors of the ergonomics and only focused on the physical factors. The empirical data was not affected by the social phenomena in any high degree. Important to point out is that the pre-study was very much affected by the social context and can therefore be seen to have an ontological position of being constructionism

2.2 Research Design

Bryman and Bell (2015) describes the basic case study as an intensive analysis of a single case. The purpose of this study was to do a thorough examination of a single case. The project group performed ergonomic evaluations on the mechanics in a specific scenario: a development workshop at Volvo Group.

The study's intention was partly to raise the awareness of the current ergonomic situation in the development workshop so that a change for the better can occur. Therefore, it will be hard to measure the stability of the study (Bryman and Bell, 2015). During and after the thesis project, it is likely that improvements will be done regarding the ergonomic conditions. To perform another test after this study at the same department and environment would therefore most likely not give the same results since the preconditions would be different. Even if the same or a similar study would have taken place at another development workshop at Volvo Group or another company, the prerequisites and preconditions would not be the same, making it hard to do another test and get equal observations. However, the study was also partly to see how well current ergonomic evaluation methods suit the development workshop. These results have a higher stability since it is more general findings and conclusions. Studies at other development workshops, obtaining similar results, would increase this thesis' trustworthiness.

On the topic of validity, the project group interviewed experts within the ergonomic area to get a good guidance and a good understanding of what evaluation methods to use when performing the study. The project group therefore urge that a good measurement validity is achieved (Bryman and Bell, 2015). The project group reasoned that a good external validity also was achieved even though it was a case study since the results in the study can be generalized beyond the specific research context. The methods chosen and their executions are described in great detail in the next chapter.

2.3 Ethical Considerations

The project group video recorded the mechanics to be able to analyse their postures. In order to lower anxiety regarding the video recording the project group informed the mechanics what the recording was for: only for the project group's own study and the recordings would not be spread or seen by anyone else without asking the mechanics. Before any recording was performed the mechanics were asked if it was alright if they were recorded to ensure that no harm was made to them. When the study was ended the project group deleted all video recordings to ensure protection of the material.

2.4 Research Methods

In this section the research methods used in the project will be described. A data collection was used for gathering information regarding the present ergonomic state in the GB workshop.

2.4.1 Literature review

Bryman and Bell (2015) state that a competent literature review can increase the credibility towards someone who is knowledgeable in the chosen area. They also write that the purpose of exploring existing literature is for the purpose to gain knowledge and can be concluded into the following bullet points.

- What is already known about this area?
- What concepts and theories are relevant to this area?
- What research methods and research strategies have been employed in studying this area?
- Are there any significant controversies?
- Are there any inconsistencies in findings relevant to this area?
- Are there any unanswered questions in this area?

The project group did an initial literature review for the benefit to collect information within the subject and learn more about the topic ergonomic. The literature review continued throughout the whole project and more knowledge was gained contributing to the master thesis report, as recommended by Bryman and Bell (2015). The project group used Chalmers library database to search after books (both e-books and physical) and also used recommended books from different relevant courses throughout Chalmers. Google Scholar and general search on google for information was also performed.

Keywords: "ergonomics", "ergonomic work environments", "ergonomic evaluation methods", "human factors", "importance of ergonomics" and "ergonomic factors".

Also specific phrases or words about specific methods were used based on gained knowledge both within the project group but also gained from interviewed experts.

2.4.2 Observations

Field observations were conducted for the benefit of learning how the mechanics in the real work environment perform certain tasks. When conducting an observation, it is important that the investigator (in this case the project group) tries to ensure that the effect of their presence is as small as possible (Jordan, 1998; Osvalder, Rose and Karlsson, 2015).

The project group performed observations with video recordings for the purpose of better documentation of the task performed and to be able to evaluate from an ergonomic point of view. The project group observed a number of the mechanics when working, examining different

postures and movements, asking questions when necessary for the overall understanding. The project group did interfere during the observations but to gain knowledge of the tasks this was a necessity. For efficiency the project group sometimes divided into two groups.

2.4.3 Interviews

There are three different types of interviews; structured, semi-structured and unstructured. The structured interviews are prepared questionnaires that contain predetermined questions with no or little room for follow-up questions, often used for surveys. Semi-structured interviews contain several key questions for guidance and have a lot of room for follow-up questions. This will give the interviewer possibilities to go in depth on certain areas. The unstructured interviews are performed with no or little organisation and can start with an open question and develops depending on the answer. Therefore, unstructured interviews are considered time consuming and can be difficult to manage, not only for the interviewer but also for the participant since lack of predetermined questions provides little guidance (Chadwick et al., 2008; Osvalder, Rose and Karlsson, 2015).

The interviews were a complement to the observations and also helped the project group to better understand the task performed. The interviews that were conducted in the project were mostly unstructured but with some sort of prepared questionnaire to enable room for follow-up questions. The unstructured interviews were chosen since both semi-structured and structured interviews limits the project group during their observations. Since the mechanics prefer Swedish the interviews were conducted in Swedish but is for the sake of the report translated into English. The interviews were conducted while the mechanic was performing the task observed. The project group also conducted two unstructured interviews with two experts, both certified Europe ergonomists. They were also conducted in Swedish but translated into English for the report (see Appendix II).

2.4.4 Evaluation methods

The project group used ergonomic evaluation methods to analyse the mechanics' postures. When the data was collected the project group went through a few of the methods together to try them out as a trial and afterwards completed individually. All the methods were completed separately and then gone through together were the members of the project group had to motivate and discuss why they set a scoring, while looking at the video recording. This was from the project group's point of view a good way to perform and complete the methods due to inexperience of carrying through the methods. As mentioned before the project group did not use all methods found. When evaluating from a physical ergonomic perspective the project group choose the ones that were found most beneficial to the project. The methods not used were either too vague and only used if not a clue of where in a process the greatest risks occurs, e.g. PLIBEL (Plan for Identifying Ergonomic Hazards), or the method was not recommended by Cecilia Berlin, e.g. PEEA (Predictive Ergonomic Error Analysis) and OWAS (Ovako Working Postures Analysis System).

3 Theory of the body and ergonomics

This chapter will first present background facts, based on a literature study, and then continue onwards into more specific detail depending on the area, to address important aspects. The areas are heavy lifting and vibrations caused by handheld tools. The chapter will also include theory of the ergonomic evaluation methods used in the project.

There are so many individual combinations of biological variations that it is impossible to create a workplace that fits a "standard" person, since there is none. If you design the workplace around the "average" person you might find that the statistical majority of employees are not within that value. Workplaces should instead be designed for a variety of persons, e.g. from small to large, from weak to strong, which enables many to be able to work in an ergonomic way. Thus, the focus should be on the needs and capabilities of the collective and not on the mere individual.

3.1 The musculoskeletal system

Together the skeleton, muscles and joints form the musculoskeletal system, which allows the body to withstand outer physical forces and to perform physical work. In short the system turns chemical energy into physical movements (Berlin and Adams, 2017). As part of the skeleton the spine upholds the trunk, arms and head weight as well as any external weight that is put onto these body parts. External weight or load affects the human body differently and are dependent of a lot of parameters, such as: age, gender, physical health, and what kind of load the body are exposed to (Hägg, Ericson and Odenrick, 2015). Further, Hägg, Ericson and Odenrick (2015) describe how an injury caused by strain occurs in muscles and tendons. The literature uses words like Work Related Musculoskeletal Disorders (WRMD) or Cumulative Trauma Disorders (CTD) to describe the corresponding type of injuries that are work related. Sudden over-load can for instance lead to fractured skeleton, torn ligaments and muscles, and broken cartilage. A load that is unharmed to the body can, if repeated frequently, impose injuries similar to the ones that occur when a sudden and powerful load strikes the body. Not only does WRMDs cause injuries but they are also costly, both for the society, the employer and the individual. People who suffer from musculoskeletal pains are leading in disability pensions, sick pay and compensation insurance benefits (Linton, 1990).

3.1.1 General

A condition for individuals to feel well and develop during the own work is to be able to influence the setup and the carrying through of the tasks at hand. The influence also contributes in preventing musculoskeletal diseases (MSD) e.g. the worker has influence of planning and structure the work, choice of method, distribution between work and breaks, work rate and use of tools. The interaction between the workers, but also the interaction with the management plays an important role how the MSDs occurs and are experienced.

A good action space (AFS 2012:2) is for instance to be able to:

- Change between different tasks.
- Change between performing a task while standing or seated.
- Take shorter breaks to recover whenever it feels necessary.
- Choose or adapt the work pace.
- Get help from someone else when needed.
- Influence purchase of new equipment and introduce new work methods gained from own experience.

3.1.1.1 Volvo Group

Volvo Group Trucks Operations (GTO) has a standard regarding ergonomic requirements that functions as guidelines. In 2017 the standard will become rules instead of guidelines and act worldwide for the whole Volvo Group. The standard also includes supplementary requirements issued by the Swedish Work Environment Authority (AFS 1998:1 replaced 1 December 2012 by AFS 2012:2).

A good job from an ergonomic point of view depends on product, process and operator as well as organisation. Workers are equipped with different capabilities and the workplace must meet the requirements and needs that exist due to different sex, age and physics (Volvo Standard STD 8003,2, 2009).

3.1.2 Posture

Berlin and Adams (2017) describes what factors postures are affected by:

- Space: we adapt postures to preconditions.
- Vision: what you are able to see controls your posture.
- Stress: leads to e.g. more muscular tension which increases static loading.
- Protective clothing: prevents awkward postures in order to protect clothes.

A good posture is when the body is in its best position to carry out high force or high precision movements. Instead of leaning on muscular strength of what the body can do one should use balance, even distribution of forces, and skeletal loading as an indicator to determine a good posture. A bad posture is when the body is in a weak position and being put under excessive loads. The tissues in the body are put under unnecessary loads.

Examples of bad postures are positions at the outer range, unevenness, a bent back and forced muscular loading instead of skeletal loading (Berlin and Adams, 2017).

In order to keep the body in a certain posture the muscles in the body have to work and this is a form of internal loading. With internal loading Berlin and Adams mean how forces within the body are distributed. External loading takes place when you handle weights, e.g. pushes or lifting. Force is usually a component of a loading, external loading. Time let us know for how long, how frequent or how often the parts in the body are loaded. Naturally, the legs and back are strong and can carry high loads for a long time if the loading is in the axial direction. Hands are naturally very flexible and good precision "tools". With training people can of course strengthen their abilities to do certain tasks but the ideal is that the workplace is designed in such a way that the body uses its segments in a proper way.

The United States Department of Labor, Occupational Safety and Health Administration (OSHA) addresses another aspect, awkward postures, and can be read about where bending while lifting something so small as a screwdriver to heavier objects involves a risk. The bending position strains the back and increases the stress on to the lower spine and makes the muscles weary. When addressing awkward positions OSHA also mention reaching, that place considerable strain on shoulders, and carrying loads that creates uneven pressure on the spine, e.g. on one shoulder, under one arm or in one hand. Possible solutions are again to move objects into the power zone and minimizing the bending by placing the materials on shelves, tables or racks, or to lift the object by moving it close to your body and bending your knees while lifting. The power zone is the area close to your body. This way you do not only activate the arm muscles but also the power from the legs and minimize the strain on the back. Another risk is when twisting and bending forward while lifting. An easy way to minimize the risk of injury is to move the feet rather than twisting the torso. By always keeping your arms and elbows close to your body you keep the load as close to your body as possible. It is important to not start the lifting underneath mid-thigh and or above shoulder height. Lifting below will put stress on legs, knees and back and lifting above shoulder height puts stress on upper back, shoulders and arms.

During a long period of time the focus in ergonomics containing heavy lifting was to minimize the amount or amplitude (Hägg, Ericson and Odenrick, 2015). Nowadays physical loading is defined as, physical loading = posture x forces x time, from an engineering perspective. The interaction of posture, forces and time will determine the total risk of injury.

3.1.2.1 Volvo Group

Concerning work postures and working movements, the operator should be able to work in a comfortable and ergonomic work postures 80 % of the working time. Work including e.g. lifted arms, raised shoulders or back bent forward means a risk for injuries or strains on joints and muscles and should not occur. The standard also agrees with the previous statement earlier that a good work posture is when the body's muscles and joints are exposed to outer forces when close to a neutral position, relaxed and standing upright. The work should also be varied in its work postures, there should not be any squatting, kneeling or standing on one leg for longer periods of time or repetitively. Changing between different tasks should be done after 2 hours or more often. Work postures are targeted as e.g. <20° bending forward, <15° twisting or sideways bending of the neck and elbow and forearm in a neutral position. The previous are stated as goals and the risks that the Volvo Group standard mentions are

foremost fixed work postures during a long period of time or frequently repeated. Working or gripping outside an arm length distance, and bending or twisting of the back or neck; e.g. neck $>15^\circ$ bent forward, bent sideways, rotated or $>0^\circ$ bent backwards and back $>20^\circ$ bent forward, $>15^\circ$ rotated. An angle $>60^\circ$ between upper arm and body for a long period of time or on a frequent basis or working using hands at or near extreme positions are also considered risks. The standard also states that vibrations in combination with a bad working posture are risk factors and should be avoided.

The workplace should be designed to enable good work postures that take the worker's physical dimensions into consideration. It should be possible to adjust the workplace and tools should be easy-to-use to suit each individual (Volvo Standard STD 8003,2, 2009)

3.1.3 Physical load and outer forces

The United States Department of Labor, Occupational Safety and Health Administration (OSHA), provides information about ergonomic solutions for electrical contractors and the potential hazards and possible solutions in their work environment. The work of an electric is similar to a mechanic's in ways that they occasionally lift heavy objects, more or less frequently stand in awkward positions, and unavoidably work with the arms and hands. Because of the similarities the project group saw the importance of including these potential hazards and possible solutions in the report.

Heavy lifting above ca 23 kg will increase the risk of injury and a truck contains parts high above that magnitude, e.g. only one truck tyre weighs 100 to 125 kg. Possible solutions that are mentioned are mechanical machines or tools, such as: forklifts, lift junctions, or if materials must be lifted manually they should be placed in the "power zone", mid-thigh to mid-chest, to decrease the direct load on the body. It is important to remember to never lift heavier than ca 23 kg alone but to be at least two when carrying out such heavy lifts (note: tyres are not lifted without a machine).

The last thing that the report mentions is risks connected to "High-Frequency and Long-Duration Lifting". Here a potential hazard is holding an item, even if the load is light, during a long period of time. This will increase the risk of back and shoulder injuries. Also, repeatedly exerting force such as pulling wires can fatigue the muscles. A possible solution is to use a lightweight material for a template, e.g. mark drill holes before mounting a heavy drilling machine to ensure the drill does not need to be held on place while levelling and measuring activities. Another solution is to provide stands or mechanical lifting devices to hold larger and heavier objects while fastening or attaching them. It is also important to rotate tasks between the employees so that one person is not exposed to the same activity for too long. Yet another solution is to work in teams of minimum two where one employee lifts and holds the object while the other attaches the object. The last important solution is to enable regular breaks to give the muscles time to rest. Working through breaks increases the risks of accidents, musculoskeletal disorders (MSDs) and can reduce quality because the employee is tired.

3.1.3.1 Gender differences

Studies show that sick leave is more prevalent for women. In 2011, cost regarding women's sick leave were 69% higher than men's (RAP 2013:9). The major cause of the strain injuries is probably caused by loads at work. In Sweden 6.4% of the working women and 5.7% of the working men 2011 reported that wearing work postures had caused them injury within the year. Short but repetitive tasks were stated as the cause of injury by 2.6% of the women and by 1.8% of the man. Heavy loads were stated as the cause by 4.2% of the women and 4.1% of the men. Women are overrepresented when it comes to sick leaves and injuries due to work tasks.

As previously described Hägg, Ericson and Odenrick (2015) stated that factors like age, gender and physical health are parameters that affects in what extent the body is exposed to loads. For example, a parameter is the difference in overall height of Swedish adults where 95% of the women were shorter than 1789 mm compared to men that were shorter than 1902 mm (Hanson et al., 2008). The main difference between an average woman and man is that women has 50-80 percent of men's maximal muscle strength, and the largest difference is in the upper extremities as e.g. grip strength.

Nordander (2004) sheds light on the topic work-related musculoskeletal disorders (WRMD) and how it affects different genders: man and woman. Generally, MSDs are more common among the female population, something Nordander investigated further in her article 2004. In the study she found that even though females and males performed the same work tasks, disorders in the neck and upper extremities were twice as common among females. However, for low back and lower extremities no difference was found. When it came to working postures of the head, upper arm and wrists, no big differences could be seen between male and females. Females, however, worked with a higher upper arm, higher velocity and with 40% higher wrist flexion/extension velocities.

The perceived psychosocial work environment was however not different between females and males. The females being studied spent more time on household chores and less time on physical exercise, compared to the males. Smoking was also more usual in the female population.

In conclusion, the study found that females generally worked with high repetitive tasks with a high degree of constrained neck postures whereas males worked with heavier loads but with more varied tasks. Prevalence of MSDs in the neck and upper body was also very much higher for females compared to males working with the same tasks.

3.1.3.2 Volvo Group

Volvo Group standard states that there should not be any physically monotonous, highly repetitive, large or rapid movements. The planning of work should allow dynamic muscular work where a chance for the body to have natural micro pauses for recovering. When workers manually handle heavy or slow-moving objects they must be relieved by mechanical aiding tools. The standard also mentions that work that includes force combined with precision should not exist (Volvo Standard STD 8003,2, 2009).

3.2 Hands

The hands are also a part of the musculoskeletal system described previously but is described in more detail in this chapter because of its importance for the project.

The hands and wrists are very important limbs to have when performing some kind of a task. The hand, wrist and arm form a very complex structure that quite easily can wear out or get injured during physical work (Berlin and Adams, 2017). An injured hand can have very big consequences since it usually hinders the person from doing much other work. The skin of the hand has alone 17,000 receptors for senses that enables us to touch, feel pressure, pain, heat and cold. Moreover, the hand is used to express emotions like e.g. body language. Non-functioning hands can not only remove the ability to work but also the ability to express feelings through body language.

The components of the hand make it very good for high precision work, but not for using high force. This implies that it is of great importance to create work that is adapted to the hands ability to exert force and precision, this includes the design of hand tools.

Possible motions of the hand are flexion and extension (for both fingers), deviation (sideway wrist bending) and the twisting motions pronation and supination (see figure 1).

The hand is also crucial for grip functions depending of the task. While working or handling loads you should not overload the hand by too much twisting and bending. The hand has a functional resting position when the muscles are relaxed, the wrist is straight, the fingers slightly curled, and the pressure is as low as possible in the carpal tunnel. The carpal tunnel is a passage in the wrist that encloses the median nerve and several tendons. The ideal scenario would be to design work for the hands close to the functional resting positions. Movements outside far away from the functional resting position will decrease the strength and precision of the hand.

A few typical work-related problems that can bring injury to the hand are:

- Repetitive tasks
- High forces
- Punctual pressure on a small area
- Incorrect grips
- Vibrations
- Cold and heat
- Extreme positions during work

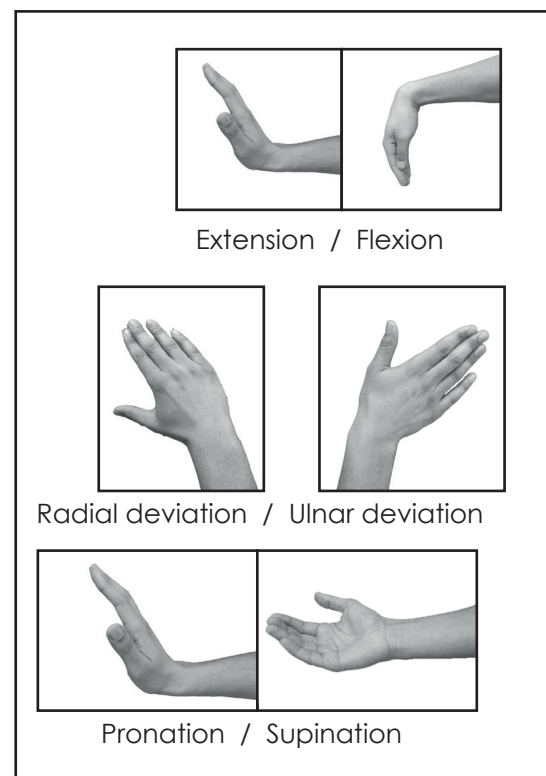


Figure 1. Overview hands motions

3.2.1 Designing hand tools

Often when a purchase is made for a new tool or equipment within a larger organisation the purchaser usually does not have the important facts about ergonomic aspects and sometimes limited or not existing contact with the end-user. Therefore, it is common that the purchaser only choose the tool based on price, Hägg, Ericson and Odenrick (2015) write. Besides the specific functions of the tool you must take into consideration adjustments to the human hand, such as transfer of power, comfort and maximal control of the tool. A lot of the tools today are designed from a male's hand shape and size even if the tools commonly is used by both men and women.

Keeping the hand close to its functional resting position when working with hand tools is important in order to make sure the hand has good conditions for strength and precision development. When a tool has a good design it is designed to meet those good conditions and lowers the risk for long-term consequences, e.g. injuries. The tool itself is one factor but it is also important to take the context and the work environment into consideration, e.g. how the tool is gripped is determined by the use of gloves or other protective clothing, due to vibrations or/and caused by substances that makes the tool wet, slippery or dirty. Hägg, Ericson and Odenrick (2015) write that the material and the tool design of the handle plays an important role in reducing the transfer of vibrations to the hand. The softer the material is the more the power is distributed over the whole surface and is preferred when it comes to subjective values.

Berlin and Adams gives a short list of questions to ask before designing a hand tool:

- Who is going to use the tools, and for what purpose?
- What is the function - what task is to be solved?
- Are there differences to consider in the design population, e.g. sexes (male/female grip strength ranges) or cultures (preferred for different activities)?
- What anthropometric data is useful? E.g. different sizes, left/right hand prevalence etc.

Usually machines and tools are not adapted to those who have smaller hands and lower muscle strength. Since women usually have both smaller hands and lower muscle strength they are often affected by higher loads when using these kinds of tools. One and the same grip do not fit all hand sizes. Also when there is a focus on precision the challenge of avoiding static forces or loads are more important, these tools the function as well as the possibility to rest and comfort are equally important. To reduce the risks of MSDs the employer must provide the worker with handheld tools that are;

- Provide sufficient grip that are adapted to the requirements due to force and precision, with good friction and the force is well divided over the hand to avoid unsuitable point pressure e.g. no sharp edges.
- Fits different users individual hand size.
- Possible to use both with right and left hand.
- Permits a neutral position with wrist and arm, it should be relaxed.

- Provide sight and give access to the work to be executed.
- Vibrate as little as possible.
- As light as possible as the function for the tool allows.
- Well balanced.

Another important aspect besides the design is the weight of the tool. The overall principle is that the handheld tool should be as light as possible to minimise the external load. Recommended from Hägg, Ericson and Odenrick (2015) according to studies the maximal weight carried by the user is 1.75 kg for precision tools and for other 2.3 kg.

3.2.1.1 Volvo Group

According to the standard the maximum weight of manual handling using only one hand is 0.5 kg when using overhand grip and 5 kg when using underhand grip. Powerful movements of the wrist upwards-downwards and sideways for a long period of time or on a frequent basis, are not good for the hand. Hand-held tools should be designed to support good working movements and work using vibrating hand-held tools should be minimized (Volvo Standard STD 8003,2, 2009).

3.2.2 Handheld vibrations

The Swedish Work Environment Authority (Arbetsmiljöverket) states that vibrations are a recurring problem they notice when inspecting different workplaces (AF1). According to a new EU directive 2002/44/EG the Swedish Work Environment Authority change their regulation, AFS 2005:15, so that the two corresponded. In the regulation information regarding two important values can be accessed; limit and action value. The so called action value for the daily limit is 2.5 m/s^2 and the value determined when the employer is demanded to react can be read as maximum of 5 m/s^2 . The work should also be planned in such a way that exposure to vibrations is minimized, considering technical development and the possibilities to limit the vibrations. Hand and arm vibrations normally occur when working with vibrating machines and tools that is used by the hand, e.g. drilling machines, chain saws or impact wrenches. Vibrations can also come from other sources like steering wheel and handheld controls. Consequences are cold fingers, numbness and reduced feeling in the hands, that in turn can increase the risk of accidents. Permanent injuries like white fingers, nerve and muscle impacts can also occur as a consequence of exposure to vibrations (AFS 2005:15).

Berlin and Adams (2017) write that vibrations at work affect us both physically and mentally. When working in an environment with vibrations for a long-term ambient noise can decrease the concentration or hearing. This might result in the person missing important information and signals during the workday. Physically, the body tissues and organs absorb the energy from vibrations which is a risk factor and the muscles are trying to compensate for the vibrations exposed to. In the long run this creates a form of small static loading which tires the muscles and imposes a high risk to the joints. The joints in the body have a contact surface that is covered with cartilage in order to work as a shock-absorber and lessen the friction between the bones gliding against each other. However, if the body is exposed to vibrations over a longer time period the cartilage can break down, resulting in joint pain and problems. Coming in contact with vibrations in extreme postures, during a longer period of time, is extra

dangerous for the body since the shock-absorber cartilage is even thinner at the outer edges and the bones, thus have less protection.

3.2.2.1 Hand injuries

If you expose your body, especially, your hands to vibrations over a longer time you risk to get different hand injuries.

3.2.2.1.1 Carpal Tunnel Syndrome (CTS)

The syndrome is due to compression of the median nerve that runs along the wrist called the carpal tunnel. This condition is caused by very repetitive work in extreme postures and high force development but can also be due to vibrations. The symptoms are numbness, tingling, less function and less strength in fingers and areas affected by the median nerve (Bohgard et al., 2015).

3.2.2.1.2 Inflammation in tendons

Inflammation in tendons occurs due to repetitive finger work or sharp edges on hand tools resulting in irritation in the tendons sheaths. The symptoms are pain when moving wrist or fingers because of a pressure and swelling feeling in the knuckles (Berlin and Adams, 2017).

3.2.2.1.3 White fingers or Hand-Arm Vibration Syndrome (HAVS)

When you get white fingers your fingers turn pale and loses feeling. The symptoms usually occur when you are cooled down and when you are exposed to vibrations, e.g. when you are swimming, fishing or other times when the whole body is cooled down. Other factors like stress, nicotine and medicine can increase the risk for the symptoms (AFS 2005:15).

3.3 Evaluation Methods

In this part methods for helping the project group to evaluate and assess the present ergonomic state will be presented. The methods used were chosen since they were the most suitable for the three ergonomic areas that had been chosen; heavy lifting, handheld vibrations and sound and light. To be able to evaluate, the project group filmed the mechanics during different tasks. The project group also asked questions during the tasks and afterwards as a complement to the video recordings.

3.3.1 Rapid Upper Limb Assessment (RULA)

RULA focuses on the upper body like hand and arm intensive tasks (Osvalder, Rose and Karlsson, 2015). The method has an easy design so that no need for an advanced degree in ergonomics or usage of expensive equipment is needed (Ergonomics Plus, 2016). The method focuses on one specific posture that occurs during a task. Chosen postures are usually identified through observations and dialogue with the practitioners (Berlin and Adams, 2017).

The loads that are handled in RULA are usually not very heavy (Osvalder, Rose and Karlsson, 2015). In RULA seven body regions are assessed from a posture/position point of view. These regions also have numbers: (1) upper arm, (2) lower arm, (3) wrist, (4) wrist twist, (5) neck, (6) upper body and (7) legs. The assessment is done for right and left hand and arm separately and the side that gives the highest score is used as an indicator. A score is then generated depending on the body postures, the weight of the load and if the movements are static or dynamical. The higher the score, the more dangerous the postures are and the injury risk is higher.

The RULA consists of four stages.

1. There are three ways of choosing which body postures that should be studied.

1. Identification of bad work posture

The whole work cycle is observed and potential risky postures are identified. The postures are chosen by observing what postures seem to be risky, uncomfortable or that does not follow ergonomic guidelines.

2. Analysis based on time sampling

The posture the person being studied has after a certain time interval, e.g. 10 seconds, should be chosen. The work cycle might be between 10 and 20 minutes. These postures are then analysed one by one.

3. Analysis based on task analysis

The work cycle or the work task is broken down into smaller parts using task analysis, e.g. HTA. After this an analysis is done for the work posture for every work task.

2. Collecting data of body postures

No matter the method used to identify the bad body postures, video recording is a good way to capture them. But one can also take photos and do the assessment live since the work tasks can be paused and a certain body posture can be studied directly.

3. Assessment of body posture

The assessment of the body postures is done in the same way no matter what method was used to identify the body postures.

4. Compilation of results

Finally, the results are compiled and if possible the scores for the different postures will be explained.

Since RULA concentrates on the upper body and many of the tasks performed in the workshop is concentrated to the arms and hands this method suited the project group well. From RULA an estimation and results from what positions are harmful can be concluded (see Appendix III).

3.3.2 Rapid Entire Body Analysis (REBA)

Like RULA, REBA is used to analyse body postures but is more focused on the whole body (Osvalder, Rose and Karlsson, 2015). In REBA six body regions are assessed from a posture/position point of view. These regions also have numbers: (1) neck, (2) upper body, (3) legs, (4) upper arm, (5) lower arm, and (6) wrist position, main difference to RULA is that the positions of the legs are much more taken into consideration. REBA does not only analyse the loads on the body but also includes coupling effects, e.g. how well the person is holding the load. Moreover, the method considers if the posture of the upper extremities is caused by gravity and if there are big dynamical changes in the body posture. Like RULA and many other methods a score is generated that will determine what the recommended actions should be. As RULA, REBA consist of four stages: 1) choosing one of three ways how body postures should be studied, 2) collecting data of body postures, 3) assessment of body postures and 4) compiling the results. Likewise, REBA analyse the right and left hand and arm separately and the side that generates the highest score is used (Ergonomics Plus, 2016).

Although the method is very similar to RULA it was chosen as a complement to the RULA method. Additionally, REBA focuses more on coupling effects and the position of the legs which both were of interest to study (see Appendix IV).

3.3.3 Key Item Method (KIM) 1, 2 and 3

Michael Schröder, Europe certified ergonomist, recommended different assessment methods from the Swedish Work Environment Authority (Arbetsmiljöverket) in order to identify harmful work postures. These are called KIM 1, KIM 2 and KIM 3, these can be downloaded from their website. KIM 1 assesses the risks of lifting and carrying loads, KIM 2 assess the risks of pushing and pulling heavy loads, and KIM 3 looks at how fingers, hands and arms are affected by loads and objects (manual work). KIM starts with the task and generates a score and this score determines if the posture, e.g. pushing, is hazardous. The method was good when analysing specific scenarios and functioned as a good complement to the other methods used.

The project group decided to not to use KIM 1 since the mechanics in the workshop have good aiding tools for lifting heavier things and they seldom carry parts for an extensive time or distance. KIM 2 and 3 served as a complement to RULA and REBA but with more specific information regarding load and time as well as an overall focus on e.g. the organisation. The project group felt that it was important to include and gain more specific results than from the previous methods used (see Appendix V).

3.3.4 Hand Arm Risk-assessment Method (HARM)

The purpose of HARM is to determine risks regarding arms, neck and shoulders when performing tasks. The method is suitable for hand or arm oriented tasks such as e.g. involving assembly or disassembly of components or packaging and sorting of products. It helps the conductor to get insight in the most important risk factors associated to the work and determine which intervention measures have the most benefit and reduces the risks. The method should be used only on tasks that take longer than one hour per day in total and when force exertions exists, involving one hand exertions less than 6 kg and tasks other than computer work. It is also unsuitable for tasks primarily involving activities of the back

and/or legs when carrying, lifting, pushing, pulling and working while bent forward, kneeling or crouching.

HARM involves eight steps in the paper-based version and six steps in the computer-based because of the slight difference in calculation between the two approaches. The method is especially useful to apply when a video recording of the task can be observed. If the performance differs significantly between employees an average value should be used and it also means that several different employees must be observed to be able to draw conclusions. They also recommend to assess together with a colleague the first time conducted.

The first step is to determine the task duration score that includes how long and how often the task is performed. The second step is to identify the most active hand or arm and then continuing to the third step to determine the force score on both hand separately. The highest value is determined by how much force is added, for how long time (in seconds) and how frequent the force exertion occurs. Step four is to determine the posture score by assessing the posture or angles for head/neck and shoulder/upper arm, and the duration in percentage of the total duration of the task from <10 %, 10-50 % or >50 %. In the same way the posture score for the lower arm/wrist is determined. Step five determines the impact of the vibration value or vibration score, if the task involves usage of a vibrating tool (if not, set a zero value) and the duration of the exposure per day. The sixth step includes the score determined by other factors answered with yes or no, were dependent on the number of yes or no determine the final score. The last two steps conclude the risk, first determine the score based upon step 3-6 times step 1 and the final score is used to determine the level of risk, the last and final step. Depending on the value the score of the task end up in a 'traffic light table', were green does not pose a risk, if amber the task can pose a risk for some employees and must be lowered to protect the majority. Red means that the risk pose a significant risk for the majority of the employees and measures must immediately be done.

The project group will use the paper-based version from the Swedish Work Environment Authority (Arbetsmiljöverket), see Appendix VI. This because the paper-based was easy to access and print. The method then performed by looking at the recorded video the same way as for the previous methods.

3.3.5 Benchmarking

The Swedish Institute of Quality (SIQ) define benchmark as "... a systematic approach for comparing, evaluate and learn from role models, regardless of industry and geographical location. The purpose is to gain insight and knowledge which reacts to improvements within the own organisation" (Johansson J. & Abrahamsson L., 2015). Often benchmarking is used for improving methods, routines or processes not working. A sort of benchmarking is also performed within the Quality Function Deployment (QFD) and in the House of Quality. The QFD can be divided into four parts, performing a market analysis to find the needs and expectations of the customers and next examining competitors and how they satisfy the customer. The two other parts are identifying key factors and the last is to translate these keys into product characteristics. All these parts can be used when setting up a matrix for evaluation. The House of Quality is one of the seven management tools and is a part of the QFD process. Its consists first step customer needs ("the what's", vertical axis) and product characteristics ("the how's", horizontal axis) are described and these are concluded in the middle as a 'Relationship matrix',

and form the 'body' of the House. After concluding the essentials, the House of Quality also consists of a 'Correlation matrix', that describes how the different product characteristics affects each other, is found on the top as a 'roof' of the House. Underneath the House the 'basement' can be found, the basement consists of two floors and the first is 'Target values' and the second 'Engineering competitive assessment'. Last to the right a balcony where the 'Competitive assessment' are being performed (Bergman and Klefsjö, 2010).

The project will use a benchmark for being able to evaluate foremost the different impact wrenches used today. The project group will foremost use 'Customers needs', 'Product characteristics' and 'Competitive assessment' with the customer set and defined as the mechanics within the workshop and identifying their demands and requirements on the products.

4 Results

In this chapter the differences between working with ergonomics at a production line (Tuve) and a development workshop (GB) will first be described. Hereafter, the results from the different scenarios and evaluation methods will be described. The purpose is not to give exact score values from the evaluation methods but to indicate what the evaluation methods concluded.

4.1 Ergonomic in production line compared to development workshop

Michael Schröder and Cecilia Berlin, both certified Europe ergonomists (experts in the area), saw the possible difficulties with evaluating a development workshop and not a production line. It is generally easier to evaluate a repeated movement and movements that you see different employees perform so you can collect a lot of data. In a traditional production line the products are manufactured and constructed. In contrast we have the GB workshop, a so called development workshop, in which special tasks are performed on the trucks. The development work can include tasks like testing a new part that has been improved or preparing for different kinds of tests.

A production line that the project group studied to understand the differences in relation to the GB workshop was the Tuve factory where Volvo Group has its production of the Trucks. Here the project group met a certified Europe ergonomist, Michael Schröder. The project group learned some differences between both facilities, from an ergonomic point of view, for instance the character of the work. Frequencies are higher in a production line than in a development workshop and the managers can justify their purchase of more ergonomic friendly tools. Tuve also has its own ergonomists that regularly are working with improving and proactive seeing over the work as well as having an active dialog with the managers. In development workshops the ergonomists have to be requested and this often occurs when injuries have been detected. Another aspect is that they have a rotation time of 2 hours between the different stations on the production line. But the work they perform on a production line can be monotonous in its execution. The workers do however have trainings so that everyone knows what the recommended heights and weights are, and have it before designing new work stations. But a disadvantage of working on a production line is the lack of flexibility and limits the employees to take a small break when necessary and the work can be described as monotonous.

In a development workshop as GB the benefits are as described the freedom to an extra break for reflection and planning of the task besides the ordinary breaks. In the workshop they also have a need of constant problem solving since they get the truck with a description of what "to do" and since they do development work it always occurs problems e.g. new holes must be drilled to attach new bolts and a rear axle on this specific truck might be in the way.

Problems they have in the workshop are related to the need of specific parts for conducting the work properly and right. Since an ergonomist is not present on a regular basis but has to be requested often when it is too late there is no one who can ensure that the work is performed in an ergonomic good way or that the tools are gentle to the mechanic's hands. The mechanics are usually not so experienced or have never heard how to work in a properly way and since they do not have any supervision the lack and knowledge might result in injuries.

4.2 Postures

The workers performed different work tasks depending on what kind of order that was required. To get an understanding of the mechanics' work and to understand what was included in different tasks several tasks were studied. These tasks became different scenarios that the project group analysed in closer detail to identify risky body postures. In this chapter only selected tasks, that according to the manager are more frequently performed within the workshop, are chosen. One exception was 'building chassi' scenario which was picked because lack of frequency so that the manager would know how to address these kind of orders.

From the results the project group saw that many of tasks involved postures that needed further investigation and change according to for example RULA and REBA. This points the result towards the direction that many of the postures today can be harmful or cause injuries in the long run. RULA and REBA gave often results with "further need for investigation and change" but HARM, KIM 2 and KIM 3 usually gave results with "no risk etc."

4.2.1 Change engine

The task was to replace an engine with another and the task was performed mostly by one worker (usually two workers operate on these kind of tasks). In order to reach the engine and its nearby parts the cab was opened.

4.2.1.1 Loosen couplings

In order to lift out the engine several couplings had to be disconnected. However, they were very hard to loosen and take apart. The space the operator had to work in with the couplings was very narrow, making it hard to get a good grip on parts. These factors made the decoupling very tedious.

HARM identified positions of the head bent forward and the arms not being close to the body 10 to 50 % during the total time for the task. Although it was challenging for the mechanic to loosen the couplings, HARM did not see any high risk for work related injuries. Since the task occurred about one hour in total and was not repeated more than twice a week it got the lowest time score, resulting in a total low HARM score. RULA saw the need for further investigation, mostly due to bad neck and trunk positions during the task. Because of the narrow area and bad visibility, the operator had to bend the neck in order to see what he was doing. The wrist was also twisted in order to get a sufficient grip, scoring in higher wrist twist scores. Upper arm and leg positions were otherwise good and decreased the total score of RULA.

4.2.1.2 *Bent knees*

When loosening the engine, the mechanic had to stand on the tyres with bent knees in order to reach the necessary components. This meant bending the trunk forward in order to reach the components on and next to the engine. The arms were outstretched resulting in bad postures in almost all areas: trunk, neck, arms, wrist and legs.

REBA gave results that pointed towards medium and high risk and that change needs to be done. This mostly because of the bad upper body postures but the bent knees also contributed to the bad results. Because the knees were bent more than 60 degrees, scores were added that resulted in high scores for the trunk postures. The shoulders were raised but the arms and wrists were in good positions resulting in low arm and wrist scores. RULA also pointed towards the same direction, that change needs to be done. The trunk position score was very high while the neck and leg score was fairly low, resulting in a moderate neck, trunk and leg score. The wrist twist score was high, increasing the total arm and wrist score.

4.2.1.3 *Awkward position*

Due to work behind the engine the mechanic stood on one leg in the small space between the engine and the tyre. The operator had one supporting leg that stood on the ground and the other leg was resting on the tyre while the trunk was bent forward in order to reach the components.

REBA pointed to medium risk and that further investigation needs to be done. The neck was slightly twisted and side bended resulting in higher neck position scores. Due to the awkward posture the trunk was bent backwards slightly twisted and side bended. Likewise, the legs were bent increasing the total neck, trunk and leg score. The arm and wrist wrist generated low scores since the positions were in an acceptable range. Results from HARM were in the category "not a high risk for injuries in arm, neck or shoulder due to the task". HARM identified that the head was bent forward between 10 and 50 % of the total time of work and that the upper arm was positioned away from the body 10 to 50 %. This generated a moderate score on head/neck and shoulder/upper arm score. Some hand positions were identified as being close to the hands outer position between 10 and 50 % of the task. Since a vibrating impact wrench was used the vibration exposure was added to the scores. However, the task occurred about one hour in total and was not repeated more than twice a week so it got the lowest time score, resulting in a total low score.

4.2.1.4 *Standing upright with raised arms*

The truck was elevated in order to loosen/fasten parts under the truck. Tasks included using an impact wrench and this meant outreached arms above the shoulders when inserting the bolts. The trunk was quite straight but the neck was slightly bent backwards during this operation. Sometimes the mechanic had to stand on the toes and stretch the arms quite much to be able to reach the highest points.

The operation that increases the scores for REBA is the upper arm position. The upper arm was raised above the shoulders and abducted, resulting in the highest scores possible for upper arm position. The lower arm and wrist position scored the lowest possible points since they were

in natural positions. The total score for arm and wrist became very high due to the upper arm position. The neck, trunk and leg positions were good, resulting in low scores. The neck, trunk and leg scores kept down the total score for the task, resulting in a medium risk task that needs further investigation and change soon.

RULA identified high arm positions and side movements of the arms that scored very high. This resulted in one the highest scores for arm and wrist. The neck was bent backwards and that resulted in high neck position scores. The trunk and legs were in good positions but since the neck had a high score the total neck, trunk and leg score still became quite high. These high scores resulted in a total high score pointing towards "investigation and implement change soon" for the task.

4.2.2 Change tyre

The task was to replace tyres on the truck with new tyres standing on a stand. The work required one person.

4.2.2.1 Remove/attach bolts

In order to take down the tyre the bolts that hold the tyre to the hub were removed by using a pneumatic nutrunner. Since the truck was on the ground the operator sat on a stool, with a slightly bent back and operated with a pneumatic nutrunner that weighed 4.8 kg. When attaching the new tyre, the same procedure was done but vice versa.

RULA identified higher scores in the wrist twist position when the pneumatic nutrunner was lifted up and down when screwing on/off the bolts. Since the pneumatic nutrunner weighs 4.8 kg additional scores was given to the arm and wrist position, increasing the total arm and wrist score. Both neck and trunk were bent forward during the task, resulting in moderate scores for neck and trunk. The legs were supported since the mechanic was sitting on a stool but the motions were repeated more than four times per minute and thus additional scores was given to the task. In total a fairly high score was given by RULA, pointing towards further investigation and that change may be needed.

The results from KIM 3 varied between low risk for injury and moderate risk for injury. The force exerted by the mechanic was not so high so the force score was low. Of all the categories to examine only the hand and arm position scored a score. The element that caused it was the twisting of the wrist when lifting the pneumatic nutrunner up and down when screwing on/off the bolts. The total time for the task was not more than one hour, resulting in the lowest time score, i.e. one, and thus keeping the total score low.

4.2.2.2 Roll tyre

After the tyres were taken off the truck they were rolled away by hand and put on a stand. The stand was elevated a bit forcing the user to roll/push the tyre up on the stand.

When the tyre was positioned on the stand it was with precision and fast movements, resulting in the highest score for movement when positioning. Apart from that no other activities during

the task scored high. The time score was determined by how many times the operation was done per day and since it was less than 10 times, the lowest time score was generated, i.e. one. This resulted in a total score that was low. KIM 2 showed low risk for work related injuries due to the postures involved in rolling the tyre.

4.2.3 Change battery

One person worked on the change battery task. The mechanic lay on a board on the ground under the truck in order to reach necessary parts under the battery cage. The arms, especially the right arm, was outstretched to the side in order to operate on the battery cage. The work involved many heavy components and uncomfortable postures for the operator.

When the mechanic was lying down the neck was bent and twisted in order to see what he was doing. This gave high neck position scores in RULA. The trunk was likewise bent and twisted in order to facilitate the task and this gave high trunk position scores. Since the mechanic was lying down the project group reasoned that the legs were supported and the lowest leg score was given. However, the total neck, trunk and leg score was still very high. The arms were lifted up, raised above the shoulder and abducted resulting in high upper arm position scores. The lower arm and wrist position score was low keeping down the total arm and wrist score. The total RUBA score was although very high and the task laid in the medium high risk area. The suggestions were to investigate and implement change.

4.2.4 Build chassis

The master is constantly rebuilt depending on how different projects look like. Since the master stands only have one height the operator had to sit down in an awkward posture when installing parts.

Both the neck and trunk positions gave high scores in REBA. The mechanic was sitting down with his legs bent more than 60 degrees, resulting in high leg scores. Since the neck, trunk and leg scores were high the total neck, trunk and leg score became high. The upper and lower arm were in acceptable ranges, giving the arm low scores. However, the wrist position score was high but it did not increase the total arm and wrist score substantially. Because of the high neck, trunk and leg scores the total REBA score was quite high, resulting in a medium to high risk task. The recommendations were to further investigate and change soon.

4.2.5 Change anti-roll bar and air springs

The task was to change anti-roll bar and air springs and this work required two persons.

4.2.5.1 Bent back

Initially much pre-work was done drilling new holes to be able to set a new attachment for the air spring and then fastening it with bolts on the chassis. The mechanics leaned over the chassis and worked mostly in positions with bent backs.

The trunk was bent forward quite heavily resulting in high trunk position scores in RULA. The neck was also bent forward but not as much as the trunk. Since the legs were supported and

the trunk position was the only position that distinguished itself in the scores the total neck, trunk and leg score was moderate. While operating on the chassis, the wrist was bent a bit resulting in higher wrist scores but not enough to impact the total arm and wrist score. In total RULA suggested further investigation and that change may be needed. REBA scored high in the trunk position and low in the neck and leg position, leaving the total neck, trunk and leg score moderate. The arm positions were in acceptable ranges and the wrist was not twisted resulting in low arm and wrist scores. The total REBA score suggested medium risk, due to the bent trunk position, and that further investigation was needed.

HARM identified medium force used by the hands. The head was bent forward and the upper arm was lifted forward 10 to 50 % during the task, resulting in higher scores. The forearm was twisted 10 to 50 % of the task, also increasing the score. The mechanic used a vibrating impact wrench which adds scores to the method. The total duration of the task was estimated to two hours but since the task did not occur more than twice that week, the lowest time score was given. Since the time score was the lowest, one, the total HARM score became low. HARM identified the situation as very low risk for injuries linked to overload in arm, neck or shoulder.

4.2.5.2 Standing, using impact wrench and torque wrench

When the pre-work was done the truck was elevated and the operators worked under the truck. The work included usage of impact wrenches and torque wrenches. When the operator stood under the truck the knees and neck were bent in order to fit under the truck. Likewise, the back was slightly bent backward. This posture was held during the use of the impact wrench. A torque wrench was later used to fasten the bolts with specific torques. However, the arms were held above the shoulder and much force was utilized when using the torque wrench.

With REBA a forward side bending neck was identified and high scores were given to the neck position in REBA. Since the trunk also was forward bending the trunk position got a higher score than if it would have been straight. The legs were bent between 30 to 60 % which resulted in high leg scores. Therefore, the total neck, trunk and leg score became high. The arm was raised above the shoulders, thus the upper arm position scored high. The lower arm was not in its most natural position and also scored high, resulting in high arm and wrist scores. The total REBA score for the task was therefore high with the classification "high risk" task. REBA suggested investigation and that change should be implemented.

RULA identified high arm positions and lower arm positions that scored high. The wrist was bent and twisted, increasing the total wrist and arm score. The neck was bent forward resulting in a high neck position score. The trunk was straight and the legs were supported, giving low trunk and leg scores. Because of the low trunk and leg scores the total neck, trunk and leg scores were low. The total RULA score landed in the category of further investigation and that the task should soon be changed.

KIM 3 was used to assess the standing posture under the truck while using the impact wrench. Forces used when using the impact wrench varied between moderate forces to "peak" forces. The "peak" forces increased the force score. Some hand and arm positions were unfavourable, giving scores to the arm and hand position. The work conditions were usually good but somewhat cramped for this task, resulting in scores for work condition. High scores were given for a bad working posture. The total time for the task was about two hours and

this gave very low time scores that kept the total KIM 3 score down. The total KIM 3 score indicated a moderate load situation and that overload was possible for people with lower physical strength.

After the impact wrench a torque wrench was used and REBA identified upper arm position above shoulder with raised shoulders, resulting in high upper arm position scores. The lower arm position and wrist were in natural positions that gave low scores. The neck and trunk positions scored low since they were almost straight. The legs were however not supported by both feet when tightening the bolts with the torque wrench, resulting in a higher leg score. The upper arm position and the leg position increased the total REBA score, resulting in a medium risk activity with the recommendations of further investigation and a change soon.

HARM identified high forces exerted by the mechanic when using the torque wrench, giving high scores in the force category. During the task the head was bent forward 10 to 50 % and the upper arm was bent forward 10 to 50 %, resulting in moderate scores for head/neck and shoulder/arm positions. The arms were fully stretched when pushing the torque wrench, and this was done 10 to 50 % during the task, resulting in moderate scores on the lower arm/forearm positions. The total time for the task was less than one hour, resulting in the lowest time score. This kept the total HARM score down and the task was not seen as risky for the arm, neck and shoulder.

4.3 Hand

During an interview with Cecilia Berlin, certified Europe ergonomist, she stated that all positions/postures are bad using a vibrating hand tool.

4.3.1 Designing hand tools and hand held vibrations

Many of the persons in the GB workshop have more or less serious injuries due to handheld vibrations. Symptoms like white fingers and numbness are common when speaking to the mechanics and several of them have been through surgeries due to the hand injuries. A lot of them are middle-age and have worked as a mechanic all their life but started out as mechanic in a production line. The more knowledge we have gained about injuries due to handheld vibrations, the more regulations have emerged, resulting in a more focus on better handheld vibration tools.

The handheld tools, impact wrenches, that they are using today is of the brand Ingersoll Rand and is an impact wrench that exposes the hand to vibration values between 3.1 and 5.9 m/s² depending on the tool size used. One of the mechanics has an impact wrench of the brand Rodcraft with a vibration value of 7.9 m/s².

Atlas Copco is one of the suppliers of technical and mechanical tools to Volvo Group. They have many different models and within the large assortment, impact wrenches, pneumatic nutrunners and pulse tools. Some of the several models of the pneumatic nutrunner are vibration free. These so called pneumatic nutrunners use another bolt connected, or take support on beams or other attached objects in the near surrounding, in order to use their

force to loosen bolts. They are more ergonomic for the hand since they reduce the vibrations transferred to the hand to less than 2.5 m/s^2 .

After research and with requirements from the mechanics the project group have found several tools that can replace the current ones and that are even or more suitable from an ergonomic point of view; minimizing the vibrations value and sound pressure. The brand that the project group found that are used for professionals are Ingersoll Rand (used today), Rodcraft (used today by one mechanic) and Atlas Copco (pneumatic nutrunner used today). Since it depends on which size of tool used the values also vary a lot.

After a visit to the auto fair in Gothenburg in January the project group found a lot of additional brands that was said to be equal to the ones found. The project group also learned that depending on how the measurement of the vibrations is performed the value can differ a lot, therefore it is hard to trust the manuals. The project group also found special gloves that absorb the vibrations and spare the user's hands when using a hand vibrating tool. The gloves are equipped with quilted palm and the fingertips are possible to remove since the gloves are perceived as a bit ungainly due its quilted palm. This is an easy and cheap way to assure that the risk is lowered to a minimum.

The project group found a calculator for calculating daily vibration exposure on the Swedish Work Environment Authority. On the webpage 'Arbets - och miljömedicinbloggen', that is a serious blog where all the bloggers have a relevant education, e.g. leg physiotherapist and certified professional and environmental hygienist, as well as work experience. Here Per Leandersson (2015), toxicologist at work- and environmental medicine, says that since the hand vibrating tool has been measured in ideal conditions the value in the user manual should be doubled to reflect the usage of the tool in real life. Therefore, the calculations done with the calculator has been multiplied by two.

Brand	Model	Weight [kg]	Vibration [m/s ²]	Vibration value*2 [m/s ²]	Action value [2.5 m/s ²] Time [h:min]	React value [5.0 m/s ²] Time [h:min]
IR 3/8"	2115 QTIMAX	1.1	3.1	6.2	01:15	05:06
IR 3/8"	2102XP	0.62	4.4	8.8	00:38	02:32
IR 1/2"	2135 QTIMAX	1.8	5.3	10.6	00:26	01:45
IR 1/2"	2125 QTIMAX	1.1	3.1	6.2	01:15	05:06
IR 3/4"	2141S	3.2	5.9	11.8	00:21	01:25
IR 1"	2155 QTIMAX	3.3	5.9	11.8	00:21	01:25
RC 3/8"	RC2177	1.25	7.9	15.8	00:12	00:48
RC 1/2"	RC2277	2.0	9.2	18.4	00:09	00:35
AC ErgoP. 3/8"	EP8XS HRX10	1.0	3.0	6.0	01:21	05:27
AC ErgoP. 3/8"	EP8PS HR10	1.0	4.1	8.2	00:43	02:55
AC ErgoP. 3/8"	EP8PTX70 HR10-RE	1.2	3.5	7.0	00:59	04:01
AC sl�ende 1/4"	W2110	0.98	7.0	14	00:15	01:01
AC ErgoP. 1/4"	EP8XS HRX42	1.0	2.8	5.6	01:32	06:16
AC sl�ende 1/2"	W2216	2.5	6.1	12.2	00:20	01:20
AC sl�ende 1/2"	W2815	2.0	7.9	15.8	00:12	00:48
AC sl�ende 1/2"	W2815 XP	2.7	4.6	9.2	00:35	02:19
AC ErgoP. 1/2"	EP14XS HR13	2.4	4.0	8.0	00:46	03:04
AC ErgoP. 1/2"	EP10XS HR13	1.3	4.6	9.2	00:35	02:19
AC ErgoP. 1/2"	EP9PTX80 HR13-AT	1.5	5.6	11.2	00:23	01:34
AC ErgoP. 1/2"	EP12XS HR13	1.6	6	12.0	00:21	01:22
AC ErgoP. 1/2"	EP10PTS90 HR13-AT	1.8	4.8	9.6	00:32	02:08
AC ErgoP. 1/2"	EP12PTS150 HR13-AT	2.5	4.7	9.4	00:33	02:14
AC ErgoP. 1/2"	EP10PTS90 HRF13-RE	1.8	4.8	9.6	00:32	02:08
AC ErgoP. 1/2"	EP12PTS150 HR13-RE	2.5	4.7	9.4	00:33	02:14
AC sl�ende 3/4"	W2220	6.3	9.2	18.4	00:09	00:35
AC sl�ende 3/4"	W2219	5.1	5.4	10.8	00:25	01:41
AC sl�ende 3/4"	W2820	3.8	7.9	15.8	00:12	00:48
AC sl�ende 3/4"	W2820 XP	4.5	6.5	13.0	00:18	01:10
AC ErgoP. 3/4"	EP15PTX250 HR20-AT	3.1	6.5	13.0	00:18	01:10
CP 1/2"	CP6748EX-P11R ATEX	2.4	8.7	17.4	00:10	00:39
CP 1/2"	CP7736	2.58	9.5	19.0	00:08	00:33
CP 1/2"	CP7733-F	2.54	7.9	15.8	00:12	00:48
CP 1/2"	CP6748EX-P11R ATEX	2.4	8.7	17.4	00:10	00:39
CP 1/2"	CP7749	1.8	10.9	21.8	00:06	00:25
CP 1/2"	CP7748	2	10.1	20.2	00:07	00:29
CP 1/2"	CP7748TL	2.2	4.8	9.6	00:32	02:08
CP 3/4"	CP6768EX-P18D	4.4	9.4	18.8	00:08	00:34
CP 3/4"	CP7630	4.8	9.8	19.6	00:07	00:31
CP 3/4"	CP6763	5.5	9.4	18.8	00:08	00:34
CP 3/4"	CP7769	3.4	12.6	25.2	00:04	00:19

Table 2. The calculated vibration value for different hand vibration tools. The "Action value" is the max recommended value and the "React value" is the value that the manager must do something.

4.3.2 Benchmarking

Three mechanics in the workshop were asked to describe what kind of tools they used and what specifications those tools had. The mechanics will be regarded as customers of the product in this case since the benchmarking will try to identify similar or better products on the market. In the table 3, we find the tool used today (current) in the left column to the right of the specifications. To the right of the current tool are other tools on the market. Many other tools were identified but only the ones that were within the requirements and specifications of the customer's needs were included in the tables below. Different specifications were included in the comparison were two are of special interest, vibrations and weight. These were seen as most the important factors when deciding what tools to use after interviewing the mechanics who stated that they preferred light and low-vibrating tools, and due to research, that states that vibrations and heavy loads is not good for the hands. These specifications are for the mechanics and group manager of the GB workshop, to be able to compare current tools to other tools on the market.

Customer 1		Current	Alt 1	Alt 2	Alt 3
Impact wrench	[brand, size]	IR ½"	CP 1/2"	AC <2.5 1/2"	AC <2.5 1/2"
Model	[model]	2125QT	CP7748TL	LTP61 HR170-13	LTP61 HR170-13-MT
Bolt capacity		M14	-	M14	M14
Free speed	[r/min]	15000	8200	1100	1100
Max. torque	[Nm]	340	96	170	170
Max. loosening torque	[Nm]	450	1250	170	170
Sound pressure	[dB]	89.7	86	80	80
Vibration value	[m/s ²]	3.1	4.8	<2.5	<2.5
Weight	[m/s ²]	1.1	2.2	3	3.3

Customer 2		Current	Alt 1	Alt 2	Alt 3	Alt 4
Impact wrench	[brand, size]	IR 1/2"	AC slående 1/2"	AC slående 1/2"	AC ErgoP. 1/2"	AC <2.5 1/2"
Model	[model]	2135 QTIMAX	W2216	W2815 XP	EP14XS HR13	LTP61 HR170-13-MT
Bolt capacity		M14	M16	M16	M14	M14
Free speed	[r/min]	9800	7000	7400	3500	1100
Max. torque	[Nm]	746	720	1085	-	-
Max. loosening torque	[Nm]	1054	640	680	160	170
Sound pressure	[dB]	94.2	93	94	85	80
Vibration value	[m/s ²]	5.3	6.1	7.9	4	<2.5
Weight	[kg]	1.8	2.5	2	2.4	3.3

Customer 3		Current	Alt 1	Alt 2
Impact wrench	[brand, size]	AC ErgoP. 1/2"	AC <2.5 1/2"	AC <2.5 1/2"
Model	[model]	EP14XS HR13	LTP61 HR170-13	LTP61 HR170-13-MT
Bolt capacity		M14	M14	M14
Free speed	[r/min]	3500	1100	1100
Max. torque	[Nm]	160	170	170
Max. loosening torque	[Nm]	160	170	170
Sound pressure	[dB]	85	80	80
Vibration value	[m/s ²]	4	<2.5	<2.5
Weight	[kg]	2.4	3	3.3

Table 3. Benchmarking different hand tools.

5 Discussion

In this chapter we will discuss the results and the evaluation methods, combined with theory and our thoughts on the matter.

5.1 Present State

This chapter discusses some differences between production line and development workshop, and the present ergonomic state in the development workshop. Here research question one will be answered.

5.1.1 Differences between development workshop and production line

After talking with Mikael Schröder we can say that the ergonomic focus has not been in development workshops like the GB workshop. This because that they have an ergonomist from Alviva AB out in Tuve that works daily with improving the work environment while in GB the manager must make a request for them to investigate. Although different, the tasks taken place are usually similar in the two work environments. There are obvious advantages of working in a development workshop compared to a production line. Just to mention a few, there are not as much repetitive work where, even if they change tasks at the production line, they do not repeat the same task over and over again. Here the largest advantage that can be mentioned is the problem solving, flexibility and more freedom during the performance. The mechanics can choose in which order to do the task and take shorter breaks when needed. One of the mechanics told us that he "...has the best job in the world" due to the flexibility and problem solving. Since the work in the development workshop is perceived to be less wearisome and repetitive it is easy for both mechanics and outsiders to neglect the ergonomic risks. Because of the non-repetitiveness there seems to be a prevalent thought that certain postures or positions are acceptable even if they are bad from an ergonomic point of view. It is important to understand that although not repeated often, movements and postures can still be dangerous. Moreover, nowadays we tend to retire in later ages, exposing the body to greater risks if not properly taken care of. By performing ergonomic studies in the workshop and educating the mechanics and their managers we believe that much can change for the better in the workshop environments. This by bringing someone to tell them how to work in an ergonomic way, to give them the possibility of being able to affect their own work environment is the most important thing. Giving them the knowledge is a first step towards a more ergonomic work environment.

Therefore, we see the importance of a continued focus on workshops like GB. Not only is it important to educate the personnel but also influence them to act accordingly and provide them with the tools necessary.

The advantage of working in a development workshop compared to a production line is the non-repeating activities. Although you may repeat some tasks during the day or during the week you do not repeat the same task hour after hour like in the production line. From a vibration point of view this is good, it means that the mechanics in the workshop have the chance to rest the hand between certain tasks. This means that one could argue that it would be acceptable to use vibrating hand tools that have high vibration values since the tool only will be used for a couple of minutes. Someone from the auto fair in Gothenburg also reasoned this way. However, we think that it is better to always bring the vibrations to a minimum independent of how much the individual uses the tools. This not only prevents the mechanic from getting handheld injuries but it also sets the ergonomic standard in the workshop. It would be easy and cheaper to allow one big vibrating tool that only is used for certain jobs and not very often. In our case, we saw that one mechanic in particular had a very big impact wrench that he used for certain tasks. In the long run, if continuing using it, he might face hand injuries like numbness and white fingers. In the production line at Tuve, the vibrating equipment is monitored very well. The ergonomists know exactly what kind of tools are used, how they are supposed to be used and so forth in order to minimize the risks and increase satisfaction among the operators. In the GB workshop it is the manager that is responsible for the tools and equipment bought and used. Since it is easier to motivate a purchase for a more ergonomic tool in a production line than in a development workshop it is a dilemma for the manager, between economy and ergonomics.

Berlin and Adams (2017) discuss the problem with designing a workplace that fits all the employees. Compared to the production where you have many operators on one station, there is only one mechanic at one ship in the GB workshop. At the production line there are several operators that have to cooperate, working on the same product and using the same tools and equipment. You can not simply adjust the workplace to one person with one type of prerequisites but you have to think about the larger population. However, in the GB workshop you actually have the chance to adjust the workplace to the mechanics since they mostly work alone in their specific ships. This is also an advantage when working in a development workshop and connects to the flexibility of the work.

It is important that the employer follows ergonomic standards and ensures that work environment is good. We have earlier talked about the importance of not accepting one standard solution for the work environment since there are many different people with different prerequisites. We hope this will motivate companies to invest more in the employees and make the workplace possible to change, being able to customise for different people. The manager at the GB workshop wants a diverse work team which includes gender and not only age, experience and culture differences. So for the manager it is especially important to see how they can improve the work environment to be able to include women in the workshop. However, instead of attracting a diversity of people companies might want to save money, time and effort and only recruit similar people in order to motivate "a good ergonomic working area".

5.1.2 Body postures

We chose tasks that frequently were performed in the workshop and this means that there might exist other interesting and harmful positions that we have not studied. When looking at the video recordings from the tasks studied we selected postures and movements that we thought were harmful and suspected posed risk for injuries. Some positions that we thought were harmful turned out not to be and in the same way it could be the opposite, that we have missed some positions or movements that could have been harmful. We have also interviewed the mechanics to understand what positions or tasks that they suspected to be harmful. Unfortunately, we did not have the possibility to look at the same task performed by different mechanics so it is hard to draw definite conclusions. The mechanics are individuals and perform task differently, both in performance and how much they care for their bodies ergonomically. Important to remember is that we are not experts in the ergonomic area and many of the methods state that you need to have experience in the specific task evaluated. A deeper knowledge of the different tasks and a longer experience within ergonomics would therefore have been beneficial. But since we had an open approach to all situations and tasks our inexperience might have found aspects that an experienced would have missed.

From the results we found some tasks that were given the recommendations to further investigate and/or change due to the ergonomic conditions when performing the task. The evaluation methods, especially REBA and RULA, identified some risky hand and arm postures during some tasks. Example of tasks are changing the engine, changing the tyre and changing the anti-roll bar and air springs. The reason behind the bad hand and arm postures were often related to inconvenient work areas. When changing the engine, the mechanic had to stand in an awkward position since there was very limited space to stand in. This not only forced the mechanic to have a forward bending trunk but also meant hand and arm postures far away from the body, working outside the power zone. Another posture commonly seen was arms stretched above the shoulder in order to attach or loosen bolts using e.g. an impact wrench under an elevated truck. Instead of using the strength of the whole body the hand and arms have to carry the weight of the tool and exert force when the body and arms are in a weak position.

Volvo Group standard states that the operator should be able to work in a comfortable posture 80 % of the task. According to the standard, lifted arms and raised shoulders are not comfortable positions but these types of postures were seen several times throughout different tasks. Neither were the arms close to a neutral position as recommended by standards. The evaluation methods identified some tasks involving neck and trunk postures that scored high values. Examples are changing the battery, changing the engine and building the chassis. As for the hand and arms, the reason behind these bad work postures were mostly inconvenient work areas. When changing the battery, the mechanic lay on a board with wheels down on the ground and in order to reach the necessary components he twisted the back upwards. When changing the engine, the trunk was forward bent for quite a while, making it a very static position for a longer time. When identified, the neck and trunk were usually bent forwards or backwards, sometimes side bending or twisted simultaneously. The standard mentions that a good body posture is when the body's muscles and joints are exposed to outer forces when close to a neutral position, relaxed and standing upright. Although the mechanics

use tools and equipment during their work it seems like it is more often the postures that are problematic and not the weight of the tools and equipment they are using or handling. The bad postures in combination of carrying loads does not improve the situation but the underlying problem seems to be the postures. Some bad leg postures were identified but the area that was overrepresented in our study was the upper body: hand, arms, neck and trunk. This indicates that a change needs to be done to improve the work conditions for the mechanics, especially in the upper body area.

Berlin and Adams (2017) describe some factors that affect our body postures: space, vision, stress and protective clothing. In our case we clearly see how space is a factor that affected the body postures of the mechanics. Many times when the evaluation methods scored high it was because the mechanic stood in an awkward posture due to the space in which he was working in. Sometimes the space was too narrow or the truck was elevated in a way that did not suit the mechanic in a good way. Either way, to change the space to get a better ergonomic situation can be tricky depending on different factors. In some cases it would require a change of the truck since the design of the truck might interfere with the mechanics working area. For instance, this was the case with one mechanic when he was working on the engine change. In order to reach the engine he had to stand on and between the wheel and engine. Many times, the mechanics have to come up with their own ideas for getting around obstacles on the truck in order to reach the desired components. These kind of 'space' obstacles, or preconditions, can sometimes be dealt with. For example, instead of standing on and between the wheel during the engine change the mechanic could have taken away the tyre, thus gaining more area to operate on. Although, it might not always be possible to remove parts to get the desired space. To remove parts, for instance the tyre, would be time consuming.

Extra tools and equipment might be needed and the task becomes bigger and takes longer time. If the mechanic is working under strict deadlines he or she might not find it motivating enough to make more space, or make a 'better' space. Another aspect of space is the equipment and tools they use. If the equipment is unwieldy it can prevent the mechanic from having a good ergonomic posture while working. For example, when elevating the truck the mechanics use certain lifts placed at the tyres of the truck. The mechanic often has to work under the truck and reach components above the head, e.g. when changing anti-roll bar and air springs. In this case, adapting to the preconditions means that the mechanic has outstretched arms above the shoulders for a longer time which is a bad ergonomic posture. Important here is to take the extra time and planning needed to ensure good ergonomic postures. Yet another aspect of space is the actual environmental space where the mechanic stands and works, e.g. the size of the workshop. This is probably the hardest area to change since you can not simply change a building, structure or size.

There is the aspect of having a workshop that fits all body types and sizes. The instruments used might be very good and within ergonomic standards without paying attention to the actual workers in the environment. We know from literature that it is impossible to design a workplace that fits a 'standard' person. Instead, the focus should be on the needs and capabilities of the collective and not on the mere individual. We see some good examples of this in the GB workshop: from a selection of tools the mechanics are allowed to order their own impact wrenches depending on their own preferences. We have also seen times where it has been more problematic. When changing anti-roll bar and air springs two mechanics were working

on the task simultaneously. While one was bending the trunk forward over the chassis in order to drill holes the other one was drilling holes on another place with the trunk more upright. The easy fix would be to change the height of the truck with the lifts so that a more comfortable posture would be achieved. However, this would be more time consuming.

Vision is another factor that affects your posture along with work environment. This has been evident when the mechanics have been working under trucks or in darker areas of the truck and where shadows are created. In order to see, especially details, the mechanics use torch lights or headlamps. Several times we have seen how the mechanics are troubled by the lack of light when they operate in darker areas. From an ergonomic point of view this means reaching out a little bit further, or to bend the trunk forward a little bit more in order to see better. The United States Department of Labor, Occupational Safety and Health Administration (OSHA) write about how small reaching or bending movements can affect the body negative if done incorrectly. The extra effort to see well can, if occurred repeatedly, lead to injuries. Another dimension of the vision is how visible the components are. For example, when changing the battery, the line of vision was blocked by other components. Improving the vision can sometimes be hard when working on a truck since it is a complex product. Methods like design for assembly could improve this but the responsibility is often at the manufacturing engineers. However, one should consider the difference in assembling a truck in an assembly plant to disassembling the truck in the GB workshop. Although easy to assembly might not necessarily mean easy to disassembly. Working with such a complex and big product like a truck it is unavoidable to have complex disassembly solutions. In this matter, the mechanics do not have much input, making it hard to change the situation. The last factor is protective clothing that the mechanics wear to help them stay clean when working in dirty environments. From an ergonomic perspective this is good since it enables the mechanics to for example handle heavy loads next to the body instead of carrying the loads away from the body in order to stay out of dirt.

Studies show that individuals feel well and develop if they are able to influence the setup and the carrying through of the task (AFS 2012:2). If the mechanics were proper educated with the risks and benefits of certain movements and postures they would be able to have a greater proper influence in the planning of tasks, purchase of tools and equipment, and regarding other activities taking place in the workshop. Not only does it make the worker more engaged in their work but it also prevents musculoskeletal diseases (MSDs). For example, many of the mechanics suffer from white fingers because of the use of vibrating hand tools. If proper education and influence over his/her work was given the mechanic would be able to make sure that the work at hand is ergonomic good in areas like choice of tools and equipment that vibrate within the exposure limit.

We recommend that the manager should follow the created checklist to improve and eliminate the risk of injuries (see Appendix VII) but we also found a more general checklist on the Swedish Work Environments webpage. As a complement to the checklist we also recommend the manager to invite someone to lecture about how they can reduce risks and hazards by working in a more ergonomic way and how to take care of their bodies. Since the mechanics do not have a history of quitting it could be a challenge when one new employee is introduced so another recommendation is to have an ergonomist stationed at Lundby so that it is easy to inform and make requests. Also for being able to follow-up the work and contribute to an increased focus in development workshops.

It is also important to listen to the mechanics' suggestions and thoughts, due to their experience of different tasks, and when necessary be two persons on an order. Some tasks require more force and are more demanding than others, and at the same time they might require a lot of problem solving. This is positive since it gives the mechanics short breaks between the hard work and thought process of how to solve the next step.

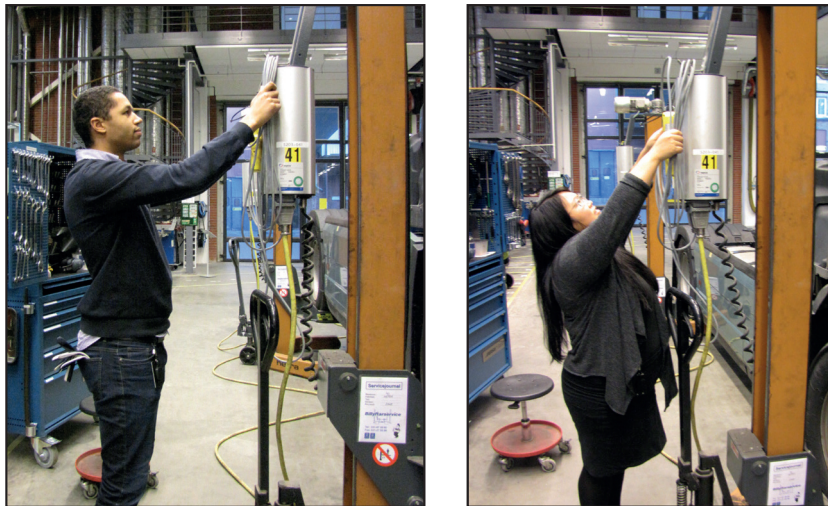
5.1.2.1 Gender differences

By including more female mechanics in the workshop the diversity increases in one area, this area was important to the GB workshops manager and will therefore be addressed a little further. The largest challenges when including more women in this environment are according to us the gender roles, that hinders the women's interest. Due to the gender role there are not a lot of women that might be encouraged to develop their interest for this particular part of work, mechanics, and therefore not apply to these educations. Another challenge is to attract them to choose a heavier industry that the automotive industry general is, and also attract them to trucks which is even a heavier vehicle than cars. We think that one way of boosting the interest is to be present at both fairs when applying to upper-secondary schools as well as career fairs if the school provides one. This way students know that there exist work opportunities in the area and that they are attractive for the employer. Also include internships and summer employments for the possibility to try out the work. We think it could overall increase the amount of appliance and close the gap between the education/training and companies like Volvo Group. We can read on the webpage for 'Gymnasiedagarna' (2017) that Volvo Group will be present at the fair but their focus is divided and does include more areas than just educations for mechanics. We do not know how they handle the split focus and maybe they have someone there to represent the company from the mechanic's perspective. But if not we think that it would be most beneficial for Volvo Group to have someone that could represent and answer questions in the same way they have other representatives from other areas.

Because of the lack of females the tools have not been developed to fit a woman's hand. This might be a vicious circle: the females that choose to be mechanics do not feel comfortable with the different hand tools and the heavy work it contains resulting in lack of female mechanics. Due to the domination of men the hand tools are designed for larger hands and reducing the weight is not the first priority even though improvements have been done. We did however encounter smaller tools at the auto fair, e.g. a tool that was designed with a missing back part making it more front-heavy. Since a requirement when designing hand tools described by Berlin and Adams (2017) was that the tool should be well balanced we do not think that these tools fulfil this requirement and are not suited even if the weight is reduced.

To be able to include more females in the workshop environment something must happen with the tools and equipment. One way is if the larger companies put pressure on the manufacturers of different hand held tools that the requirements should be widened e.g. lower the weight and reduce the size of the handle, but also make sure that all requirements when designing a hand tool is fulfilled as stated by Berlin and Adams (2017). It is important to purchase the hand held vibrations tools that are most suited and at the same time update all tools. Including women would justify investing money in tools that are adapted to different persons, e.g. small and big hands, and updating all tools to the best in all aspects, e.g. vibration, weight and noise.

One factor we saw that could hinder females in the workshop environment is height. The large difference in height between the average man and women is 113 mm and since these are just an average it can differ even more. There are some tasks that are dependable on height, e.g. to be able to lift the truck the mechanics must take off the cord from a hook and this hook is mounted high up on the elevator (see picture 9). Another task that is dependable on the mechanic's height is the possibility to be able to reach certain components as described in 'change engine'. Women also have 50-80 % of men's maximal muscle strength with the largest difference located in the upper extremities that effects e.g. grip strength. Another aspect is working in a team, that is recommended by us, and it can obstruct the work since a lot of the tasks involve working from underneath a truck and it might be harder to work in an ergonomic posture for both male and females. But of course this is a present challenge for the mechanics, even if most of them have the same height.



Picture 10. To the left "tall" man, to the right "short" women.

Another risk is to perform different tasks that today "always" have been performed in a certain way which requires more strength than other possible solutions. The manager wants the mechanics to rotate more and to be able to perform many different tasks that provides a diversification in what women, unlike men, can do as mechanics in a development workshop. From theory we saw that females generally worked with high repetitive tasks with a high degree of constrained neck postures whereas males worked with heavier loads but with more varied tasks. Prevalence of MSDs in the neck and upper body was also very much higher for females compared to males working with the same tasks. It would be easy for the manager to justify that women should work with lighter loads, but then the work might become more repetitive. Whether it concerns women or men, it is pretty clear that changing work is preferred. It is important to be open for new ways to perform different tasks and to be open minded, e.g. that women might not cope with tasks in the same way as men or that women can not do certain tasks due to physical differences. But instead of removing the women from certain tasks one can develop the way the tasks are performed and change the work environment.

5.1.3 Hands

From the results we see that the mechanics are exposed to some unfavourable hand and wrist movements as well as handheld vibrations. The hands, wrists and arms can very easy wear out or get injured during heavy work (Berlin and Adams, 2017). It is therefore important to limit these movements and vibrations as much as possible. Much of the work in the workshop requires precision and the hands are the perfect tools for this (Berlin and Adams, 2017). The only problem is that most of the times these precision works involve loads or high forces, something that is less favourable for the hand. We noticed that many tasks involved supination and pronation, flexion and extension or radial deviation and ulnar deviation of the hand and wrist. For example, when changing tyres, the hand/wrist was in a flexion motion repeatedly when using the pneumatic nutrunner. Moreover, if the mechanic does not have the right pre-conditions e.g. good space, forcing the mechanic to operate in a bad posture, the hands may be forced to compensate with using force. Heavy tools will automatically make it harder to maintain a good body posture, especially if they are used for a longer time. Even if the tools should be lighter in general we have also learnt that the lesser weight the more it vibrates, since the weight absorbs part of the vibrations. This was also one thing several of the mechanics thought or knew, e.g. a result was that one of the mechanics used the largest impact wrench in the workshop that the manager had forbidden to use for a longer period of time. However, one favourable aspect is that since GB is a development workshop the work is more free and the mechanics can take breaks when they feel tired and need a rest. But in contrary since the ergonomists are present at Tuve they can control the tools and ensure the latest model and solutions are used.

We think that many times the unwanted hand movements could be prevented by having good body postures in general. During the engine change scenario, the mechanic had to stand in an awkward posture in order to perform his work because of the narrow space operating in. As a natural consequence of the narrow space, the worker had a bad posture that complicated the hand gripping. This shows how important it is to have the right pre-conditions when working, in order to facilitate healthy and good postures.

The certified Europe ergonomist, Cecilia Berlin, stated that all postures involving vibrations are bad for the body. Most precision work is carried out with vibrating hand tools, e.g. an impact wrench, and these weigh different depending on the size of the tool used for that task. In the workshop all mechanics use vibrating hand tools, some more than others. Either way, the hand is exposed to vibrations. We can see the results of this, for example numbness and white fingers among the mechanics. Some of the tools are within the action value of 2.5 m/s^2 , in theory, but should preferably be replaced with new tools since they are wear out over time. In the long term we think it is important to have a plan for upgrading the tools to new and better models since the development advances and due to the wear out. The Volvo Group standard (STD 8003.2, 2009) states that the maximum weight for manual handling using one hand is 0.5 kg for overhand grip and 5.0 kg for underhand grip. Carrying more than 0.5 kg overgrip with one hand is not pleasant, depending on how strong you are. However, many of the tools used by the mechanics weigh more than 0.5 kg and are carried with an overhand/side grip, but not necessarily for a longer time. Since we found out that the vibration value also should be the double when calculated due to the wear out and that the measurements are performed in a confined and controlled environment the urge for changing the tools more frequently is more than just a recommendation. This also includes the need for a time plan when to replace tools. A short-term solution to decrease the vibration exposure could be to purchase protective equipment such as vibration reducing gloves. They do not have this glove in the GB workshop

but it was found during the auto fair we visited and since they use vibrating hand tools this could be seen as protective clothing that we discussed in the posture section. Another recommendation is to invest in a number of pneumatic nutrunners which do not vibrate since the mechanics change tires multiple times or have to loosen the bolts. For the time being, the mechanics have to share one pneumatic nutrunner which means that they only can use one at the same time, or that if the current one breaks they are without one. A larger torque leads to larger vibrations so by replacing the impact wrench used for loosening bolts with a pneumatic nutrunner would decrease the vibration exposure significant.

We have learnt that it is very hard to measure vibrations that is transferred into the hand and arm. It depends on factors connected to the individual's anatomy of the hand and arm. It can also depend on the age of the vibrating hand tool, which deteriorates over time. Since the planned measurements could not be performed within the time frame of the project we are limited to the theoretical and perceived result that was presented in the previous chapter regarding the hand.

5.2 Evaluation methods

This chapter discusses how the evaluation methods were used as an introduction for better understanding how they were used in the project. From this the report will discuss how well the methods did or did not suit a development workshop.

5.2.1 General

A prerequisite when performing the different evaluation methods was to have a very good understanding of the task being performed, rough estimations could lead to incorrect results. Prior to recording the different scenarios we familiarised ourselves with the mechanics, their work and the workshop to get as good understanding as possible of the work. Our focus was to study the ergonomics so an in depth study in the area was performed and the mechanics were observed. However, there are many mechanics in the GB workshop and they all have different work styles and body postures while performing certain tasks. In the time frame of the thesis work it was impossible to get a very in depth knowledge of all mechanics in several different scenarios. We had to select mechanics for different scenarios and then study them. In this way we got a very good understanding of the mechanics during certain tasks, e.g. person x at task 1, person y at task 2, person z at task 3 and so forth. This means that we can have missed aspects in postures and tasks that other mechanics not studied would have done or not have done.

We used similar methods for identifying risky body postures such as RULA and REBA. We saw this as a strength, having methods that complement each other. But in the same way the results from one method was strengthened by another method, the different methods had a greater focus on different aspects. Some methods, e.g. HARM, focused more on hand and arms and other methods, e.g. RULA, focused more on the upper body. So even though they were used on the same scenario different parts of the body were focused on, complementing the results. RULA and REBA were good to use to get an overview of the task being evaluated since they were straightforward and simple to use. However, it would be of interest to have a similar method with more in-depth. Although it is easy to understand what areas of the body that

generate the high scores the total score in RULA and REBA do not indicate what the problem area is, it only says e.g. 'further investigation, change soon'. The methods used only gave us an indication if the evaluated task was harmful or not and to which degree. We can, based on our knowledge, draw conclusion which movements in the task that were harmful but it would be preferable if the methods indicated that in the method. KIM 2 and KIM 3 was used in this study to evaluate movements/postures within certain categories. Both KIMs were easy to use with clear instructions. For example, KIM 2 had three steps and each step contained different categories depending on the execution of the task. Depending on the postures and weight of the obstacle being moved you just had to mark that category. Eventually you got the total score. However, KIM 3 was somewhat trickier, especially determining the type of force used during the task, e.g. it was hard to determine if it was a 'moderate' force or a 'big' force used due to the description of the differences. These methods and HARM both used time score to decide if the task performed was considered harmful and needed to be taken into action.

5.2.2 Applicability of evaluation methods

During our study we have noticed that the ergonomic evaluation methods many times suited a production line, where the same work is repeated the whole day and where it is easy to monitor what the operators do. They have not been as suitable for evaluating work performed in a workshop like the GB, development workshop, where most work is not repeated for a longer period of time. We can sense that the focus has changed throughout time due to the change of work environments. Ergonomics in work environments have expanded and widened in perspectives and almost all work is now covered and guidelines can be found at the Swedish Work Environment Authority. By including several work areas together with the uprise of many new professions and foremost that many companies' production lines have partly or totally moved abroad the focus have now shifted from the industry towards more e.g. desk related injuries. This might affect the introduction of new evaluation methods where we e.g. see a void within the methods for evaluating a development workshop.

Methods like RULA and REBA have been good to use in our scenarios since they more focused on the body postures. If there were any bad postures that imposed a risk for the body RULA and REBA has pointed them out and scored high. HARM and KIM have been good to study specific scenarios where tasks were more focused on hands, e.g. pushing, pulling or repetitiveness. For example, if we identified one task involving a lot of pushing we could use KIM 2 to evaluate if the pushing imposed risk for injuries.

The tasks being studied did not last for such a long time, mostly between one and two hours. This meant low time scores. Since the posture scores from HARM were multiplied with the time score to get the total HARM score, the total scores usually became very low. Even if there were individual postures that scored high in HARM it would not impact the total HARM results due to the low time score. This can be seen as positive since it means that the mechanics do not engage in a specific task for such a long time, lowering the risks for injuries. We should, however, not neglect the risk for injuries because of short time. Movements and postures done, even during a short time, can still damage the body if they are done incorrectly. However, RULA and REBA often got results that contradicted HARM and KIM 3. This mainly because RULA and REBA did not use time as a factor in the same way as HARM and KIM 3, instead they used repetitiveness as a factor and this could be seen as a complement to the time factor HARM and KIM 3 used. However, the repetitiveness factor in RULA and REBA did not impact

the total score as significant as the time factor affected the total results of HARM and KIM 3. The evaluation methods HARM and KIM 3 used the time factor how many hours the tasks were performed. HARM also used percentages to determine how long certain movements were held. While it is good to use both the time and percentage factor to estimate the degree of risk we have noticed some downsides with the methods as well. As we discussed earlier the time aspect makes so that the whole result becomes low if the task is not repeated for more than one hour. The percentage score depends on the duration of the task. Instead of solely looking at time and percentage, a recommendation would be to use the amount of postures/movements done during the task. For example, if the back was bent several times during an activity, the amount of movements could be specified and evaluated. No matter the time, one would easily see how many 'bent back' postures were performed during the task. One of the methods, KIM 2, used this kind of time score but it was restricted to pushing and pulling activities. We think that it is important to include time in evaluation methods since time is a factor that determines the load on the body. From the theory chapter we saw that $\text{load} = \text{time} \times \text{force} \times \text{posture}$. The mechanics work about eight hours a day with different tasks, e.g. drilling, carrying and pushing. All activities together would reach several hours but when evaluating certain tasks individually they seldom reached more than one hour. Adjusting the methods so that they contain time frames in minutes would also be a recommendation for better suiting this kind of tasks, or if there is a way to add time scores from different tasks into one total time. The latter idea, to add times, sounds very suitable to evaluate work environments like a development workshop. Then it would maybe not be as problematic to use current time factors that exist in e.g. HARM and KIM 3. For example, in our case it means that we would be able to evaluate one mechanic a whole day when he (all the mechanics are men at the time being) is working on several task. We would then probably identify similar postures and movements within the different tasks that add up to time that better fit the hourly interval that the evaluation methods use. Instead of only or barely reaching one hour we would maybe see times closer to hours and this would increase the scores in the evaluation methods, representing a more accurate picture of the situation compared to our results. But since the focus of the study was not to try new ideas or methods, this theory was not tested by the project group.

From both the Swedish Work Environment Authority, the interviewed Europe ergonomists and the auto fair we learned that vibration injuries have again increased during the last few years and therefore an increased focus on evaluating vibrations and prohibiting vibration injuries are called for. The only evaluation method involving vibrations was HARM, containing different vibration values and the evaluator chooses the vibration value the worker is exposed to. Due to optimal test conditions and that the hand tools wear over time, this value could be twice as high in reality than to the value described in manuals. If this is the case we think that the methods should take this in account, either by compensating the scores or by providing additional information. Generally, we think that all methods should contain vibrations in a greater extent since vibrations imposes a dangerous risk to the hands and the body, or that evaluation methods containing vibration as a factor should be included when studying ergonomics in these kind of environments. However, as we understood earlier it is hard to measure handheld vibrations since it requires complex equipment and the results will depend on tool and the individual. This complicates the matter and makes it harder to use simple evaluation methods to gain an understanding of how the vibrations impact the person. It is stated that all body postures combined with vibrations are bad for the body. This is true but we think that it is too easy to only say that. If we reason that all vibrations are bad, we think it is a risk that we only state it without actually doing anything about it. If, however, there were easier

ways to measure the harmfulness of vibrating tools we believe that it is easier to have action plans against vibrations. One might now reason that we just mentioned that all vibrations are bad so how come we need to measure how harmful they are? To simply state that vibrations are not good can still mean that someone uses a really bad vibrating tool. If we instead state how bad, e.g. on a scale, we believe it will be easier to motivate change and also create action plans, e.g. what should be prioritised.

When you lift something you often feel when it was too heavy and if you have bad luck you can damage your back. With other words, the pain and injury can come directly. When you deal with vibrating hand tools the injury always comes when the hand has been exposed to the vibrations for a longer accumulated.

6 Conclusion

The project group studied five different scenarios with help of evaluation methods to get a better understanding of the mechanic's work: change engine, change tyre, change battery, build chassis, and change anti-roll bar and air springs. RULA and REBA mostly focused on the upper body complemented with lower body regions, HARM focused on hand and arm intense activities, KIM 2 focused on push and pull activities and KIM 3 focused on the repetitiveness of work. Potential harmful movements and postures were identified and injuries among the mechanics like white fingers and body pain were found. The body parts that imposed highest risk for injuries were mostly found in the upper extremities: hand, arm, neck and trunk. The reason for this can be connected to inconvenient work areas. From the results the project group also saw that the mechanics were exposed to unfavourable hand and wrist movements as well as handheld vibrations. Therefore, the project group concludes that it is important to further improve the work environment in the workshop from an ergonomic point of view.

After gaining an understanding of the present state as well as the differences between a production line and a development workshop, conclusions could be taken regarding the applicability of the evaluation methods.

The evaluation methods used in the project were most suitable for a development workshop, based on research and recommendations from experts, and they were RULA, REBA, HARM, KIM 2 and KIM 3. The methods RULA, REBA and KIM 2 were all simple to use, very straightforward in their execution with pictures for better understanding the different postures and movements. RULA and REBA had an additional score which was connected to repetitiveness with little impact on the total score while KIM 2 used the number of repetitions as time score. The methods HARM and KIM 3 were more complicated to use and sometimes hard to understand. The results gained from HARM and KIM 3 often contradicted the results from RULA and REBA, the main reason was identified as how the methods used time scoring. Since the development workshop does not contain as much repetitive work as a production line the methods using time score based on intervals using hours are not seen as suitable for this environment. Due to this the project group sees the need for further development and adjustments of current ergonomic evaluation methods, to better fit the workshop and other work environments. Since one of the chosen areas was handheld vibrations one particular method including that area was recommended by an expert, HARM. The method has a vibration category that gives you a predetermined value depending on time (hours) and vibration value. From a vibration perspective the method is very general due to the lack of focus on vibration exposure. The project group learnt that it is very difficult to measure vibration exposure but at the same time it is very important because of the increased hand injuries caused by overexposure. Since the project group did not find additional methods to evaluate vibration exposure the master thesis concludes that there is a need for more evaluation methods with focus on handheld vibrations.

The master thesis only focused on physical ergonomics and excluded organisational and cognitive ergonomics. It is important to know and understand that all three aspects affect the ergonomics at work and that depending on their correlation it can increase or decrease the overall ergonomic state.

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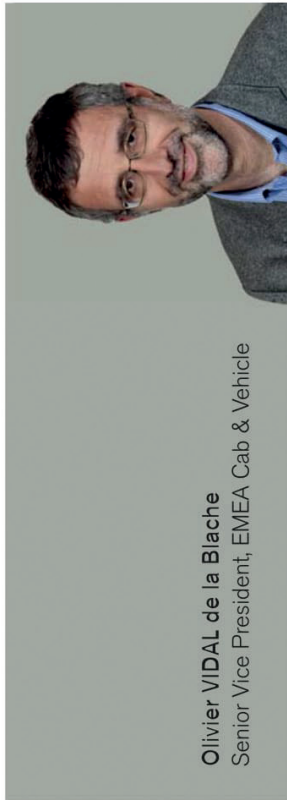
Appendix

Appendix I

Ergonomiska riktlinjer Volvo Group, 2015



LEDARE



Olivier VIDAL de la Blache
Senior Vice President, EMEA Cab & Vehicle

Ergonomi är ett tvärvetenskapligt forsknings- och tillämpningsområde som i ett helhetsperspektiv behandlar samspelet mellan människa-teknik-organisation i syfte att optimera hälsa och välbefinnande samt prestanda vid utformning av produkter och arbetssystem.

I överensstämmelse med koncernens strategi tillhandahåller Group Trucks Operations en stimulerande och hälsosam arbetsmiljö för sina anställda. Ergonomin är en av grundprinciperna inom Volvo Production System (VPS). Den främjar säkerheten och hälsan hos medarbetarna och bidrar samtidigt till högre effektivitet och produktivitet.

Framför dig har du de viktigaste ergonomiska rekommendationerna som sammanställts av våra experter. De bygger framförallt på deras erfarenhet och feedback från arbetet med projekt och processer vid de olika anläggningarna i Europa. Målet är att hjälpa dig att införliva ergonomin i förbättringen av våra tillverknings- och logistikprocesser.

Jag räknar med att du gör den här handboken till ett arbetsredskap i det dagliga arbetet för koncernens medarbetare.

Svenska avvikelser: För Sverige gäller Volvo Standard 8003.2 och Volvo Standard 860-0006 i de fall nivåerna i Volvostandarden skiljer sig från nivåerna i Memorandum.

x) = se Volvo Standard 8003.2, bilaga 1 sidan 48-49. **xx)** = Volvo Standard 860-0006.

Viktenhet: 1 daN = ca. 1 kg Nm = enhet för vridmoment och åtdragningsmoment

MEMORANDUM

Ergonomiska riktlinjer

Huvudsakliga rekommendationer

Det här dokumentet har utarbetats med hjälp av följande element:

- Volvos ergonomiska standard (8003.2)
- Franska och internationella standarder
- Dokumentation om ergonomi från olika företag

Dokumentet sammanfattar de viktigaste ergonomiska specifikationerna i dessa källor och innehåller några allmänna principer för hur man tillämpar ett ergonomiskt förhållningssätt vid utformningen av layout och konstruktion av arbetsstationer.

SAMMANHANG

Genom sina policyer för hälsa och säkerhet har Volvo förbundit sig att skydda sina medarbetares hälsa. I detta ingår att erbjuda bra arbetsförhållanden och att införliva kriterierna för hälsa, säkerhet och arbetsförhållanden i utformningen av företagets produkter och anläggningar.

MÅL

- Bistå i utformningen, genomförandet och förbättringen av arbetsstationer.
- Hjälpa ansvariga för tillverkningsprocessen och tillverkare att optimera driften av produktionssystem.

Det här dokumentet ska bifogas specifikationerna och leveransdokument.

För att kunna använda detta dokument måste ergonomiutbildning ha genomgått.

Beroende på vilka val som ska göras (t.ex. på fysiskt krävande områden eller i andra specialfall) kan det komma att krävas validering av en ergonomiexpert.

ALLMÄN INFORMATION

Utformningen av en arbetsplats anpassad till operatörernas arbete och egenskaper är en komplex process som kräver bästa möjliga balans mellan

- operatörernas kapacitet/ tekniska begränsningar
- investeringskostnader/driftkostnader.

TILLVÄGAGÅNGSSÄTT

- Beskriv troliga framtida aktiviteter.
- Fastställ karaktären, frekvensen och platserna för de olika operatörernas aktiviteter.
- Kontrollera arbetsställningar och arbetstygnd med hänsyn till antropometrisk data för varje berörd kategori (produktion, logistik, underhåll).
- Möjliggör lämpliga arbetsrörelser och enkla montering och materialhantering.
- Erbjud en ändamålsenlig arbetsplats vid långvarigt, repetitivt arbete eller arbete över axelhöjd.
- Undvik isolerade arbetsstationer/ensam arbete.
- Prioritera tydlig överblick och förståelse av utrustningens funktion och materialflödet.
- Se till att sikten över komponenten är god från stationen.
- Fastställ belysningsnivå anpassad efter varje arbetsplats/arbetsområde.
- Skapa en trafikflödesplan för operatörer, delar, komponenter, verktyg, oljor och färdter, avlopps- och avfallsprodukter. Denna ska sedan användas vid anpassningen av arbetsredskap och gångar.

Appendix II

Interview questions - mechanics

Swedish

Generellt

Anser du att det är ett 'tungt' jobb?

Varför/varför inte?

Hur många gånger har du utfört just detta arbetet?

Har du något utarbetat arbetssätt?

Tycker du att något är jobbigt? (ur ett ergonomiskt perspektiv)

English

General

Do you think this is a heavy job?

Why/why not?

How many times have you performed this particular task?

Do you have a specific approach?

Do you think something is tough? (from an ergonomic point of view)

Interview questions - Michael Schröder

Swedish

Kan du berätta hur man mäter handvibrationer?

Vad har ni för hjälpverktyg för mutterknackare, liknande eller inte?

Vad har ni för hjälpmedel vid tunga lyft?

- Är det andra än i GB?

"Hur" mäter ni tunga lyft?

Hur avskärmar ni buller?

- Hur håller ni ljudet nere?

Kan ni hjälpa oss att mäta bullernivån?

Kan ni hjälpa oss att mäta ljusnivån?

English

Can you tell us how to measure vibration exposure?

What kind of "help" do you have for impact wrenches, similar or not?

What kind of aiding tools do you have when it comes to heavy lifting?

- Other than in GB?

"How" do you measure heavy lifting?

How do you shield noise?

- How do you keep the sound/noise levels low?

Can you assist us in measuring noise?

Can you assist us in measuring the environmental light?

Interview questions - Cecilia Berlin

Swedish

Generellt

Vilka utvärderingsmetoder skulle du rekommendera för vår studie?

o Skulle du rekommendera OWAS?

Känner du till några bra utvärderingsmetoder för att utvärdera vibrationer i handen?

o Kan man använda PLIBEL för att utvärdera vibrationer i handen?

Vad är intressant när man studerar olika kroppställningar? Vilka faktorer spelar in?

English

General

What evaluation methods would you recommend for our study?

o Would you recommend OWAS?

Do you know of any good evaluation methods for handheld vibrations?

o Can you use PLIBEL to evaluate vibrations in the hand?

What is of interest when studying different body postures? What factors are important?

Appendix III

RULA - Rapid Upper Limb Assessment

RULA Employee Assessment Worksheet

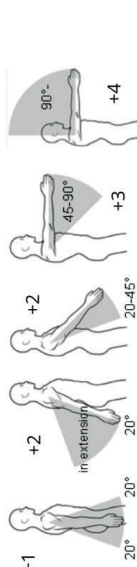


Date:

Task Name:

A. Arm and Wrist Analysis

Step 1: Locate Upper Arm Position:



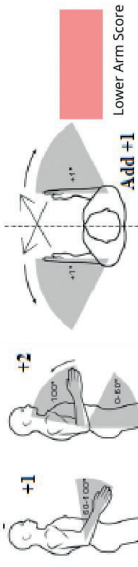
Step 1a: Adjust...

If shoulder is raised: +1

If upper arm is abducted: +1

If arm is supported or person is leaning: -1

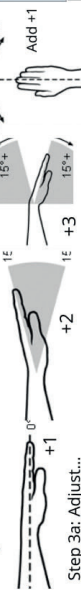
Step 2: Locate Lower Arm Position:



Step 2a: Adjust...

If either arm is working across midline or out to side of body: Add +1

Step 3: Locate Wrist Position:



Step 3a: Adjust...

If wrist is bent from midline: Add +1

Step 4: Wrist Twist:

If wrist is twisted in mid-range: +1

If wrist is at or near end of range: +2

Step 5: Look-up Posture Score in Table A:

Using values from steps 1-4 above, locate score in Table A

Step 6: Add Muscle Use Score

If posture mainly static (i.e. held > 10 minutes),

Or if action repeated occurs 4X per minute: +1

Step 7: Add Force/Load Score

If load < 4.4 lbs. (intermittent): +0

If load 4.4 to 22 lbs. (intermittent): +1

If load 4.4 to 22 lbs. (static or repeated): +2

If more than 22 lbs. or repeated or shocks: +3

Step 8: Find Row in Table C

Add values from steps 5-7 to obtain

Wrist and Arm Score. Find row in Table C.

Scores

Table A		Wrist Score			
		1	2	3	4
Upper Arm	Lower Arm	Wrist Twist	Wrist Twist	Wrist Twist	Wrist Twist
1	1	1	1	1	1
2	2	2	2	2	2
3	3	3	3	3	3
4	4	4	4	4	4
5	5	5	5	5	5
6	6	6	6	6	6

Table C

Wrist / Arm Score		Neck, Trunk, Leg Score						
		1	2	3	4	5	6	7+
1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9
10	10	10	10	10	10	10	10	10

Scoring: (final score from Table C)

1-2 = acceptable posture

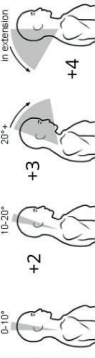
3-4 = further investigation, change may be needed

5-6 = further investigation, change soon

7 = investigate and implement change

B. Neck, Trunk and Leg Analysis

Step 9: Locate Neck Position:



Step 9a: Adjust...

If neck is twisted: +1

If neck is side bending: +1

Step 10: Locate Trunk Position:



Step 10a: Adjust...

If trunk is twisted: +1

If trunk is side bending: +1

Step 11: Legs:

If legs and feet are supported: +1

If not: +2

Table B: Trunk Posture Score		Posture Score					
		1	2	3	4	5	6
Neck	Legs	Legs	Legs	Legs	Legs	Legs	Legs
1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6

Step 12: Look-up Posture Score in Table B:

Using values from steps 9-11 above, locate score in Table B

Step 13: Add Muscle Use Score

If posture mainly static (i.e. held > 10 minutes),

Or if action repeated occurs 4X per minute: +1

Step 14: Add Force/Load Score

If load < 4.4 lbs. (intermittent): +0

If load 4.4 to 22 lbs. (intermittent): +1

If load 4.4 to 22 lbs. (static or repeated): +2

If more than 22 lbs. or repeated or shocks: +3

Step 15: Find Column in Table C

Add values from steps 12-14 to obtain

Neck, Trunk and Leg Score. Find Column in Table C.

RULA Score

Appendix IV

REBA - Rapid Entire Body Analysis

REBA Employee Assessment Worksheet

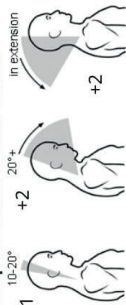


Date:

Task Name:

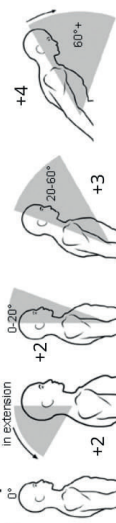
A. Neck, Trunk and Leg Analysis

Step 1: Locate Neck Position



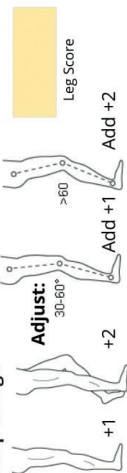
Step 1a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

Step 2: Locate Trunk Position



Step 2a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

Step 3: Legs



Step 4: Look-up Posture Score in Table A

Using values from steps 1-3 above,
Locate score in Table A

Step 5: Add Force/Load Score

If load < 11 lbs.: +0
If load 11 to 22 lbs.: +1
If load > 22 lbs.: +2
Adjust: If shock or rapid build up of force: add +1

Step 6: Score A, Find Row in Table C

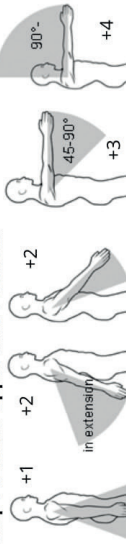
Add values from steps 4 & 5 to obtain Score A.
Find Row in Table C.

Scoring

1 = Negligible Risk
2-3 = Low Risk. Change may be needed.
4-7 = Medium Risk. Further investigate. Change Soon.
8-10 = High Risk. Investigate and Implement Change
11+ = Very High Risk. Implement Change

B. Arm and Wrist Analysis

Step 7: Locate Upper Arm Position:

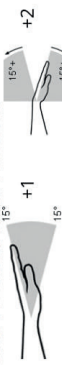


Step 7a: Adjust...
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

Step 8: Locate Lower Arm Position:



Step 9: Locate Wrist Position:



Step 9a: Adjust...
If wrist is bent from midline or twisted: Add +1

Step 10: Look-up Posture Score in Table B

Using values from steps 7-9 above, locate score in Table B

Step 11: Add Coupling Score

Well fitting Handle and mid rang power grip, **good: +0**
Acceptable but not ideal hand hold or coupling acceptable with another body part, **fair: +1**
Hand hold not acceptable but possible, **poor: +2**
No handles, awkward, unsafe with any body part, **Unacceptable: +3**

Step 12: Score B, Find Column in Table C

Add values from steps 10 & 11 to obtain Score B. Find column in Table C and match with Score A in row from step 6 to obtain Table C Score.

Step 13: Activity Score

+1 1 or more body parts are held for longer than 1 minute (static)
+1 Repeated small range actions (more than 4x per minute)
+1 Action causes rapid large range changes in postures or unstable base

Scores

Table A	Neck											
	1				2				3			
Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk	1	1	2	3	4	1	2	3	4	1	2	3
Posture	2	2	3	4	5	3	4	5	6	4	5	6
Score	3	2	4	5	6	4	5	6	7	5	6	7
	4	3	5	6	7	5	6	7	8	6	7	8
	5	4	6	7	8	6	7	8	9	7	8	9

Table B	Lower Arm											
	1				2				3			
Wrist	1	1	2	2	1	2	2	2	1	2	2	2
Upper Arm	2	1	2	3	2	3	4	4	3	4	5	5
Score	4	4	5	5	4	5	5	6	7	7	8	8
	5	6	7	8	7	8	8	9	8	9	9	9

Score A	Table C											
	Score B											
1	1	1	1	2	3	4	5	6	7	8	9	10
2	1	1	2	3	4	5	6	6	7	7	7	7
3	2	3	3	4	5	6	7	7	8	8	8	8
4	3	4	4	5	6	7	8	8	9	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	10	10	11	11	11	11
8	8	8	8	9	10	10	10	10	11	11	11	11
9	9	9	10	10	11	11	11	11	12	12	12	12
10	10	10	11	11	11	12	12	12	12	12	12	12
11	11	11	11	12	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

Table C Score	+	Activity Score	=	REBA Score

Appendix V

KIM 2 - Key Item Method

Bedömning av arbeten som involverar att dra och skjuta med stöd av nyckelindikatorer.

Version 2012

Den totala aktiviteten måste delas upp i separata aktiviteter. Varje separat aktivitet som innehåller stor fysisk ansträngning måste bedömas separat.

Arbetsmoment / aktivitet:

Datum för bedömning: _____ Bedömd av: _____

Steg 1: Bestämning av tidspoäng (Välj endast en kolumn!)

Dra och skjuta korta avstånd eller många stopp (enstaka distanser över 5 meter)		Dra eller skjuta längre avstånd (enstaka distanser över 5 meter)	
Antal gånger per arbetsdag	Tidspoäng	Totalt avstånd under arbetsdagen	Tidspoäng
<10	1	<300 m	1
10 till < 40	2	300 m till < 1 km	2
40 till <200	4	1 km till < 4 km	4
200 till < 500	6	4 till < 8 km	6
500 till < 1000	8	8 till < 16 km	8
≥ 1000	10	≥ 16 km	10
Exempel: användning av manipulatorer, uppställning av maskiner, distribution av måltider på sjukhus		Exempel: sophämtning, möbeltransporter inomhus med hjul, avlastning och omlastning av containers	

Steg 2: Bestämning av bedömningspoäng för massan, noggrannhet i positionering, hastighet, arbetsställning och arbetsförhållanden

Massa som ska flyttas lastvikt rullande	Transport och förflyttning hjälpmedel				
	Utan, lasten rullas	Kärra	Vagn, rullvagnar, dragkärror utan fasta hjul (endast styrbara hjul)	Gallervagnar, handkärror, rullbord, med fasta hjul dragkärror	Manipulatorer
< 50 kg	0.5	0.5	0.5	0.5	0.5
50 till < 100 kg	1	1	1	1	1
100 till < 200 kg	1.5	2	2	1.5	2
200 till < 300 kg	2	4	3	2	4
300 till < 400kg	3		4	3	
400 till < 600 kg	4		5	4	
600 till < 1000 kg	5			5	
≥ 1000					

Skjuta	
<10 kg	1
10 till < 25 kg	2
25 till < 50 kg	4
>50 kg	

Gröna områden i tabellen:

Kritiskt eftersom en kontroll av industritrucksens/lastens rörelser i hög grad beror på skicklighet och fysisk styrka.





Vita områden utan nummer i tabellen:

Ska undvikas eftersom de nödvändiga rörelsekrafterna lätt kan överstiga de maximala fysiska krafterna.

Noggrannhet vid positionering	Rörelsehastighet	
	Långsamt (< 0,8 m/s)	Snabbt (0,8 till 1,3 m/s)
Låg – inga angivelser av avståndet – lasten kan rullas till den stannar eller fram mot ett stopp	1	2
Hög – lasten måste placeras noggrant eller stoppas – avståndet måste följas exakt – flera ändringar av transportriktningen	2	4

Obs! Normal gånghastighet är cirka 1 m/s.

[Rensa formuläret](#)
[Hjälpinformation](#)

Arbetsställning			Arbetsställning		
	Upprätt överkropp, ej vriden	1		Kroppen djupt böjd i rörelsens riktning Sittande på huk eller på knä, böjd	4
	Antingen frambådd eller vriden överkropp (ensidiga dragrörelser)	2		Kombination av böjd och vriden kropp	8

Använd den vanligaste arbetsställningen. Man kan bortse ifrån en stor lutning av överkroppen vid start, bromsning eller styrning, förutsatt att det endast sker vid enstaka tillfällen.

Arbetsförhållanden	
Bra: → golvet eller andra underlag är jämna, hårda, utan nivåskillnader, torra → ingen lutning → inga hinder i arbetsområdet → hjulen rullar lätt. Ingen uppenbart slitage i kullagren.	0
Begränsade: → smutsigt golv, lite ojämnt, mjukt → svag lutning på upp till 2 grader → hinder på arbetsplatsen som måste övervinnas → hjulen är smutsiga, de rullar trögt, kullagren är slitna.	2
Svåra: → underlag utan golvbeläggning eller ojämnt underlag, gropar, mycket smutsigt → 2 till 5 graders lutning → industri-truckar måste ryckas loss när de startar → hjulen är smutsiga, kullagren går mycket trögt.	4
Komplicerade: → steg, trappor → lutningar över 5 grader → kombinationer av indikatorer från "begränsade" till "svåra"	8

Indikatorer som inte nämns i tabellen måste läggas till efter behov.





Steg 3: Utvärdering – fyll i poängen och beräkna

+	Massa-/hjälpmedel	---
	Positionering/rörelsehastighet:	---
	Bedömningspoäng arbetsställning:	---
	Bedömningspoäng arbetsförhållanden	---
=	Totalt:	---

x --- x **1,3** = ---

Tidspoäng: ---

Med stöd av beräknad poäng och tabellen nedan är det möjligt att göra en grov utvärdering.

Riskområde		Riskpoäng	Beskrivning
1		< 10	Låg belastningssituation, fysisk överbelastning är osannolik.
2		10 till < 25	Ökad belastningssituation, fysisk överbelastning är möjlig för personer med lägre fysisk kapacitet. För denna grupp är det fördelaktigt att ändra arbetsplatsens utformning.
3		25 till < 50	Kraftigt ökad belastningssituation, fysisk överbelastning möjlig även för personer med normal kapacitet. En ny utformning av arbetsplatsen rekommenderas.
4		≥ 50	Hög belastningssituation, fysisk belastning är sannolik. Ny utformning av arbetsplatsen är nödvändig.

Gränserna mellan riskområdena är flytande på grund av de individuella arbetsteknikerna och prestationsvillkoren. Klassificeringen kan därför endast betraktas som ett riktvärde.

Typiskt för drag- och skjutarbeten är att muskler och skelett riskerar att utsättas för plötsliga överbelastningar till följd av halkolyckor eller oväntade och stora krafter vid ändrad transportriktning eller stopp.

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KIM 3 - Key Item Method



KIM III – Riskbedömning av repetitivt arbete med stöd av nyckelindikatorer

Om flertalet olika arbetsuppgifter utförs inom en och samma arbetsdag måste dessa aktiviteter registreras separat.

Arbetsuppgift:

Steg 1: Bestämning av tidspoäng

Aktivitetens totala varaktighet per skift [upp till ... timmar]	1	2	3	4	5	6	7	8	9	10
Tidspoäng	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5





Steg 2: Bestämning av bedömningspoäng för typ av kraftutövning, greppförhållanden, arbetsorganisation, arbetsförhållanden, arbetsställning samt hand/arm position och rörelse

Typ av kraftutövning i finger-/handområdet		Hålla				Rörelse					
		genomsnittlig tid för att hålla [sek. per minut]				genomsnittlig rörelsefrekvens [antal per minut]					
		60–31	30–16	15–4	<4	<1	1–4	5–15	16–30	31–60	>60
		Bedömningspoäng									
Nivå	Beskrivning, typiska exempel	2	1	0,5	0	0	0,5	1	2	3	
	Väldigt låga krafter t.ex. knapptryckningar/skjutrörelser/sortera	3	1.5	1	0	0	1	1.5	3	5	
	Låga krafter t.ex. materialföring/insättning	5	2	1	0	0,5	1	2	5	8	
	Medelstora krafter t.ex. att greppa/sätta ihop små arbetsstycken manuellt eller med små verktyg	8	4	2	0,5	1	2	4	8	13	
	Stora krafter t.ex. att vrida/linda/paketera/greppa/att hålla eller sätta ihop delar/pressa in/skära/att arbeta med små motordrivna handverktyg	12	6	3	1	1	3	6	12	21	
	Mycket stora krafter t.ex. att skära som innebär större kraftanstängning/arbete med små häftpistolar/förflyttning av, eller att hålla i, delar eller verktyg	19	9	4	1	2	4	9	19	33	
	"Peak" krafter t.ex. dra åt, lösgöra bultar/separera/pressa in	–	–	–	1	1	3	6	12	21	
hög	Slag med tumbasen, handflatan, knyttnäve										
Observera arbetscykeln och markera bedömningspoängen för de olika kraftkategorierna. Summan av riskpoäng för hålltid och rörelsefrekvens ger kraftbedömningspoängen (vänster och höger hand beräknas var för sig). Det högsta värdet, för höger eller vänster hand, används för att beräkna den totala bedömningspoängen.								Vänster hand:	Höger hand:		
Bedömningspoäng för kraftutövning:											

Kraftöverföring / greppförhållanden**Poäng**

Optimal kraftöverföring / igångsättning / arbetsobjekten är lätta att greppa (t.ex. rörformade, infällda grepp) / bra ergonomisk greppdesign (grepp, knappar, verktyg)	0
Försvårad kraftöverföring / igångsättning / större kraft för att hålla krävs/inga formade grepp	2
Avsevärt försvårad kraftöverföring / igångsättning / arbetsobjekten är knappt möjliga att greppa (hala, mjuka, vassa kanter) / inga grepp eller olämpliga sådana	4

Hand-/armposition och rörelse*)**Poäng**

 Bra: position eller rörelser i leder i medelläge (avspänt) / endast sällsynta avvikelser	0
 Begränsad: enstaka positioner eller rörelser i lederna i ytterläge	1
 Ogynnsam: ofta förekommande positioner eller rörelser i lederna i ytterläge	2
 Dålig: ständiga positioner eller rörelser i lederna i ytterläge / långvariga statiska armbelastningar utan hand-/armstöd	3

*) Typiska positioner ska beaktas. Sällan förekommande avvikelser kan ignoreras.

Arbetsorganisation**Poäng**

Frekvent variation av belastning på grund av andra aktiviteter / flera arbetsmoment / tillräcklig återhämtningsmöjlighet	0
Mindre frekvent variation av belastning på grund av andra aktiviteter / få arbetsmoment / återhämtningstid tillräcklig	1
Ingen / nästan ingen variation av belastning på grund av andra aktiviteter / få enskilda rörelser per arbetsmoment / högt arbetstempo på grund av linjestyrning och / eller hög ackordsprestation / ojämnt arbetsflöde med tidvis höga belastningstoppar / för lite eller för kort återhämtningstid	2





Egenskaper som inte har nämnts i tabellen kan beaktas på motsvarande sätt.

Arbetsförhållanden**Poäng**

Bra: lätt att urskilja detaljer / ingen bländning/goda klimatförhållanden	0
Begränsade: svårt att urskilja detaljer pga. bländning eller alltför små detaljer / drag / kyla / fukt / störd koncentration till följd av buller	1

Egenskaper som inte nämns i tabellen kan beaktas. Under mycket ogynnsamma förhållanden kan 2 poäng tilldelas.

Arbetsställning **)**Poäng**

 Bra: växling mellan sittande och stående är möjligt/växling mellan stående och gående / dynamiskt sittande är möjligt/vila för hand och arm är möjlig efter behov / ingen vridning / huvudets ställning kan varieras / inget grepp över axelhöjd	0
 Begränsad: bålen lutar svagt mot arbetsområdet / övervägande sittande ställning med tillfälligt stående eller gående / tillfälliga grepp över axelhöjd	1
 Ogynnsam: bålen tydligt framtåtlutad och/eller vriden/huvudets ställning anpassad för att urskilja detaljer/begränsad rörelsefrihet/endast stående utan gående/frekvent greppande över axelhöjd/frekventa grepp långt från kroppen	3
 Dålig: bålen kraftigt vriden och framtåtlutad / kroppshållningen är starkt begränsad / visuell kontroll av aktivitet genom förstoringsglas eller mikroskop/stark lutning eller vridning av huvudet / frekventa böjningar / konstanta grepp över axelhöjd / konstant greppande långt från kroppen	5

**) Typiska ställningar ska beaktas. Sällsynta avvikelser kan ignoreras.

Steg 3: Värdering

Ange i diagrammet de bedömningspoäng som är lämpliga för arbetsuppgiften och beräkna riskpoängen.

	Typ av kraftutövning(ar) i finger-/handområdet	
+	Kraftöverföring/Greppförhållanden	
+	Hand-/armposition och rörelse	
+	Arbetsorganisation	
+	Arbetsförhållanden	
+	Arbetsställning	
=	Summa	

X

Tidspoäng	
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=

Riskpoäng

Baserat på det beräknade riskpoäng och tabellen nedan är det möjligt att göra en grov värdering.

Riskområde ***)	Riskpoäng	Beskrivning
1	<10	Låg belastningssituation, fysisk överbelastning osannolik.
2	10 till <25	Måttlig belastningssituation, fysisk överbelastning är möjlig för personer med lägre fysisk kapacitet. För denna grupp är det fördelaktigt att ändra arbetets och arbetsplatsens utformning.
3	25 till <50	Ökad belastningssituation, fysisk överbelastning möjlig även för personer med normal kapacitet. Ny utformning av arbetet och arbetsplatsen rekommenderas.
4	≥50	Hög belastningssituation, fysisk överbelastning är sannolik. Arbetets och arbetsplatsens utformning måste ändras.

***) Gränserna mellan riskområdena är flytande på grund av de individuella arbetsteknikerna och prestationsvillkoren. Nivåbestämningen kan därför endast betraktas som ett **orienteringshjälpmedel**. I grund och botten måste antas att allt eftersom riskpoängen stiger ökar risken för överbelastning av det muskuloskeletala systemet.

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www.baua.de

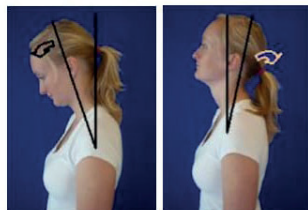
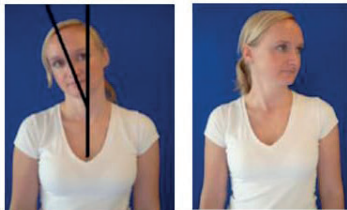


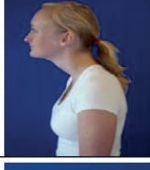
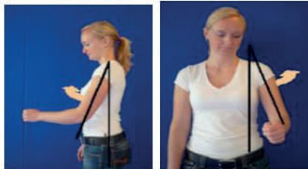

Appendix VI

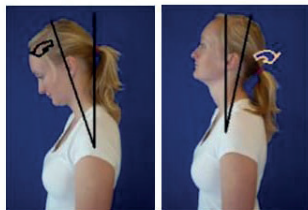
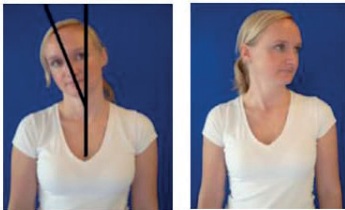



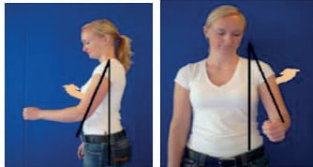

HARM - Hand Arm Risk-assessment Method

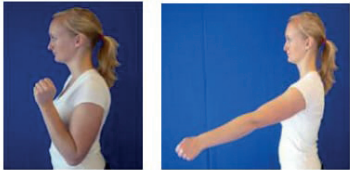
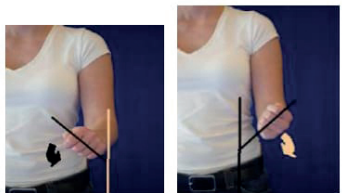
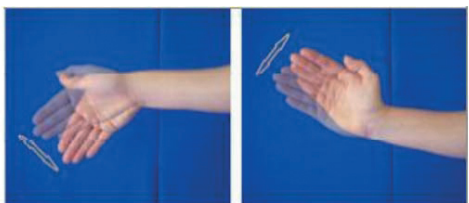
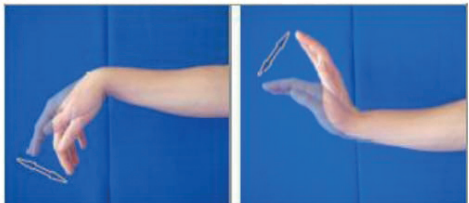
HARM: Hand Arm Riskbedömningsmetod	
Bedömningsmall	
Version 2008	
Arbetsuppgift – arbetstagare (initialer)	Datum
Arbetsställe - avdelning	Bedömning utförd av
Steg 1: Bestämning av tidspoäng	
<p>Steg 1A: Den sammanlagda tiden som uppgiften förekommer i snitt under en arbetsdag (alla perioder tillsammans). Ange tiden enbart för de dagar uppgiften förekommer (max en decimal)</p> <p>Steg 1B: Hur många dagar/vecka förekommer uppgiften?</p> <ul style="list-style-type: none"> - 1 eller 2 dagar/vecka: dra bort 1 poäng - 3 eller flera dagar: poängen kvarstår <p>Steg 1C: Minst 7,5 min. paus* per 1,5 timme?</p> <ul style="list-style-type: none"> - om ja: dra bort 1 poäng - om nej: poängen kvarstår <p><small>*Läs i handledningen vad som räknas som paus</small></p>	<p>.... timme - 0,5 =</p> <p>- 1</p> <p>- 0</p> <p>-1</p> <p>-0</p>
<p>Steg 1D: Beräkna tidspoängen Om poängen <1, sätt 1</p>	

Steg 2: Den mest aktiva handen	ringa in	höger/vänster/båda
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Steg 3: Bestämning av kraftpoäng								
Steg 3A		Steg 3B			Steg 3C			
Ange den mest aktiva handen (H,V,B)		Hur länge varar kraften i sek/min. (för varje rörelse/moment)			Antal kraftansträngningar/minut (frekvens)			
Kraft	Beskrivning och exempel	< 4	4 - 30	31 - 60	< 4	4 - 30	> 30	
Liten Vikt < 100g Kraft < 1 N	Litet tryck med fingrar (t.ex. hålla en blyertspenna med 2 eller 3 fingrar), sortera, trycka lätt med fingrar	0	1,5	3	1	2,5	4	
Medel V 100 – 1000 g K 1-10N	Hålla litet motordrivet verktyg med fingrar/hand. Ta/gripa, hålla delar, montera, trycka hårt	0	2,5	4	1	2,5	4	
Stor V 1-3 kg K 10-30N	Stadigt grepp med handen (användning av kniv/tång, hantering av delar el. verktyg, genomförande av tyngre delar (t.ex. kassaarbete))	0	3,5	6	2	3,5	6	
Större V 3-6 kg K 30-60N	Mycket kraft med armen, (tunga verktyg, tung manöver)	0	4,5	7	2	4,5	7	
"peak"	Slå med handflata eller knytnäve	-	-	-	3	5	8	
<p>Steg 3D Kraftpoäng = högsta inringade värdet</p>					<p>=</p>			
Obs! Om belastningen överstiger 6 kg bedöms den med annan metod (t.ex. för skjuta/dra eller manuell hantering)								

Steg 4A Arbetsställningspoäng för HUVUD/NACKE och SKULDRA/ÖVERARM		Procentandel som arbetsställningen förekommer av den totala tiden som uppgiften pågår		
		0 – 10 %	10 – 50 %	> 50 %
Huvudet mer framåtböjt än på första bild ELLER bakåtböjt		0	1,5	3
Huvudet mer sidoböjt än på första bild ELLER vridet				
Huvudet både framåtböjt och vridet		0	2	4
Huvudet både bakåtböjt och vridet		0	3	4
(Mycket) Framskjutet huvud/haka		0	1,5	3
Överarmen längre framåt, åt sidan eller bakåtlyft än på bilderna och utan stöd		0	2,5	3,5
(Starkt) uppdragna axlar		0	3	4
Poäng för arbetsställning nacke/skuldra = högsta poäng =		.....	

Steg 4A Arbetsställningspoäng för HUVUD/NACKE och SKULDRA/ÖVERARM		Procentandel som arbetsställningen förekommer av den totala tiden som uppgiften pågår		
		0 – 10 %	10 – 50 %	> 50 %
Huvudet mer framåtböjt än på första bild ELLER bakåtböjt		0	1,5	3
Huvudet mer sidoböjt än på första bild ELLER vridet				
Huvudet både framåtböjt och vridet		0	2	4
Huvudet både bakåtböjt och vridet		0	3	4
(Mycket) Framskjutet huvud/haka		0	1,5	3
Överarmen längre framåt, åt sidan eller bakåtlyft än på bilderna och utan stöd		0	2,5	3,5
(Starkt) uppdragna axlar		0	3	4
Poäng för arbetsställning nacke/skuldra = högsta poäng =		.....	

Steg 4B Arbetsställningspoäng UNDERARM/HANDLED		Procentandel som arbetsställningen förekommer av den totala tiden som uppgiften pågår		
		0 – 10 %	10 – 50 %	> 50 %
<p>Maximalt böjd eller sträckt.</p> 		0	1	2
<p>Underarmen är (i pilens riktning) mer vriden än på nedanstående bilder</p> 		0	1	2
<p>Handen tydligt böjd i sidled från handleden, nära ytterläge - ställningen i handleden ligger mellan lägena på respektive bild. Rörelsen är i riktning mot tummen eller lillfingeret.</p> 		0	1,5	3
<p>Handen är tydligt böjd från handleden, nära ytterläge - ställningen i handlederna ligger mellan ställningarna på respektive bild.</p> 		0	1,5	3
Poäng för arbetsställning underarm/handled = högsta poäng =		.....	

Steg 5 Vibrationspoäng

Används vibrerande verktyg vid uppgiften?

- Om Nej, fyll i en "0" på vibrationspoängen på den grå raden under tabell 5A och gå vidare till steg 6.
- Om Ja, är verktyget accelerationsvärdet känt?
 - Nej, gå till 5A
 - Ja, gå till 5B

Steg 5A Accelerationsvärdet är inte känt

Vilken av nedanstående förhållanden stämmer bäst? Ringa in passande poäng och för ned till den grå raden under tabellen.	Exponeringstid inom arbetsuppgiften	
Beskrivning	0-4 timmar	4-8 timmar
Vibrationer inte eller knappast kännbara eller synliga för operatör och observatör	0	0
Vibrationer inte synliga, men kännbara av operatör och observatör (kittlar)	2	2
Vibrationer synliga (lite) i underarm och hand, tydligt kännbara av operatör och observatör	2	4
Händer, armar och skuldror vibrerar tydligt synbart, vibrationer också tydligt kännbara.	4	4

Vibrationspoäng: ta med det inringade talet

.....

.....

Steg 5B Accelerationsvärdet är känt

Vilken av nedanstående förhållanden stämmer bäst? Ringa in den poäng som stämmer och för ned till den grå raden under tabellen.	Exponeringstid inom uppgiften	
Accelerationsvärdet	0-4 timmar	4-8 timmar
< 2,5 m/s ²	0	0
2,5 – 5 m/s ²	2	2
> 5 – 10 m/s ²	2	4
> 10 m/s ²	4	4

Vibrationspoäng: ta med det inringade talet

.....

.....

Steg 6 Andra faktorer:

Ange för varje faktor om den stämmer med de aktuella förhållandena	Ringa in
Fasta tider för raster o pauser (motsats till att själv kunna bestämma när man tar paus)?	Ja / nej
Ogynnsamt klimat (t.ex. kyla, drag) ?	Ja / nej
Svårt att koncentrera sig (enbart vid koncentrationskrävande arbete)	Ja / nej
Dålig kontakt med verktyg och material, t.ex. genom handskar?	Ja / nej
Precisionskrävande arbete?	Ja / nej
Poäng andra faktorer	Ringa in
0 "Ja" – svar ger poängtalet	0
1 "Ja" – svar ger poängtalet	1
2 eller fler "ja" – svar ger poängtalet	2

Steg 7 Total riskpoäng:	
Notera poängen från steg 3 - 6 (A)	Poäng
Kraftpoäng (steg 3)	.....
Poäng arbetsställning nacke/skuldra (steg 4A)	.....
Poäng arbetsställning underarm/handled (steg 4B)	.....
Vibrationspoäng (steg 5)	.....
Poäng andra faktorer (steg 6) +
Summera poäng (A)	.....
Tidspoäng (steg 1) (T)	..... X
Beräkna riskpoäng (A x T)	.....

...

Steg 8. Riskbedömning		
Bedöm risk med hjälp av nedanstående tabell:		
Total poäng	Risk	
< 25	GRÖN	Ingen förhöjd risk för belastningsrelaterade besvär i arm, nacke eller skuldra för majoriteten av arbetstagarna.
25 - 50	GUL	Risk för besvär i arm, nacke eller skuldra för en del av arbetstagarna. För att skydda arbetstagarna är det viktigt att vidta åtgärder för att minska risken.
> 50	RÖD	Hög risk för belastningsbesvär i arm, nacke eller skuldra för en stor del av arbetstagarna. Vidta åtgärder omgående.
UTTALADE BESVÄR		Om någon arbetstagare har besvär och misstanke finns om samband med arbetsuppgiften är det ALLTID viktigt att undersöka orsaken och vidta åtgärder.

Appendix VII

Checklist - English

- ☐ Stand with both legs and feet supported in the floor.
 - ☐ Avoid working with bended knees.
 - ☐ Avoid kneeling for a longer period.
- ☐ Keep back and upper body as straight as possible.
 - ☐ Avoid twisting of the back.
 - ☐ Avoid positions where you must bend or twist back even for a shorter time.
- ☐ Work with arms within reach and shoulders lowered.
 - ☐ If possible lower the truck even if only for a short while.
 - ☐ Avoid positions with arms that force the arms to work obliquely.
- ☐ Keep hands and wrist in a neutral position.
 - ☐ Avoid twisting the wrist.
- ☐ Make sure you use the lowest vibrating hand tool possible.
 - ☐ Take an extra minute to change tool and give yourself a little break and body to recover!

Checklist - Swedish

- ☐ Stå med både fötter och ben stadigt på marken/golvet.
 - ☐ Undvik att arbeta med böjda knän.
 - ☐ Undvik att stå på knä längre perioder.
- ☐ Håll rygg och överkropp så rak som möjligt under arbetet.
 - ☐ Undvik att vrida ryggen.
 - ☐ Undvik kroppsställningar där du måste böja eller vrida ryggen under längre perioder.
- ☐ Arbeta inom armlängds avstånd och med axlarna sänkta.
 - ☐ Om möjligt sänk vagnen för en kort stund för att underlätta din arbetsställning.
 - ☐ Undvik arbetsställningar där armarna tvingas arbeta långt från kroppen i sneda positioner.
- ☐ Håll händer och handlederna i en neutral position.
 - ☐ Undvik att vrida handlederna.
- ☐ Arbeta med det minst vibrerande verktyget du kan.
 - ☐ Det är inte så bråttom att du inte hinner byta verktyg och låta din kropp återhämta sig för en liten stund!

Ergonomic evaluation in a development workshop, Volvo Group.
Chalmers University of Technology, 2017

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