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ERGONOMICS ASSESSMENT IN AN ALUMINUM FACTORY IN ICELAND

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The purpose of this study was to do an ergonomic assessment in aluminum factory and to write a literature review of factory work and health. The results from the ergonomic assessment where then compared to the literature. The aluminum factory in which the ergonomic assessment was carried out was the Rio Tinto Alcan factory in Iceland. The reason why I did choose to do the assessment there was my work experience as summer worker for 2 summers in the factory's casthouse.

What was found in the literature review supported the results from the ergonomic assessment, that factory workers are at risk of developing work related musculoskeletal disorders due to awkward, repetitive or static working positions and heavy lifting. But what was also found was that factories are modernizing workstations with aim of making them ergonomically safer for workers. The ergonomic assessment showed that workers are aware of their ergonomics while working and are creative in figuring out ways to improve their ergonomics themselves.

CONTENTS

1 INTRODUCTION

My thesis main focus was to perform an ergonomic assessment and compare the results from that to the literature, the ergonomic assessment was carried out at an aluminum factory in Iceland. The reason why this thesis was done in co-operation with the aluminum factory in Iceland was to make them more special. From my work as a summer employee in that factory I knew that sometimes the machines and the equipments require workers to work in awkward or uncomfortable position. Often when that happens they start to wonder themselves is there a better way to perform this task but sometimes it is impossible to realize yourself that working position can be harmful and at those times someone else needs to point it out and give advises. Therefore I wanted to make an ergonomic assessment and try to find what workers could do differently to improve their ergonomics.

Ergonomics is a relatively new subject, it was first brought to awareness as scientific discipline in 1940s and the term ergonomics was created in 1949. Therefore it is a young but popular subject, ergonomics have been researched quite a lot since it was first defined. Ergonomics is divided into 3 domains of specialization physical, cognitive and organizational. It is an economically important subject, because work related musculoskeletal disorders are known to be main cause of occupational injuries. Occupational injuries are costly both for employer and the health care systems. (Website of Institute of Ergonomics and Human Factors 2011, Choobineh, Tabatabaei & Mokhtarzadeh 2007, 418)

At the Ford Foundation-International Labour Organization High Level Event on the 23rd of September 2014 Guy Ryder Director-General of the International Labour Organization stated; “Unless you have people earning money, you don't have customers". (Ryder 2014) Although Ryder was discussing the topic of workers salary I believe these same thoughts relate to workers health and ergonomics. Because the employees are those who produce the product that the employer then sells and makes profits off. Therefore checking or assessing ergonomics and finding ways to improve them is crucial. Improved ergonomics will result in lower absentees from work due to work related musculoskeletal disorders which will mean more workers to produce.

2 PURPOSE AND AIM OF THESE THESIS

The purpose of this thesis was to do an ergonomic assessment at an aluminum factory in Iceland and to compare the results to current researches about ergonomics in factory and industry work. Then the aim of this thesis was to find out if something could be done ergonomically better and if so, to give suggestions to the workers at this workstation about how they could improve their ergonomics and decrease the loading while doing their job. In addition, compare the results from the ergonomic assessment to results from other researches. The ergonomic assessment was carried out at one workstation within the factory. The production of aluminum is a long and complicated process, a combination of multiple different phases which are carried out at different workstations at the factory. To limit the extent of this thesis I decided to do the assessment at one workstation, which the contact person at the aluminum factory chose.

3 RIO TINTO ALCAN ICELAND

In 1966 an agreement of building an aluminum factory was signed between the Icelandic government and the Swiss aluminum company Alusuisse. This factory was formally taken into use in May 1970. At the beginning the production capacity of the factory was 33.000 tons of aluminum per year. Since then the factory has grown both in its size and production capacity and today they produce 190.000 tons per year. Today the aluminum factory in Iceland, Rio Tinto Alcan Iceland, is owned by the international mining company Rio Tinto. The aluminum division is called Rio Tinto Alcan and is one of the largest producers of aluminum in the world. In total they have 23000 employees in 27 countries but Rio Tinto Alcan Iceland employs 450 employees (Website of Rio Tinto Alcan Iceland).

The production process of aluminum consists of many different stages which are all controlled by computers so the whole production process is computerized and uses hi-tech technology. It all starts with alumina which is white powder compound of aluminum and oxygen. In the potrooms the aluminum is produced in the pots, the alumina is dissolved in an electrolyte (liquid cryolite) at temperature 960°C and so

electrolysis can take place electric current needs to be sent through the pot. When this electric current goes through the electrolyte the alumina molecule breaks down into the two elements it is composed of, aluminum and oxygen. Every other day the aluminum is then tapped from the pots and transported to the casthouse. Where the molten aluminum is poured into the mixing furnaces and then different metals are added to the aluminum so that the chemical composition will be what customer has ordered. Once the right composition is reached the aluminum is poured into the casting machines via filters and cleaning treatment system that removes last impurities before the casting (Website of Rio Tinto Alcan Iceland).

4 ERGONOMICS

The International Ergonomics Association (IEA) defines ergonomics like this: "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 optimize human well-being and overall system performance." Those that practice ergonomics and ergonomics itself help to make tasks, jobs, products, environments and systems meet needs, abilities and limitations of the people who do, use or take part in them. In other words ergonomics adjust things interacting with people to their needs, abilities and limitations (Website of International Ergonomics Association 2014).

The main focus of ergonomics is always the human and by taking into account his or her physical and psychological capabilities and limitations avoid unsafe, unhealthy, uncomfortable or inefficient situation for that human at work or in everyday life. Ergonomics have many factors playing their own role and determining mainly safety, health, comfort and efficient performance of person. These factors can be for example body posture and movement as in sitting, standing, lifting, pulling and pushing or environmental factors such as noise, vibration, illumination and chemical substances. Ergonomics also combine knowledge from many fields within human sciences and technology and their aim is always to fit the environment to the people not the other way round (Dul & Weerdmeester 2001, 1-2).

4.1 The three domains of specialization in ergonomics

First there are physical ergonomics that focus on the physical activity and how we adapt human anatomical and physiological characteristics. In this domain the main emphasis is on the work environment, the workplace, the work equipment and the working methods. Furthermore looking at work postures, materials handling, repetitive movements and then work related musculoskeletal disorders, safety and health of workers. Second, there are cognitive ergonomics that focus on mental processes, for example perception, memory, reasoning and motor response since all these affect interactions between people. The focus is on mental workload, decision-making, human-computer interaction, human reliability, works stress and training. Third are organizational ergonomics which focus on improving the social and technical systems. This includes organizational structures, policies and processes. Emphasizing on personals, work processes, work packages and design of working time, teamwork, cooperative work, virtual organizations, quality management and so on. (Website of International Ergonomics Association 2014; Työterveyslaitos 2014)

4.2 Legislations

The purpose of the Icelandic ACT on Working Environment, Health and Safety in Workplaces (No.46/1980) is to ensure safe and healthy working environment that is comparable to social and technical development in the society. As well as make sure that at it is possible to solve problems with safety and health that might occur within the workplace according to acts and regulations (ACT on Working Environment, Health and Safety in Workplaces No.46/1980 article 1). The act is valid for all actives where one or more person is working no matter if they are the owners or the employees (ACT on Working Environment, Health and Safety in Workplaces No.46/1980 article 2).

In the chapter that discusses risk assessment, health protection and medical checkups it is stated in the first article that in cooperation with health authorities prevention of occupational diseases should be practices as provided for by this Act (ACT on Working Environment, Health and Safety in Workplaces No.46/1980 article 64). Employer

is obligated to make a written plan of safety and health in the workplace, this plan needs to include risk assessment and health protection schedule (ACT on Working Environment, Health and Safety in Workplaces No.46/1980 article 65). The risk assessment should evaluate the risks involved in the work in regards to safety and health of the workers and the work environments risks. When risk assessment gives indications of that health and safety of workers are in danger the employer should take all needed precautions to prevent the risk or if that is not possible then lower it as much as possible (ACT on Working Environment, Health and Safety in Workplaces No.46/1980 article 65a).

The health protection schedule is based on the risk assessment and should include a health protection plan of precautions that will aim to reduce work related illnesses and accidents. It has few specified aims, first that the worker is protected against health risks or damage which might be results of their work or working condition. As well as it is meant to support that work is organized so that workers are assigned to tasks that suit them. Furthermore it should reduce absence from work caused by illness or accident related to work and at last it promotes workers well-being both mental and physical. (ACT on Working Environment, Health and Safety in Workplaces No.46/1980 article 66).

5 RESEARCH METHOD

Research is an examination and judgment of a subject that is considered important by the researcher. Rehabilitation research is a way to test how rehabilitation professionals make difference in clients or patients lives. Rehabilitation professionals are in these days required to search for or create evidence for the value of their practices and even modify their practices in response to evidence. Research has been described to have 3 important characteristics, first to challenges the status quo, second to be creative and last to be systematic. (Carter, Lubinsky & Domholdt 2011, 1-2)

Non-experimental researches are opposite to experimental researches and do not deal with manipulation of variables, the researcher needs to take things like they come

and then try to solve them. Non-experimental researches vary greatly in design and because it is not required to fit a rigid definition of controlled manipulation. As a matter of a fact there is a design that fits all non-experimental researches. A prospective descriptive research is a non-experimental research where the researcher controls what data is collected with the aim of describing a phenomenon. This type of research has 4 types of data collection methods observation, examination, interview and questionnaire. (Carter, Lubinsky & Domholdt 2011, 139-142) This thesis was a prospective descriptive research where 3 data collection methods where used, observation, interview and questionnaire.

6 IMPLEMENTATION AND ASSESMENT

This study consisted of 3 visits to the aluminum factory in June 2014 where the purpose was to form an ergonomic assessment of one work station. The data was collected with interviewing, observation, photographing and videotaping the worker during his work. The interview was an open discussion and in addition the worker was asked to fill a questioner regarding the working environment (Appendix 1). This was a questioner designed by the factory and used by them to document workers feedback of working environment, own working positions and whether they have experienced pain related to work. A small camera with the option of recording videos was used both for taking the photos and videos. The Ergonomic Workplace Method form was used as an assistance to form the ergonomic assessment.

As explained previously the study was carried out at one workstation with in the factory to limit the extent of the thesis. Regardless of the size of the aluminum factory the production process of the aluminum is usually the same or similar. The subject in this study was the mold workshop which is located in the casthouse, the workshop is manned by one man, a mechanic, but every now and then he has an assistant, another mechanic, from the main workshop of the factory. Since most of the time the mold workshop is only manned with one mechanic he was the main focus of the study. The mold workshop is where the molds that are used to cast the aluminum into logs

are maintained and repaired. Due to changes in technique in the casting of the aluminum the mold workshop was changed almost 3 years ago.

7 THESIS PROCESS

The process of this thesis started in August 2013, in the beginning it was slow and not much happened after the agreement had been signed in December 2013 until the visits at the factory in June 2014. After the visits the process was faster and all the writing was done in during the autumn and early winter 2014. Then finally in beginning of January 2015 the thesis was presented but the whole process is explained in more details in table 1.

Table 1. Process of thesis

August/September 2013	Got the idea of doing ergonomic assessment in a aluminum factory.
October/November 2013	Was in contact with Leader of Health at Rio Tinto Alcan Iceland.
December 2013	Meet with the Leader of Health and we discussed possible station in the factory where the study would be done and agreement signed.
June 2014	Completed the online security course required and started planning my visits to the factory. I visited the factory 3 days in a row and collected all my data during those visits.
September to December 2014	Writing the thesis.
January 2015	Presentation of thesis

8 RESULTS

The main work at the mold workshop consists of maintaining and repairing the molds used to cast the aluminum into logs. The molds are rounded and are integrated into a casting table (picture 1). At the moment the factory has 4 different sizes of the molds. Picture 1 shows the casting table in vertical position viewing the bottom part of it, in this position the mechanic checks the molds and if needed then they are

changed. Picture 2 then shows the bottoms which come up into the mold and make kind of a sandwich called bottom frame (picture 3). Picture 3 shows the bottom frame (the sandwich) ready to be used, then during casting the bottoms are lowered down into a pit that fills with water to cool the aluminum.

Picture 1. Casting table in vertical position waiting for maintenance/repair.

Picture 2. Bottoms waiting for maintenance/repair.

Picture 3. Bottom frame, ready to be used for casting.

All the molds need to be regularly checked and due to extreme heat parts of them need to be changed regularly. When they need to be changed they are removed from the casting table, that is a complicated process of screwing and pulling them loose and then hammering, pushing and screwing them back into the casting table. The maintains of the mold itself consists of many different stages of taking it apart and putting it back together carried out on working table with different equipments. Removing or checking the molds while they are in the casting table requires working on knees with the lower molds or over head with the higher ones. The height from floor up on the yellow platform seen in picture 1 is 50 cm and the box that is on the yellow platform is 33 cm high, mechanic uses that box to reach the higher molds. The blue thing seen on picture 1 next to the box is soft plastic mattress that he kneels on when working with the lower molds. The molds weigh from 7 to 10 kg and are 28 to 36 cm in diameter, the bottoms also need to be checked and greased regularly and single bottom can weigh from 7 to 32 kg.

The questions in the questioner (Appendix 1) the mechanic answered were focused on working position, physical strain while working and if he has experienced some pain due to the work. Both in the questioner and during the interview the mechanic commented that working positions can often be uncomfortable, difficult or demanding. He mentioned that when the molds need to be changed it can be that he either needs to be kneeling or lying to be able to work with the lowest ones or then he is reaching over head to the highest ones. And in these positions he also needs to pull the mold out of the table frame or push/hammer it back into it. Then when he has gotten the mold out from the table frame he needs to step down from the yellow platform (picture 1) and since it is quite high he needs to be careful not to step too hard

down and get a hit through the foot to his back. Often when he steps down there he is carrying a mold that weighs up to 10 kg. He also commented that he could need to lift heavy loads, for example the bottoms of the molds can weigh up to 32 kg. Changing the mold itself is complicated and time consuming process since there are many small parts that need to be dismantled or assembled in certain way.

In regards to suggestions of what could be done differently or improved in the working environment at the mold workshop. In addition to the changes the worker has already made, it would be beneficial to find a way to shorten the distance when stepping down from the yellow platform (picture 1). To decrease the impact that stepping down from the platform can have on the whole body, knees, hips and back especially when carrying a heavy object, for example a wide enough step could be created. Also to minimize the need to carry the molds, especially the heavier ones the mechanic could have a table on wheels beside the casting table to put the mold on when he has removed it from the frame.

9 RESEARCHES ABOUT FACTORY WORK AND HEALTH

Musculoskeletal disorders have been thought to be a constant worrisome burden of industry in despite of researchers effort to find the keys to efficient prevention (Riihimäki 1995, 401). The term musculoskeletal disorders referrers to health problem or ill-health of the musculoskeletal system, if this health problem is aggravated by work it is referred to as work related musculoskeletal disorder (Luttmann, Jäger & Griefahn 2003, 1). These musculoskeletal disorders have been shown to be the main cause of occupational injuries and disability in the industrially developed and developing countries. The economical loss caused by these disorders is known to affect not only the individual but as well the organization and also the whole society. Therefore the prevention of musculoskeletal disorders in the workforce is thought of as national priority in many countries. Workplace activities such as heavy load lifting, repetative tasks and awkward working postures are known risk factors of musculoskeletal disorders. (Choobineh, Tabatabaei & Mokhtarzadeh 2007, 418). Burdorf & Sorcok (1997, 254) concluded that there is a clear relationship between

back disorders and physical load such as material handling, frequent bending and twisting, physically heavy work and whole body vibration.

A study from workers in iron and steel factories showed that 12 months prior to the study 81% experienced at least one health event. Where 4 most common were those related to the musculoskeletal system (31,4%), gastrointestinal system (25,8%), cardiovascular system (24,4%) and respiratory system (18,1%). Blue collar workers had double the tendency of musculoskeletal related problems compared to the white collar workers, 43,7% versus 20,4%. In same study 66,9% of the workers stated having missed one day or more from work due to illness or injury (Manjunatha, Kiran & Thankappan 2011, 144-145). A study from 454 males working in a rubber factory showed that 39,4% of them had reported a sick leave due to musculoskeletal disorders in the last 12 months, in which lower back (28,4%), upper back (20,3%) and knees (19,2%) were most common reasons for absentee (Choobineh, Tabatabaei & Mokhtarzadeh 2007, 420-421). Another study from a sugar factory showed that 87,1% of the workers included in the study had experienced musculoskeletal disorders in the last 12 months prior to the study. In this study the knees, lower back, shoulders and upper back were the most common, those body regions also caused the highest percentage of sick leave in the last 12 months before the study. (Choobineh, Tabatabaee & Behzadi 2009, 421-422)

The workload among industrial workers was evaluated with the Need for Recovery Scale (NFR) questionnaire and an ergonomic assessment. The NFR has been proven to be useful for early identification of workers overloading. This study consisted of 191 employees, age 25 to 44 years old were 140 were women and 51 men working in 2 different sectors (A & B). The ergonomic assessment showed that both sectors had problem with physical things like repetitiveness of work, the working posture and movements. But then sector A also showed organizational problems like lack of communication and personal contact due to long distance between work station and high noise and heat levels. NFR questionnaire showed higher score for sector A. (Moriguchi, Alem & Coury 2011, 155-157)

A study of occupational safety and health in an aluminum factory in Bosnia and Herzegovina showed that after modernization workers were less exposed to harmful sub-

stances. Results were collected from mandatory measurements in working environment of chemical and physical agents that were performed from 1982 to 1988 and then in April 2004. Also measurements of noise levels in the factory's casthouse showed considerably lower levels. (Jelinic, Mustajbegovic, Zuskin, Lukic, Cavar & Ivankovic 2005, 843-844)

10 CONCLUSION

Based on the literature, it is possible to make the conclusion that work related musculoskeletal disorders are indeed something that workers in factories suffer from and my ergonomic assessment at the aluminum factory supports this. Although I did not ask in my interview about absences from work due to musculoskeletal disorder I did ask about pain related to work, to which the answer was positive. In addition I found out that working positions can often be awkward and static, the need to work with hands over head or lying on side seemed quite common in this workstation.

The literature showed that in the last 15-30 years workstations in factories have changed as they have been modernized. This has lead to better work environment, less noise at work stations and less contact to harmful substances. This also means that workers are more alert of their own ergonomics, they criticize the technology that they work with and which requires them to work in awkward positions. They are also creative in how to make a task easier or adapt workstations so that it requires less awkward working position. Organization of factories also changes and improves through the years, it is a constant road forward towards better working environment. Safety, as well as safety rules, is important and often factories have certain standards either developed by themselves or internationally.

11 DISCUSSIONS

The idea of doing an ergonomic assessment came to my mind after we had the topic of ergonomics and when, in August 2013, our class was required to present the idea

for our thesis. At this stage a plan had started to form in my mind of doing an ergonomic assessment at a factory and because of my nationality I thought it would be nice to relate the thesis to Iceland. After the thesis plan was accepted by the teacher the Rio Tinto Alcan in Iceland was contacted, they were chosen because of my job experience as a summer worker there 7 years ago. Because of that work experience at the aluminum factory as well as working in the country side I know that sometime you just have to complete a task and there is no way to make it easier or less demanding. Therefore the result from my ergonomic assessment was as expected, that the machines and technology can make workers job a lot harder. The information I found from the literature suggested that factory workers are in risk of developing work related musculoskeletal disorders. When the devices cannot be changed the person is required to change, what is possible to change is the functional capacity. Persons body awareness and body control especially core stability is very important if not essential when lifting heavy loads to support the back and prevent injuries. Therefore a review with worker about importance of good core stability and body control when lifting heavy loads would be beneficial. In addition, physical activity outside work and exercise prescription aiming to increase core stability and body awareness is beneficial in my opinion.

All in all the thesis process has had its ups and downs, first of all it took me long time to decide on topic and next was the challenge of starting to write. At last and maybe the biggest challenge was to go deep enough into the theory behind the ergonomics. On the positive side the data collection or the ergonomic assessment itself was not a problem. What I would do differently next time is to begin writing earlier because that would have been very beneficial for the whole process. If writing would have started earlier then whole thesis might have taken a completely different direction, since I found when writing this that if it would have been written earlier there would have been more time for change. My weakness is my tendency to complicate things when starting to write them down and it has really caused headaches with this thesis.

As suggestions for a further thesis I think a lecture or even could be organized for the workers, topic could be workers health and ergonomics. How important it is for them to maintain good physical capacity to be able to withstand physical load at work. Al-

so the importance of core stability when lifting heavy loads could be addressed and a training program for it could be written and handed out to workers. A different assessment form could also be used with the ergonomic assessment, a form called OWAS or Ovako Working posture Assessment System could be more suitable for assessing ergonomics in aluminum factory.

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APPENDIX 1

Loosely translated from Icelandic:

Questioner – working environment

Please read each and every one question well and chose the option that suits each time.

Employee:_____

Job:_____

1. **Is work area often about shoulders?**
   Often per day Sometimes No
2. **Are you working repeated or prolonged bends/turns on back/neck?**
   Often per day Sometimes No
3. **Are you working lying down, kneeling or on fours?**
   Often per day Sometimes No
4. **Does the job require repeated movements?**
   Often per day Sometimes No
5. **Is physically demanding work prolonged or repeated?**
   Often per day Sometimes No
6. **Do you need to lift object heavier than 15 kg?**
   Often per day Sometimes No
7. **Do you need to use physical strength to push or pull an object?**
   Often per day Sometimes No
8. **Do you experience mechanical vibration at work?**
   Often per day Sometimes No
9. **Does a device/equipment encourage bad work position?**
   Often per day Sometimes No
10. **Does the job require precision and concentration?**
    Often per day Sometimes No
11. **Are standing or sitting prolonged?**
    Often per day Sometimes No

What possible solutions do you see to decrees the demands while working?

_____

_____

_____

1. **How many hours in average do you move (HR raises) per week in or outside work?**

   0-1 hour 1-3 hours 3-6 hours more than 6 hours

2. **Have you experienced pain related to your job on the last 3 months?**

   No Yes

   If you answer question 2 with a no you don't need to answer the following

3. **If yes how often in the last 3 months?**

   Always while working

   7-10 days / month

   1-2 days / month

   Less than 1-2 days / month

   Then here was a photo of a human body where worker was asked to mark with an X the area where they had experiences pain in the last 3 months.

   Options where:

   - Neck
   - Elbows and shoulder
   - Back and lower back
   - Fore arm and hand
   - Legs, ankles and foot
   - Left side of the body
   - Right side of the body