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Evaluation of RH Logic 400 office chair
Influence on comfort, physical loads and performance during computer work

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ABSTRACT

Today there is a large amount of knowledge about ergonomics and working sitting postures during long hours of office computer work. There is also a large selection of office chairs available on the market with numerous possibilities of individual adjustments for optimal and varied sitting postures. For the manufacturers it is of great interest to show advantages such as increased productivity, decreased discomfort and reduced physical disorders as well as improved health and well-being when their ergonomic chairs are used at work. For optimal usage it is important that the users take advantage of all the ergonomic features offered. However, often problems arise when a chair has a large amount of settings with various design and functionality. It is difficult without instructions and training to understand how the various settings work and how they should be handled and adjusted optimally for a specific individual.

The purpose of this study was to examine if the possibilities that the RH Logic 400 office chair offers to create an ergonomic, individual and varied working posture were employed optimally by the users and also what effects the features had on comfort and work performance. The goal was to determine if positive effects regarding comfort, health and performance arise during 5 weeks of office computer work. Furthermore the goal was to find out how the RH chair and its adjustments were perceived and handled by the users when they were informed in different ways during introduction of the chair in their company.

84 office computer workers at two companies participated in the study during a period of five weeks. 48 of workers got the RH Logic 400 office chair, while the others kept their ordinary office chairs. These functioned as a control group. Among the RH chair users, 28 received an verbal introduction/training session of the chair's functions from a manufacturer sales person together with a physiotherapist. The others only got access to a small written information brochure from the manufacturer hanging under the chair.

Before the study all participants filled in a comprehensive questionnaire about their personal data, working situation and health status. Then they answered a questionnaire each week during a five weeks period about their health and well-being status as well as if the had adjusted their chair and used its features. Finally another comprehensive questionnaire was filled out when the test period was finished. In total 18000 data points were collected from 7 questionnaires (together including 82 questions with sub-questions). The data was statistically analysed using Wilcoxons signed-rank test and Student's t-test. The significant level was set to 5%.

The concluding results from the study showed that the RH Logic 400 chair significantly decreased the physical strain in the neck, shoulder and lumbar regions, and for the shoulders on the right hand side. People with previous long-term physical problems in the upper part of their body perceived decreased distress after five weeks work in the RH chair. The sitting posture and the comfort were perceived better for the RH chair than in the test subjects' previous chair. They also felt more relaxed in the RH chair. However the chair and back cushions of the RH chair were perceived stiffer than in their previous chair.

The RH office chair had a positive impact on the working situation as a whole, but did not affect the stress level at work. When discussing work performance and stress all parts in the working environment have an effect on well-being and it is therefore difficult to separate effects from the chair.

The understanding about how the adjustments of the RH chair should be performed, as well as usage of the rocking function, increased significantly when verbal presentation and training were given, as well as how often the adjustments were used. However, when the users had found suitable settings, they did seldom adjust their chairs again during the test period. Sitting height was the measure that most often was adjusted while the positions of the neck rest and arm rests seldom were changed.

The recommendation from this study is that when delivering office chairs to customers it is very important to introduce the users on how to adjust and handle the chair to accomplish optimal individual settings. Also point out that the chair should be adjusted several times a day and the rocking function should be used frequently to achieve necessary posture changes. Furthermore, explicit written information material need to be developed, explaining how good individual ergonomic working postures can be found by adjusting the chair's different settings properly and also in which order the settings should be performed.

1   INTRODUCTION

1.1   Background

Much knowledge is available today on how to achieve a good ergonomic working situation and sitting postures during prolonged computer work in office environments. The complete picture is very important; desk, chair, monitor, keyboard and mouse are included along with space, light, sound and climate conditions around the computer workplace. However, the design and function of the office chair is one of the most important factors to achieve a good working environment.

Today there is a wide selection of office chairs on the market. Most of them are claimed to be ergonomic and offer many opportunities for individual settings in order to achieve an optimal and varied chairing position. The office chairs often offer both support for different body regions as well as potential for movement and change of postures. Furthermore they also offer opportunities for individual settings depending on body size (anthropometry) and morphology of the users.

However there are some differences in design between the office chairs on the market, both in terms of settings/features and stiffness of the seat and back cushions. Some more sophisticated chairs have, for example, a lumbar support to maintain the natural S-shape of the spine and a tilting function that can cause movements resulting in varied sitting postures. Some chairs are more stable in their design and can thereby withstand heavy wear in more exposed working environments such as production industry, while other chairs focus more on comfort issues or aesthetic aspects.

Sometimes problems do occur when an office chair has many options for individual adjustments. Various controls, such as buttons, knobs and levers can be difficult to understand and use for the users. This applies both to the purpose of the controls as well as how they should be handled. It is often difficult to know, without instructions and help, how optimal settings should made for a single individual. Therefore, instructions, both written and verbal, and also an introduction given by an ergonomist/physiotherapist are very important in the concept of how an ergonomic office chair should be fully utilized.

For the manufacturers of office chairs, it is of great interest to them, when customers are using their chairs at office work. A good selling point for manufacturers is that ergonomic chairs yield high-quality long-term positive effects both for users and employers. This can be demonstrated through increased performance and well-being, as well as reduced physical symptoms, which might lead to reduced costs for sick leave and reorganization.

1.2 Purpose and aim

The purpose of this study was to investigate whether the RH office chair can offer an ergonomic, personalized and varied posture that can be utilized optimally by the users along with the impact of this on the individual as well as on the work tasks.

The goal of the study was to determine if positive effects arise regarding comfort experience, health and performance during office computer work when an RH chair is introduced and used over a 5-week period. Moreover, the goal was to study how the RH chair and its settings were perceived and handled by the users when they received different types of information (verbal/written) along with the introduction of the chair in their company.

1.3 Study issues

Three main areas were examined: The RH office chair's impact on (1) comfort, physical problems and performance; (2) individual settings, and (3) work performance.

1) How are comfort, physical health and performance affected by the RH chair, directly and after a test period of 5 weeks?
a) Does the perceived comfort increase over time?
b) Does the perceived load decrease for different body regions over time?
c) Does the work performance increase over time?
d) Are there any differences between groups using RH chairs and other office chairs respectively?
e) Are there any differences between groups that got introduction about how to handle the RH chair or not?

2) Do the users of the RH chair use the available settings for finding optimal ergonomic sitting postures?
a) Which adjustment functions are used and how often?
b) Do the users understand how the controls should be used?
c) Are there any differences in using the controls/settings between groups that received verbal introduction about how to handle the RH chair or not?

3) Does the RH chair affect the working procedures?
a) Is there a change in working situation and working techniques?
b) Are the individual choices of sitting positions and relaxation affected?
c) Is the level of stress affected?

2   MATERIAL AND METHODS

In order to investigate the RH chair's effect on comfort, health and performance, an experimental research study was designed, where the RH chair was evaluated in computer-based office work places during a 5-week period.

2.1   The RH office chair

The type of office chair that was evaluated was RH Logic 400 with high back, arm rests, head rests, a swing (rocking feature) and rubber wheels (Figure 1). The chair is based on RH's philosophy of creating a dynamic sitting in a chair that takes into account the body's natural movements for good breathing. This may lead to better concentration and improved performance as stated at: *www.rh.se/web/startsida.aspx*.

A brief small booklet (brochure) that shows how the controls should be handled always follows the chair. The booklet is placed in a pocket under the seat cushion. On the back of the booklet a small note refers to RH's web page online. The brochure shows only the technical function of the controls. It does not explain why and how the various settings should be made for best customization or choice of posture, nor the order in which the controls are to be set.

Back:
Width: 440 mm Height 620 mm

Seat:
 Width: 465 mm Depth 475 mm
(sliding 60 mm)
Height: 410-530 mm

Figure 1 *The chair tested in the study: RH Logic 400*

2.2   Participants and test groups

Two major municipal Swedish corporations in Gothenburg, Din El and Göteborg Energi, participated in the study. At these companies a number of work entities were selected which dealt with various forms of computer-intensive office work. Tasks involving customer contacts by phone (so-called call centers), finance and administrative functions existed.

To evaluate the RH chair's effects on comfort, health and performance, the participants were divided into different test groups with varying conditions concerning type of office chair used and type of information given at the introduction of the RH chair.

The following test groups were designed (Table 1):

1) **RH chair:** This test group received an RH office chair without any information about how it should be handled and used. RH's concise booklet was appended to the chair.

2) **RH chair and verbal information (2 groups, one at each company):** These test groups received an RH office chair and verbal introduction from a salesperson who informed about how individual settings should be made using the controls of the chair. RH's concise booklet was appended to the chair.

3) **Existing chair (2 groups, one at each company):** These test groups kept their current office chair and got no information regarding adjustments etc. This group served as control group.

As one company, Din El, had a department that was willing to participate even though it was not needed, the study was expanded in order to evaluate a computer-based ergonomics program (eLearning). This is a form of web-based training in ergonomics with focus on computer-intensive office work. Furthermore, there was also a small group of five managers at Göteborg Energi, who were interested in both the RH chair and the eLearning program. This resulted in two more test groups:

4) **Existing chair and eLearning program:** This test group was allowed to keep their current office chair but had access to a computer-based training program on ergonomics for office/computer work.

5) **RH chair and eLearning program:** This test group received an RH chair and a computer-based training program on ergonomics for office/computer work. RH's concise booklet was appended to the chair

Initially, a total of 88 people participated in the study from the two companies, but four people dropped out during the study because of vacation or sick leave. Of the 84 people who participated throughout the study, 48 got an RH office chair. Table 1 provides a summary of the test groups. Test groups 4 and 7, that received the e-Learning program, were not primarily included in this specific study, but in some of the analyses these groups were used as control groups.

Table 1 *Test groups and number of participants in this study*

Group no	Company	Number of people	Function	Test Group design
1	Din El	15	Call center	1 (RH-chair)
2	Din El	13	Administration	2 (RH- chair, verbal info)
3	Din El	12	Administration	3 (Existing chair, control)
4	Din El	13	Economy	4 (Existing chair, eLearning)
5	GBG Energi	15	Call center	2 (RH- chair, verbal info)
6	GBG Energi	11	Administration	3 (Existing chair, control)
7	GBG Energi	5	Management team	5 (RH- chair, eLearning)
	SUM:	**84**		

2.3 Verbal information

In cooperation with a salesperson from RH, a uniform verbal information presentation on how the RH Logic 400 chair works and should be handled was developed. This information was then given by the salesperson to test groups 2 and 5 at the introduction of the RH chair. The two information sessions at the companies were documented to ensure equality for the two groups. At the end of the presentation a reference was made to RH's short information booklet that was appended to the chair. Also the information on the back of the booklet referring to RH's web site online was highlighted. The verbal presentation was given jointly to all participants in these test groups in a joint morning meeting. The participants were able to ask questions and test the settings on a demonstration RH chair.

Directly after the meeting, all participants received an RH chair to use in their own office space. The salesperson from RH then circulated in the office and helped out with individual settings. This procedure was in line with how RH wants their office chairs to be introduced at a company.

2.4 Data collection questionnaires

Data collection of subjective data was performed using questionnaires. Each participant filled in 7 forms during the study: First a background form, then 5 weekly forms and finally a following-up form at the end of the study. The questionnaires consisted of questions with options to tick and by subjective rating scales from 1-10.

Initially, all participants filled out an extensive background form regarding personal data, information on working conditions and computer work, perceived exertion, physical strain and stress as well as more detailed questions about their existing office chair and its settings (Appendix A). This questionnaire consisted of 39 questions, including some sub-questions. This questionnaire mapped all the essential information

about the persons included in the different test groups and was used as a basis for the interpretation of comparative analyzes between test groups. Regarding perceived exertion/physical stress (question No. 14 in Appendix A) 19 body regions on a 10-point scale were investigated. The body regions were also highlighted on a picture of a standing man. The focus of this question was on estimating discomfort in the upper body (neck, shoulder, arms and back), as these areas are most vulnerable in sitting work.

In addition to the information that the test subjects left in the background form about their current office chair, a compilation of the make, model and settings for each test subject's current chair was made. Additionally, optional accessories of the chair were noted such as chair footstool, back cushion etc. This information was essential to have access to in some of the analyzes, in order to understand what the test subjects with RH chairs were relating to concerning earlier experiences of chairs.

During each of the five test weeks, all participants filled out a 3-pages form with 16 questions for evaluating their chair's impact on work performance, stress and physical exertion. Six questions (Questions No. 10-15 in Appendix B) were then weighed in the analysis in order to make an overall assessment of the performance during the weeks.

The questions made possible an assessment of performance, effort, frustration, mental demands, physical demands and time pressure on a 10-point scale. This approach is based on the NASA TLX method. Physical exertion (question 16, Appendix B) was estimated in the same way as in the background form for making possible a comparison with prior experience in the analysis.

After the 5 weeks study had finished, a form with 27 questions was filled out (Appendix C). Most of these questions were the same as in the background form in order to compare comfort, health and performance issues before and after the introduction of the RH-chair.

The two test groups receiving e-Learning (groups 4 and 7) also filled out another form every week regarding the computer program's effect on working postures and chair settings. The result from this material is not presented in this report.

All data from the 7 questionnaires were transferred manually to an Excel document for further processing and analysis. The results involved data from 84 people who responded to a total of 82 questions (including a number of sub-questions). In total this resulted in a total of about 18 000 data points stored in Excel.

2.5   Implementation of the study

The study was conducted at the companies in November and December 2011 during weeks 45 to 51. In five of those weeks, week 46 to 50, the sharp evaluation of the RH-chair took place. During week 45, all groups were briefly informed about the project by their immediate supervisor.

The study was conducted as follows:

Start week:

• All participants met the researchers from Ergonomhuset and Chalmers, and written information about the project was distributed (Appendix D). The participants were also given information about which group they belonged to, and a unique three-digit number was handed out to make the process anonymous. Teach participants unique number was found in all seven questionnaires they were filled out during the study.

• The background questionnaire was handed out with information that it would be completed as soon as possible. Especially the groups that were going to get an RH chair must complete it before they got the chair.

• Delivery of chairs from RH in Gothenburg to the companies.

• RH's salesperson met group 2 and 5 and gave them verbal information about the chair. After that they got their RH chairs and help with individual settings if desired.

• Group 1 got their RH chairs, without any introduction, only information that the booklet was appended and that the address to the RH's web page was included at the back of the booklet.

• Brand and model of the existing chairs of all participants were documented.

Sharp 5 test weeks:

• The weekly forms were handed out personally by the project assistant to the participants at Din El on Thursday afternoons and to participants at Göteborg Energi on Friday mornings. After filled out the questionnaires were collected by the assistant at site and archived in binders.

The final week:

• The following-up form was handed out and collected at site by the project assistant.

• The participants who were not present when the assistant was there, got a form at their desk and an stamped envelope to send it back in to the assistant. Also the assistant visited each company a week later to pick up additional questionnaires.

• The project assistant asked those who had failed to submit forms previous weeks due to illness, vacation etc. if they had completed the forms and stored them at their desks. If so they were collected.

• All participants received two movie tickets for their involvement in the project. Also the managers who had been engaged in the study received movie tickets.

• The RH chairs were returned to RH in January 2012.

2.6 Analysis of collected data

The collected material was analyzed statistically to determine the RH chair's impact on comfort experience, physical complaints and performance, how individual chair settings had been used and how the tasks had been completed. Focus of the analysis was to study changes for each group during the 5 weeks test period, but also to see the differences in results between the different test groups. Moreover the group of individuals who all received the RH chair (48 people) was studied. Analysis has not been made regarding individuals' parameters such as age, gender, height, weight, body composition etc. in relation to comfort experience, performance and physical problems. There is great potential for further analysis using the extensive data set if additional research questions are formulated.

Software WinStat 3, developed at the Department of Analytical Chemistry by Professor Anders Colmsjö at Stockholm University, has been used to make statistical processing of the data collected. Data for the different test groups stored in Excel can be copied electronically to WinStat 3.

Wilcoxon sign test was used to determine if significant changes occurred during the test period for each group. The differences in values before and after a change (or no change) were measured, i.e. paired observations were calculated and compared within a group. Statistically significant differences for the group are calculated on the minimum level of significance of the program. Significance level is the same as the risk of error and is expressed as a percentage. Often this difference is considered to be significant if the level is 5% or less.

Besides Wilcoxon test of individual groups, testing of combined groups was performed to investigate differences in mean values (e.g. all participants that received an RH chair against all the participants who kept their existing chair). The material became then so large that the Student's t-test could be used to calculate differences at reliable significance levels. In these cases, a test of normal distribution of the groups was made before the analysis in order to determine if t-test can be used.

Test Group 5 (RH chair, eLearning) was only included in the analyses where all RH-chair users were merged into one large group. Since this group contained only five people, too few observations were at hand to make pair wise comparisons, thereby excluding a significance tests according to Wilcoxon sign test.

3   RESULTS

In the results, analyzes are presented in order to show whether and how the RH chair significantly influences comfort experience, physical discomfort and performance during the test period. Further, a presentation is made if the chair's controls/setting features have been used and if this has affected the performance of the work. After each analysis section the results are summarized briefly.

Regarding the nature of the existing chairs of the test participants, 85% of the participants had Kinnarp's 8000 office chair with high back and head-rest. 8% had Kinnarp's 6000 office chair of which more than half of the participants used the chair with lower back without headrest. Only 7% (8 people) had another office chair than Kinnarps (Frapett, EFG, HÅG, Höganäs, RH). Almost all participants in the test groups who received an RH chair had Kinnarp's 8000 chair prior to the study. Kinnarp's office chair 8000 has the same design and components as the 6000 chair. The difference between them is the tilting function. The 8000 model has a Synchron ™ tilt, where the relationship between the chair and back are well synchronized for a smooth rocking motion. The 6000 chair has a FreeFloat ™ mechanism with ergonomically correct freedom of swing/rocking feature (www.kinnarps.se).

3.1   Experience of comfort

3.1.1   How was the total comfort of RH chair perceived?
To find out how the overall comfort of the chair is perceived, a comparison has been made between question 29 in the background form and question 17 in the following up form. The comfort is assessed on a 10-point scale from very poor (value 1-2) to very good (value 9-10). Furthermore, question 9 in the weekly forms analyzed perceived comfort in the same way.

For group 1 with the RH chair, the significant difference is on the level of 0.9% that the comfort increased when they got a RH chair, i.e. the risk that the conclusion is wrong is 0.9% according to Wilcoxon sign test. 10 people out of 15 think they feel more comfortable with the RH chair while 3 people experience less comfort. 2 people have remained unchanged assessment. The mean comfort increased from 5.4 to 7.2 when they got an RH-chair.

Group 2 (RH-chair, verbal information) shows no significant difference in comfort experience but the average of the comfort estimate is 6.7 for the RH chair compared to 6.3 for their earlier chair. In this group 6 persons experienced more comfort and 3 less comfort with the RH chair, while 9 showed unchanged values.

Group 5 (RH-chair, verbal information) does not show any reliable statistically significant difference (level is, however, 6.5%) of comfort experience. Here is comfort assessment 6.4 for the RH chair versus 5.8 for their earlier chair. 7 participants consider comfort as better and 2 worse for the RH chair, while 9 have unchanged values.

On the average all RH chair users classified comfort around a value of 6. The median has a value of 6. 1/3 of the participants rate the comfort of the RH chair as high (value 7-9),

but also the values of the low comfort (3 and 4) can be found amongst 1/5 of the participants.

The groups that retained their existing chair (Group 3, 4 and 6) show no significant differences before and after the study. These groups rate the comfort of their office chair to be at value of 6 on average.

When it comes to comfort experience over time, including all five test week, there is a slight tendency for groups with RH chairs to categorize comfort slightly higher in the first week which fell slightly in the second week and remained slightly lower the last week.

3.1.2 How is the padding in the chair cushion and backrest experienced?

To find out how the padding is experienced in the chair cushion and the backrest of the chair, a comparison between question 20 and question 23 in the background form is made with question 9 and 12 in the following-up form. The comfort is assessed on a 10-point scale from very soft (value 1-2) to very hard (value 9-10).

For group 1 with the RH chair, the significant difference in the level was 4.1% (Wilcoxon sign test) that the chair is perceived as harder than the existing chair. 8 persons experiencing the harder, while 2 experiences the softer. 5 participants exhibited unchanged values.

Group 5 (RH-chair, verbal information) also shows significant difference (2.3%) indicating that the RH chair was perceived harder. 6 participants noted a harder experience whereas one noted softer and 8 noted unchanged values. The average change was assessed to 1.5 increments for these groups towards a harder experience.

For group 2 (RH-chair, verbal information) there is no significant difference between the RH chair and the earlier chair. In this group 6 participants experienced that the RH chair was harder than the existing one, 4 noted softer and 3 unchanged values.

The mean value for assessing the comfort of the chair cushion is 6.9 for all RH chair users, which is classified as hard, and is two increments above medium hardness. 1/3 of the users appreciate comfort against a stiff chair and these can be found at values between 7 and 9. Only 2 out of 48 RH-chair users estimate the comfort as soft (value 4).

When it comes to comfort experience from back cushion none of the groups showed that the RH chair was significant different (Wilcoxon sign test) with respect to perceived comfort of their former chair. About half experienced the RH chair back cushion as somewhat harder while half got a softer feeling. The difference was only one increment. Mean comfort evaluation of the back cushion was 6.3 for all RH-chair users, which points to a somewhat hard experience.

The control groups showed no significant differences in terms of perceived comfort during the test period, neither of the chair cushion or back cushion. The control groups showed mean values around 5.5 for the chair and 5.9 for the back cushion, which is around average hardness.

3.1.3 Summary of the experience of the RH chair comfort
The overall comfort of the RH chair is considered better than the chair the participants had previously. The comfort is considered good to very good and well above average comfort. The positive comfort experience has a tendency to decrease after the first test week.

With regard to the comfort of the chair cushion on the RH is experienced as somewhat hard, even harder than the pad of the previous chair that the participants had. Back pad is considered to have no difference in comfort compared to the back cushion on the participants' previous chair. Back pad is generally assessed as softer than the chair cushion, but still towards the hard experience.

Generally, the overall comfort of a chair is considered as somewhat more than average comfort for all groups included in the study.

3.2 Physical complaints

3.2.1 RH chair's impact on stress / load in various body regions
In order to study physical complaints, question 13 in the background form was initially summarized. This describes whether the participants had longstanding physical problems in the body for a month in the past year and if so, in what regions. The results indicated that approximately half of the participants had had no physical problems, while the other half had. Mainly, problems were located to the head, eyes, neck, shoulder and arm set.

To assess if the chair had no effect on perceived exertion / physical stress during the test period, the comparison has been made between the results of question 14 in the background form and question 16 in the last week form (week 5). In these matters 19 body regions were estimated on a scale of 1 to 10 on how tight / congested the region felt. The estimate is considered by no means strained (value 1-2) to very strained (value 9-10).

Deeper statistical analysis has been made (Wilcoxon sign test) for neck, shoulder, upper back, lower back (lumbar spine) and limbs (Appendix E). These regions are mainly influenced by the chair design for sitting computer work. Additionally, this coincide more with the body regions that participants emphasized that they had trouble with. Concerning shoulders, these have been analyzed at both sides (right and left), followed by an analysis where four values were merged, right and left shoulder and right and left axis. Concerning the arms, each side (left and right) is analyzed followed by an overall analysis of the arms made where four values are merged (right and left upper arm and right and left forearm). Analysis has been made of the wrist, fingers, abdomen and feet, as these parts are not necessarily affected by the chair but more of other issues at the computer workplace.

The result of the neck showed that symptoms had decreased significantly in group 2 and 5 (RH chair, verbal information) at a level of 1.3% and 1.4%. In group 2, seven participants gave reduced load, five had unchanged values and two increased load. For group 5 gave seven participants less strain, five were unchanged and one value

increased load. The difference was on average two increments of less perceived exertion than before. No significant difference was found in the neck for group 1 (RH-chair). In this group six participants had unchanged values, five reduced load and three increased load, but the scale steps were large both ways, up to four units. When an aggregate of all the participants in the study who received the RH chair (48 pieces) were made, this revealed that at 5% significance the stress and load of the neck had decreased after the five week period using the RH chair.

The results from total shoulder stress also showed significant difference to symptoms decreased in group 2 and 5. Nine and eight participants in the groups showed reduced effort. Also group 4 (existing chair and eLearning) showed significant difference in the improvement of the shoulder region. Group 1 (RH-chair) showed no significant difference at this point. Six participants had better values and four lower values while four were unchanged (these had very low strain rate). When all RH-chair users were merged into one group (48 in all) this showed that the significant difference to the physical effort of total shoulder decreased during the 5-week period with the RH chair. Even the right shoulder side showed significance for reduced loads.

When it came to the upper back, shown in the questionnaire as the thoracic region, there were no significant differences in any group that effort declined during the period. Most participants had unchanged values here, and effort was generally classified as low. At the merging of all participants with the RH chair no differences appeared.

The lumbar spine showed no significant difference in group 1 and group 2, while group 5 (RH chair, verbal information) showed significance with less effort at the level of 4.7%. When all RH-chair users were merged into one group, there were significant differences in the effort to decrease the lumbar spine at the level of 5%. 1/3 of the participants showed less effort (with 3 increments on an average), 1/3 were unchanged values and 1/3 for higher effort but with only one increment average.

For total arms no significant difference was showed for any of the test groups. The same number of participants in the test groups showed an increased as well as reduced effort, but the difference was only a few increments. A tendency was that the physical effort declined slightly on the right side.

Concerning the legs no significant differences for any of the groups with the RH chair could be demonstrated. Many had unchanged values after the study compared to before the study. The estimate for the leg effort was generally low. Neither the whole group with RH-chair users could be shown to have a tendency to difference before and after the test period.

3.2.2 Summary physical complaints

For the RH chair impact on perceived exertion physical / mechanical load on the various body regions there is a significant improvement by using the RH chair, i.e. reduced load, especially for the neck and shoulder regions could be registered. For shoulders, this is valid for the entire region, i.e. a merger of both the right and left sides. In particular, significant improvement could be found for the right side, although lumbar strain decreases significantly when an RH chair is used for a longer period of time. Trends are also available to reduce the load on the right arm. See Appendix E for statistical analyzes.

Half of the participants in the study had earlier in the same year long-term problems in different regions of the body, especially in the upper part. For these subjects, the effort in neck and shoulder decreased more than for the people who did not have problems before.

3.3 Performance

3.3.1 Performance

To assess performance during the 5 week test, the questions10-15 of the weekly forms was analyzed. These six questions dealt with how the participants coped with and performed their duties during the week. On a 10-point scale it was assessed how a participant managed the tasks (very low to very high performance), effort (very small to very large), frustration (very small to very large), requirements of thinking / mental performance (very low to very high requirements), requirements for physical activity (very low to very high standards) and time pressure (very small to very large). The analysis considered the responses related to these six questions as a total amount for each test subject for each week.

Comparison of the overall performance was made between weeks 1 and 5 with the Wilcoxon sign test for all groups. The results showed significant differences for group 2 (RH-chair, verbal information) and Group 5 (RH chair, verbal information) against increased performance (at significance level of 3.8% and 5.0%). Other groups showed no significant difference between first and last test week that performance increased. Group 1 (RH-chair) showed instead significance of decreased performance for week 5 compared to week 1. Similar comparisons were also made between the performance week 1 and the other week. The results indicated that the overall performance increased by week 2 compared to week 1 followed by a more constant value.

Thereafter the issues were separated in the overall performance, and questions 10-15 were analyzed separately. Especially question 14, requirements for physical activity, was interesting to study individually because the chair should affect this outcome. Reduced physical activity showed up as significant for the RH-chair groups when week 1 was compared to weeks 2, 3 or 4, i.e. physical activity decreased compared to week 1. The requirements for physical activity at work were assessed generally as low or very low (values 1-4) by many participants.

Question 10, how well they coped with their tasks, also dropped out as significant for weeks 2 and 3 of the period for group 2 and 5 (RH chair, verbal information), but not for group 1 (RH-chair). Participants generally estimated this issue that they had high or very high performance over the entire period (scores of 7-10). Other measurements showed no significance for RH-chair groups for higher performance during the weeks following the introduction of the chair.

Time pressure at work, issues 15, showed a tendency to decrease after week 1, but no significant differences were found for RH-chair groups. Depending on the tasks in the different test groups' time pressure was estimated with low values for certain groups and high values for other groups.
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3.3.2 Summary of the RH chair impact on performance

Groups with the RH chair showed an increased overall performance of the week at the beginning of the test period. Groups that received verbal presentation at the launch of the RH chair were also slightly higher in performance at the end of the test period than at the beginning.

The issues of performance measure that will most likely be affected by the chair design are how well they coped with their tasks and requirements for physical activity. These individual measurements showed better performance for the RH chair groups during the test period than in the control groups, especially the requirements for physical activity decreased slightly.

The assessments of performance from the NASA TLX method of how the tasks should be implemented and used in this analysis can be difficult to connect only to the type of chair that was used. Many other parameters at work affect these factors, such as time constraints.

3.4 Controls/adjustment features on the RH chair

3.4.1 How is the understanding of the chair controls perceived?

To find out how test subjects experiencing understanding/use of sliders on the chair responses of question 30 in the background form was compared with question 18 in the following-up form. On a 10 point scale the understanding was estimated, from 1-2 corresponding to very poor understanding to 9-10 corresponding to very good understanding.

For all groups with RH chairs, there is a significant difference (Wilcoxon sign test) for a greater understanding compared with what they rated the existing chair before the test. The level of significance is 0.7% for group 1 (RH-chair), 0.9% for group 2 (RH-chair, verbal information) and 4.8% for group 5 (RH chair, verbal information). The control groups 3 and 6 (maintained existing chair) showed no change, nor did group 4 (existing chair, eLearning).

From group 1, eleven participants exhibit changing values towards greater understanding, from the values of average understanding of 5-6 to values of 7-8 towards good understanding. The rest of the participants have unchanged values. On average, this group has increased its understanding by 2 increments. For group 2, who received verbal information and individual help with settings and displays, ten participants showed greater understanding of the values of 6-7 up to values of 9, which represents very good understanding of the controls. On average, this group has increased its understanding with 1.6 increments. One participant in this group shows less understanding with one increment, while others have unchanged values. In group 5, eight participants showed an increased understanding on average by 2 increments up to a value of 7-8. Four participants showed less understanding (an average of 1 increment) to values of 5-6 and two showed unchanged values

3.4.2. How often does a person adjust the chair?

To find out how often participants adjust their chairs, question 1 in the weekly forms has been analyzed. A more detailed comparative analysis was also made between weeks 1 and 5.

For all groups receiving the RH chair adjustments were made to chair position more frequently during week 1 versus week 5. On average, the number of times a participant adjusted the chair ranged from once a day to a few times a day during the week 1 to virtually no adjustments at all for week 5. The control groups 3 and 6 (retaining existing chair) showed no change at all considering the settings of the chair, the vast majority of participants almost never adjusted the chair during the working week, i.e. neither week 1 or 5.

Significant differences (Wilcoxon sign test) were found at a level of 0.8% for group 1 (RH-chair) and 3.7% for group 2 (RH-chair, verbal information). None of these groups adjusted the chair more than five times week 1, however, five and four people in the groups respectively had unchanged values between the two weeks.

For group 5 (RH chair, verbal information) a low significance level of 8% was found (not satisfactory statistical significance). In this group, there were some people who adjusted the chair more than 5 times at week 1, but most persons adjusted fewer times week 5. Two persons had unchanged values.

In group 4 (existing chair, eLearning) an increase was registered for the number of times chair was adjusted in week 5 compared to week 1. From virtually no adjustments at all to 1-2 times a week. This increase was significant at the 1.6% level. In this group seven participants had unchanged values.

3.4.3 Is the rocking feature of the chair used and how often?

To understand if the rocking mode is used question 15 was analyzed in the following-up form and compared with question 26 in the background form. Answers to these questions can only yield yes or no. The result shows that about one third of the test subjects used the rocking feature on the chair before the study.

In the case of Group 2 and Group 5 with the RH chair and verbal introduction, there is a significant increase (Wilcoxon sign test) of 2.7% and 3.1% in the use of the rocking mode. Eight and five people in the groups have begun to use the rocking feature when they received an RH chair. Other test persons had no change. No person had stopped using the swing after receiving an RH chair. For group 1 with RH chair but no introduction, there was no significant difference in the use of the swing when they got the RH chair. 12 out of 15 in this group did not change their behavior. For groups 3, 4 and 6 that kept the existing chair, there were no significant differences during the period. These groups show mostly unchanged values.

A total of 2/3 of those who received an RH chair used the rocking function; while one third did not use it (the swing is locked). Of these two thirds, half used it always open, that is 1/3 of the RH-chair users have it open all the time. The other third varied its use of the swing considerably, ranging from a few times a day, a few times a week to a couple times a month. The inertia of the swing function was considered to be at medium slow operation.

3.4.4 Use of other controls on the chair

In order to understand if the chair controls have been used, questions 7 (chair height), 8 (forward / reverse), 10 (back), 11 (back angle), 13 (arm) and 14 (neck) in the following-up form were analyzed. Table 2 shows how many of the 48 RH-chair users who have adjusted the different measurements during the test period. Especially in group 5 with verbal introduction, most adjusted all dimensions. Similar results were not shown by the other test group that received verbal information (group 2). The control that was adjusted by most users is the chair height (75%), while the headrest is adjusted only by half of the users. Chair dimensions are adjusted by slightly more participants than the backrest dimensions.

Generally, the frequency of how often the different measurements were adjusted can be considered as low, on average only a few times during the 5-week period. Some participants have only adjusted the dimensions a single time during the period. The chair height has on average been adjusted a few times per week while armrests and headrests are adjusted very seldom.

In Group 5 who received verbal introduction a little over 1/3 of the participants adjusted the measurements daily. The dimensions that are usually most adjusted are the dimensions associated with chair and backrest, most frequently the chair height, while the armrest and headrest were adjusted approximately once a week.

Table 2 *Number of RH-chair users who adjusted the dimensions of the chair*

Group	Test design	No. of users	Chair-level	Chair forward/ backward	Back-rest	Back-angle	Arm-rest	Neck-rest
1	RH	15	8	9	9	8	9	11
2	RH, verbal	13	10	5	6	6	8	3
5	RH, verbal	15	15	15	11	12	11	12
7	RH, eLearning	5	3	4	3	4	2	1
Sum		**48**	**36**	**33**	**29**	**30**	**30**	**27**

3.4.5 Summary of the use of the RH chair controls / setup functions

The understanding of the controls of the RH chair is perceived generally as good to very good. Compared to the chair used before this investigation, the participants showed a considerable increase in the understanding of the controls when they received an RH-chair. This was also sustained for a longer period. Verbal introduction of the chair means that understanding increases significantly and was rated as very well.

When introducing a new chair opportunities for individual settings are used initially. Adjustments are made on average a couple of times per week for 1-2 weeks. This applies to people who get deeper introduction of the chair as well as for people who are free to use the chair without instructions. After having found appropriate settings during an initial period, these are rarely changed thereafter.

Verbal introduction of an RH chair significantly increases the use of the rocking operation of the chair compared to other ways of instruction. Approximately 1/3 of the users have always the swing locked while another third always have the swing open. Other locks and unlocks the swing with great variety, from several times per day to a couple times per month.

Generally the various settings of the chair are seldom used. Often adjustments are made once on the introduction of the chair, followed by rarely changing the settings. Chair height is the variable most often adjusted while the headrest and armrests are rarely adjusted. Chair dimensions are adjusted more often than the back rest. Verbal introduction indicates that the chair controls are used more frequently.

3.5 The RH chair's impact on the work performance

3.5.1 The chair's impact on work situation and work techniques

Question 7 in the weekly form was analyzed in order to study whether the chair impacted working conditions during the test period of 5 weeks. Effects were assessed on a 10-point scale from negative (value 1-2) through neutral (value 5.5) to positive (value 9-10). In this analysis, data from all participants with an RH chair were put into one group and all participants with an unchanged chair to another group in order to compare results. Thereafter, any estimates on question 7 made during the 5 weeks for each participant were included in the calculation for each group. This resulted in 195 observations for the RH group and 147 observations for the group with the old chair. Since the groups were large data was tested whether they could be regarded as a normal distributed or not. Indeed, this allowed the Student's t-test to be used for the comparing of group means.

The analysis showed that there was a significant difference between the group averages for the test at 5% level, i.e. an error risk of 5% was set (Appendix F). This indicated that the RH chair could be considered to affect the work situation more positively than the existing chairs that the control groups had. The mean values of the estimates were at 5.91 for the RH-chair group and 5:49 for the group with the older chairs.

The issue if the chair affected work technique during the week were assessed in question 8 in the weekly form. Question 8 was analyzed in the same manner as question 7. This resulted in 195 observations for RH chair groups and 163 observations for the groups with an older chair. The results showed a significant difference at 5% level (t-test) indication that the RH chair was judged to have more positive impact on working technology (Appendix F). The average values were at 5.87 and 5.56. When an additional test was made of the exact level of significance, it was shown to be as low as 0.9%, i.e. the risk of error was only 0.9% that the demonstrated difference was incorrect.

3.5.2   Chairing position
When it came to study how the participants perceived their sitting posture, question 32 of the background form was compared with question 20 in the following-up form. The experience was assessed on a 10-point scale from very poor (value 1-2) to very good (value 9-10).

Group 1 (RH-chair) showed significant difference at the level of 1.2% that the chairing position felt to be better with the RH chair compared to the chair they had previously. The average was 4.7 for the existing chair to 6.0 for the RH chair. The improvement was on the average two increments. Nine people out of 15 in this group stated that their position has improved, and for eight of these the improvement was at least two increments.

For the other groups with an RH chair no significant differences were found. Group 2 (RH-chair, verbal information) had a mean experience of 6.7 for The RH chair while group 5 (RH chair, verbal information) had a mean of 6.2. This means that all RH-chair users experience a chairing position that points towards good and above average. The control groups showed no significant differences. Participants in these groups also indicated that they felt their chairing position slightly above average.

To find out whether the participants felt relaxed in the body during computer work question 23 was analyzed in the following-up form and compared with question 35 in the background form. Answers to these questions could only yield yes or no. The results showed no significant difference (Wilcoxon sign test) for any of the test groups. The majority of participants in all groups that received the RH chair showed unchanged values. Of a total of 48 RH-chair users, nine mentioned that they felt non-relaxed in the RH chair but had done so as well in the old chair. Four participants who did not felt relaxed before the study felt now relaxed in the RH chair. However, there were similar trends even in the control groups.

3.5.3 Stress effect
For the analysis of stress, a comparison has been made between perceived stress before the study (question 10 in the background form) and perceived stress at the end of the 5-week period (question 4 in the following-up form). Stress is assessed on a 10-point scale from 'never felt stress' (value 1-2) to 'always felt stress' (value 9-10). Furthermore, question 4 in the weekly forms analyzed stress in the same way.

No significant difference (Wilcoxon sign-test) between the perceived stress before and after the test period was shown for any of the 7 test groups. In the analysis of the 5-week period, there was a tendency that stress decreased slightly weeks 1-2 and then increased again. In the analysis of stress values (t test) for all RH-chair users (48 pieces) before and after the test period there was likewise no significant difference. On average, the level of stress for all RH-chair users is found in the middle level at the end of the test period (mean values 5-6). This was approximately the same level as before the test period.

3.5.4 Summary of the chair impact on work

The RH chair was judged to have a more positive impact on the work situation as an overall judgment and the working technique than existing chairs have. The chair's impact is slightly above the neutral value, which means that users have some kind of positive feeling of working in a chair.

The sitting position in the RH chair is considered better than the existing chairs and RH-chair users experience a sitting position that they consider good. Users also feel relaxed when sitting in the chair.

Stress levels for the participants in the study did not differ significantly before and after the test period, neither for the control groups nor groups with an RH chair. Assessment of how stressed a person feel during work is not a measure that can only be judged by the chair. The chair's contribution to perceived stress level is very difficult to assess. Stress perception is influenced by many other factors in the work situation.

DISCUSSION, CONCLUSIONS, RECOMMENDATIONS

The purpose of this study was to examine if the ergonomic features of the RH chair had effects on physical loads, perceived comfort and work performance during 5 weeks of office computer work. Furthermore the purpose was to study if the ergonomic adjustments of the chair were perceived and handled correctly by the users, especially if they got an introduction about how to use them. Also comparisons were made with the office chairs the users had used before they were introduced to work in the RH chair.

A large amount of information has been collected concerning daily function of the RH Logic 400 chair in office computer work in two companies. The material consists of in total 84 office workers, divided into 7 groups. 48 workers tested the RH chair during the 5-week period whereas the other participants maintained their existing office chair.

Weekly assessments were made regarding the RH chair's impact on comfort experience, physical loading and work performance. In addition, background data regarding a large number of parameters was collected prior to that the RH chairs were introduced. Estimates of the parameters collected before the study were also collected after the 5 week study in order to be able to make comparative analyzes.

The collected data is sufficient to perform reliable statistical analyzes on. The level of significance, i.e. risk of erroneous conclusions, was set to a maximum of 5% for all analyzes. The material also contains control groups for comparison. In all the evaluations, significance regarding changes in the control groups was also tested. No significant differences emerged for these groups. This implies that no external parameters in the company or in society have affected the results.

Using the collected material a number of analyses were made, but there is a great potential for further analysis of the comprehensive data if other issues than reported here are of interest.

As always when performing studies including subjective estimations with test subjects, there are possibilities that the participants do not report what they actually feel, or might be uninterested in participating, and thereby fill in the questionnaires without reflection. Also individual judgments can sometimes be affected by group thinking.

However, in this study both the participants and the management seemed to be motivated to participate in the study, and few people dropped out. The project assistant was also always present and met the participants every week when they should fill in the forms. This might have highlighted the importance of individual reflective answers.

The following conclusions can be drawn from the study:

• Introduction of the RH chair resulted in a significant decrease in physical loadings in the neck, shoulder and lower back. This was also the case for the right side of the shoulder. Additionally there was a trend indicating a reduced load on the right arm.

• The use of the RH chair resulted in that people who had had or have long-term physical problems in the upper part of their bodies experienced reduced loads in these regions after a 5-week period.

• The sitting position in the RH chair was considered as good and better than the chair the users had previously. The users also in general felt relaxed when sitting in the RH chair.

• The total comfort of the RH chair was considered to be very good. The comfort of the RH chair was also considered as better than in the chair the users had previously.

• The seat cushion on the RH chair was considered hard while the back cushion was experienced slightly softer, but towards a hard experience. The RH chair was assessed harder than the chair the users previously had.

• The RH chair had a positive impact on the working situation as a whole and on the work technique in general. The users experienced a positive feeling when working in the RH chair.

• Using an RH chair resulted in that the job performance increased, but this subsided after a few weeks. If verbal information regarding why it is important to adjust and how to adjust the chair was given when the chair was introduced, increased job performance was maintained over a longer period of time.

• During assessment of job performance, it may be difficult to link only the office chair to how well the users coped with their tasks. Many other parameters in the working environment affect the performance.

• The RH chair did not affect the level of stress at work. Assessment of how stressed the participants felt is not a measure that only can be affected by the office chair. The stress level depends on many different factors in the work situation.

• The understanding of how to handle the controls on the RH chair was perceived as good. Verbal introduction of how and why the chair's controls should be used made the understanding significantly better.

• The opportunities for individual settings of the chair were used occasionally during the first week after introduction of the chair, especially if the users got verbal introduction about how the handle the controls. However, after appropriate settings have been found, these were rarely changed.

• The height of the RH chair was the measure most often adjusted while the head restraint and armrests were adjusted most seldom. The seat's dimensions were adjusted more often than the seat back. Verbal introduction lead to that the chair's controls were used more frequently.

• Verbal instructions during the introduction of the RH chair significantly increased the usage of the rocking operation.

Recommendations drawn from the study:

• Upon delivery of RH chairs to a company, an verbal introduction should be made by a skilled person. This person should deliver information of how the various controls of the chair should be handled, and how and why it is important to adjust the chair to fit individual dimensions. Furthermore, it should be emphasized that the chair should be adjusted several times per day in order to achieve a varied sitting position, and that the rocking feature should be used frequently.

• An instruction presentation materials should be developed that can be used by all salespersons, for example in the form of video, eLearning program or written material. The material should focus on increasing the understanding for the users about how good ergonomic sitting postures are achieved. Also how to deal with the various controls for adjustment is important. Especially it should be emphasized how individual setting should be performed and how to choose the location of the setting in relation to the user's anthropometric measures and preferences. Furthermore, it is also highly important to clearly show in which order the various dimensions of the chair should be set.

• Improve the booklet (the brief minor technical brochure) that is set on the chair by delivery, which shows how the various controls should be set. In particular, specify the order in which the controls should be set and explain briefly why and how the settings should be linked to the user's individual measures.

Background Form - Ergonomics and Sitting

1. □ Woman   □ Man

2. Age   _____ years

3. Length _____ cm

4. Weight _____ kg

5. Describe your physique! Circle the number that best fits!

Very thin/tiny   **Mean**   **Very large / heavy**
1   2   3   4   5   6   7   8   9   10

6. Work situation

□ Full time
How many hours? _____ h

□ Part time_____ (%)
How many hours? _____ h

7. How many years have you worked with sitting (office) work or similar?

□ less than a year
□ 1-3 years
□ 4-6
□ 7-10
□ 11-15
□ 16-20
□ 21-25 years
□ more than 25 years

8. How many hours do you work on average in a sitting position in a day?

□ less than one hour
□ 1-2 hours
□ 3-4 hours
□ 5-6 hours
□ 7-8 hours
□ more than 8 hours

9. How many hours per day do you spend at a computer at home?

□ less than one hour
□ 1-2 hours
□ 3-4 hours
□ 5-6 hours
□ 7-8 hours
□ more than 8 hours

10. Do you feel stressed at work?
Circle the number that best fits!

Never				**Sometimes**					**Always**	
1	2	3	4	5	6	7	8	9	10

11. Can you influence your work situation?
Circle the number that best fits!

Never				**Sometimes**					**Always**	
1	2	3	4	5	6	7	8	9	10

12. Do you take breaks and recover from work during the day?
Circle the number that best fits!

Never				**Sometimes**					**Always**	
1	2	3	4	5	6	7	8	9	10

13. Have you had long-standing physical complaints in the body (more than a month) in the past year?

□ Yes □ No

If yes, in which body regions?
□ head
□ eyes
□ neck
□ shoulder
□ arm
□ hand
□ back
□ abdominal / stomach
□ legs
□ feet
□ other _____

14. How high physically strain have you had in the past seven days after a normal working day? Circle the number that best suits your experience!

	Not strained				Mean				Very strained	
Neck (A)	1	2	3	4	5	6	7	8	9	10
Right shoulder (B1)	1	2	3	4	5	6	7	8	9	10
Left shoulder (B2	1	2	3	4	5	6	7	8	9	10
Right front shoulder (C1)	1	2	3	4	5	6	7	8	9	10
Left front shoulder (C2)	1	2	3	4	5	6	7	8	9	10
Right upper arm (D1)	1	2	3	4	5	6	7	8	9	10
Left upper arm (D2)	1	2	3	4	5	6	7	8	9	10
Right forearm (E1)	1	2	3	4	5	6	7	8	9	10
Left forearm (E2)	1	2	3	4	5	6	7	8	9	10
Right wrist (F1)	1	2	3	4	5	6	7	8	9	10
Left wrist (F2)	1	2	3	4	5	6	7	8	9	10
Right hand fingers (G1)	1	2	3	4	5	6	7	8	9	10
Left hand fingers (G2	1	2	3	4	5	6	7	8	9	10
The upper part of the back (H)	1	2	3	4	5	6	7	8	9	10
Lower back (I)	1	2	3	4	5	6	7	8	9	10
Abdominal / Stomach	1	2	3	4	5	6	7	8	9	10
The legs (J)	1	2	3	4	5	6	7	8	9	10
Feet	1	2	3	4	5	6	7	8	9	10
Eyes	1	2	3	4	5	6	7	8	9	10
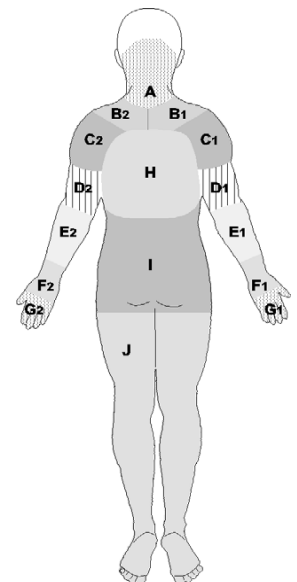
15. When did you get a new office chair last time?

□ less than a year
□ 1-2 years ago
□ 3-4 years ago
□ never, took over the existing chair
□ do not know

16. Have you received any information / training on how to use your office chair?
□ Yes □ No □ Do not know

17. How often have you adjusted your office chair?

□ 4-6 times per day
□ 2-3 times per day
□ 1 time per day
□ a few times a week
□ 1 time per week
□ 1 time per month
□ 1 time in half
□ 1 time per year
□ Never

18. Do you usually adjust the chair's chair in height?
□ Yes □ No

19. Do you usually adjust the chair cushion forward or backward?
□ Yes □ No

20. How do you experience the padding in the chair cushion?
Circle the number that best fits!

	Very soft				Moderate				Very hard	
	1	2	3	4	5	6	7	8	9	10

21. Do you usually adjust the backrest in height?
□ Yes □ No

22. Do you usually adjust the backrest depth (forward / reverse)?
□ Yes □ No

23. How do you experience the padding in the backrest?
Circle the number that best fits!

	Very soft				Moderate				Very hard	
	1	2	3	4	5	6	7	8	9	10

24. Do you usually adjust armrest?
□Yes □ No □ Have no armrests

25. Do you usually adjust headrest?
□Yes □ No □ Have no headrest

26. Do you usually use chair tilt function?
□Yes □ No □ Have no tilt function

27. If yes, how often do you use the rocking feature (have the rock open, not locked)?

□ always open
□ many times per day
□ a few times per day
□ once per day
□ a few times a week
□ a few times per month

28. If you use the rocking feature, how do you experience the adjustment (with the round knob) of the resistance / inertia?
Circle the number that best fits!

Easily Adjusted				average				Hard to Adjust	
1	2	3	4	5	6	7	8	9	10

□ Never adjusted the resistance / inertia

29. How do you experience the comfort of your office chair today?
Circle the number that best fits!

Very poor				Average				Very Good	
1	2	3	4	5	6	7	8	9	10

30. How do you understand the use of the controls of our chair today?
Circle the number that best fits!

Very poor				Average				Very Good	
1	2	3	4	5	6	7	8	9	10

31. Do you think the chair has any impact on your working technique?
Circle the number that best fits!

Very negative				Not at all				Very Positive	
1	2	3	4	5	6	7	8	9	10

32. How do you experience your posture at work today?
Circle the number that best fits!

Very poor				Average				Very Good	
1	2	3	4	5	6	7	8	9	10

33. Do you use a height-adjustable table/desk?
□ Yes □ No (If no, skip question 34)

34. How often, on average, do you change your table between sitting and standing during one day?

□ never
□ 1-2 times per day
□ 3-5 times per day
□ more than 5 times per day

35. Do you feel relaxed in your body during computer work?
□ Yes □ No

36. Have you space to relieve the forearms on the table/desk for computer work?
□ Yes □ No

37. Can you place the controller / mouse within your shoulder width?
□ Yes □ No

38. Can you sit in front of the computer screen?
□ Yes □ No

39. Can you get close to the work table when you sit in your office chair?
□ Yes □ No

If no:
□ armrests are bumping into the table
□ legs are bumping into the table
□ Upper body is bumping into the table

_____

Thank you for taking your time to fill out the form!

ergonomhuset

CHALMERS

Weekly Form - Ergonomics and Sitting
Weeks 46-50

1. How often have you adjusted your chair during the week?

□ 4-6 times per day
□ 2-3 times per day
□ 1 time per day
□ a few times during the week
□ 1 time during the week
□ not at all

2. Have you used the footrest during the week?
    □ Yes □ No □ Have no footrest

3. Have you used the armrest on the edge of the desk during the week?
    □ Yes □ No □ Have no armrest

4. Have you been feeling stressed out at work during the week?
Circle the number that best fits!

    Not at all   Sometimes   Very
        1   2   3   4   5   6   7   8   9   10

5. Have you yourself been able to influence your work situation during the week?
Circle the number that best fits!

    Never   Sometimes   Always
        1   2   3   4   5   6   7   8   9   10

6. Have you been taking breaks and recover during working hours during the week?
Circle the number that best fits!

    Never   Sometimes   Often
        1   2   3   4   5   6   7   8   9   10

7. How has the chair affected your work situation during the week?
Circle the number that best fits!

    Negative   Neutral   Positive
        1   2   3   4   5   6   7   8   9   10

8. Has the chair affected your working technique during the week?
Circle the number that best fits!

```
   Negative                 Neutral                      Positive
      1     2     3     4     5     6     7     8     9     10
```

9. How have you experienced the comfort of your chair during the week?
Circle the number that best fits!

```
     Very poor              Average              Very Good
      1     2     3     4     5     6     7     8     9     10
```

10. How good do you think you did your job during the week?
Circle the number that best fits!

```
   Very low                 Average                    High
  performance             performance              performance
      1     2     3     4     5     6     7     8     9     10
```

11. How much effort * (mentally and physically), have you put into your tasks during the week?
Circle the number that best fits!

```
   Very little              Moderate             Very high effort
      1     2     3     4     5     6     7     8     9     10
```

* Little effort is effortless
* Great effort is strained, forced to work hard

12. How frustrated* have you felt when you made your tasks during the week?
Circle the number that best fits!

```
   Very little              Moderate          Very much frustration
      1     2     3     4     5     6     7     8     9     10
```

* Small frustration is safe, satisfied, refreshed, relaxed
* Large frustration is insecure, depressed, irritable, stressed

13. How great demands* on thinking and mental performance has the work had during the week?
Circle the number that best fits!

    Very low   Moderate   Very high demands
       1   2   3   4   5   6   7   8   9   10

* Low standards mean that it was easy and simple to carry out tasks
* Major requirements mean that it was demanding and complex to implement data

14. How great demands* of physical activity have weekly tasks involved?
Circle the number that best fits!

    Very low   Moderate   Very high demands
       1   2   3   4   5   6   7   8   9   10

Low standards means that it was physically easy and comfortable to carry out
Major requirements mean that it was physically demanding, stressful and uncomfortable to perform functions

15. How much time pressure* did the weekly tasks involved?
Circle the number that best fits!

    Very little   Average   Very high pressure
   1   2   3   4   5   6   7   8   9   10

* Low pressure of time means that there was enough time to complete tasks correctly and satisfactorily
* Big time pressure means that tasks were performed quickly and hectic

16. How physically strained have you felt in different parts of the body during the week after a normal working day?
Circle the number that best fits!

	Not at all	Average	Very strained

Neck (A)	1 2 3 4 5 6 7 8 9 10

Right front shoulder (B1)	1 2 3 4 5 6 7 8 9 10
Left front shoulder (B2)	1 2 3 4 5 6 7 8 9 10
Right shoulder (C1)	1 2 3 4 5 6 7 8 9 10
Left shoulder (C2)	1 2 3 4 5 6 7 8 9 10

Right upper arm (D1)	1 2 3 4 5 6 7 8 9 10
Left upper arm (D2)	1 2 3 4 5 6 7 8 9 10
Right forearm (E1)	1 2 3 4 5 6 7 8 9 10
Left forearm (E2)	1 2 3 4 5 6 7 8 9 10

Right wrist (F1)	1 2 3 4 5 6 7 8 9 10
Left wrist (F2)	1 2 3 4 5 6 7 8 9 10
Fingers or right hand (G1)	1 2 3 4 5 6 7 8 9 10
Fingers or left hand (G2)	1 2 3 4 5 6 7 8 9 10

Upper back (H)	1 2 3 4 5 6 7 8 9 10
Lower back (I)	1 2 3 4 5 6 7 8 9 10

Abdomen / Stomach	1 2 3 4 5 6 7 8 9 10

Legs (J)	1 2 3 4 5 6 7 8 9 10
Feet	1 2 3 4 5 6 7 8 9 10

Eyes	1 2 3 4 5 6 7 8 9 10
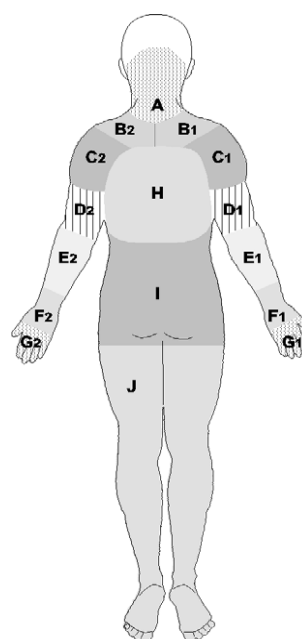
Thank you for taking your time to fill out the form!

Following-up Form - Ergonomics and Sitting

1. Work Situation
Reply only if your work situation changed in the past six weeks:

□ Full-time
How many hours include your full-time job? _____ Hours

□ Part-time _____ (%)
How many hours covering your part-time job? _____ Hours

2. How many hours do you work on average at a sitting position in a day?
Reply only if your work situation changed in the past six weeks:

□ less than 1 hour
□ 1-2 hours
□ 3-4 hours
□ 5-6 hours
□ 7-8 hours
□ more than 8 hours

3. How many hours per day you spend at a computer at home?
Reply only if your situation changed in the past six weeks:

□ less than 1 hour
□ 1-2 hours
□ 3-4 hours
□ 5-6 hours
□ 7-8 hours
□ more than 8 hours

4. Have you felt stressed out at work for the last six weeks?
Circle the number that best fits!

Never			Sometimes						Always
1	2	3	4	5	6	7	8	9	10

5. Have you yourself been able to influence your work situation for the last six weeks?
Circle the number that best fits!

Never   Sometimes   Always

  1   2   3   4   5   6   7   8   9   10

6. Do you take breaks to recover from work during the day the last six weeks?
Circle the number that best fits!

Never   Sometimes   Always

  1   2   3   4   5   6   7   8   9   10

7. Have you adjusted the chair's chair height over the past six weeks (for those who received a new chair: except in the beginning when you got it)?

□ Yes □ No
If you have adjusted the seat height - how often?
□ every day
□ 2-3 times/week
□ weekly
□ biweekly
□ a few times during the period
□ once during the period

8. Have you adjusted the chair cushion forward or backward in the last six weeks? (For those of you who got a new chair: except in the beginning when you it)?

□ Yes □ No
If you have adjusted the seat cushion - how often?
□ every day
□ 2-3 times/week
□ weekly
□ biweekly
□ once during the period
□ a few times during the period

9. How do you experience the padding in the chair cushion on your chair today?
Circle the number that best fits!

Very soft   Moderate   Very hard
   1   2   3   4   5   6   7   8   9   10

10. Have you adjusted the chair in height over the past six weeks? (For those who received a new chair: except in the beginning when you got it)?

□ Yes □ No
If you have back support - how often?
□ every day
□ 2-3 times/week
□ weekly
□ biweekly
□ a few times during the period
□ once during the period

11. Have you adjusted the angle of the backrest the last six weeks (forward / reverse)? (For those who received new chair: except in the beginning when you got it)?

□ Yes □ No
If you have adjusted/angled the backrest - how often?
□ every day
□ 2-3 times/week
□ weekly
□ biweekly
□ a few times during the period
□ once during the period

12. How do you experience the padding in the back of your current chair?
Circle the number that best fits!

Very soft   Moderate   Very hard
   1   2   3   4   5   6   7   8   9   10

13. Have you adjusted the armrest in the last six weeks?
(For those who received a new chair: except in the beginning when you it)?
Yes □ 0 □ No □ Have no armrests
If you have adjusted armrests - how often?
□ every day
□ 2-3 times/week
□ weekly
□ biweekly
□ a few times during the period
□ once during the period

14. Have you adjusted the chair's headrest the last six weeks?
(For those who received a new chair: except in the beginning when you got it)?
□ Yes □ No □ Have no armrests
If you have adjusted headrests - how often?
□ every day
□ 2-3 times/week
□ weekly
□ biweekly
□ a few times during the period
□ once during the period

15. Have you used the tilt function?

□ Yes □ No □ Have no tilt function

If yes, how often do you use the rocking feature (have swing open, not locked)?

□ always open
□ many times per day
□ a few times per day
□ approximately once per day
□ a few times a week
□ a few times per month

16. If you use the rocking feature, how do you experience that the adjustment (with the round knob) of the resistance / inertia works?
Circle the number that best fits!

Very soft				Moderate				Very hard	
1	2	3	4	5	6	7	8	9	10

□ never adjust the resistance / inertia

17. How do you experience the comfort of your office chair today?

Circle the number that best fits!

Very poor   Average   Very good
        1   2   3   4   5   6   7   8   9   10

18. How do you understand the use of the controls at your chair today?
Circle the number that best fits!

Very poor   Average   Very good
        1   2   3   4   5   6   7   8   9   10

19. Do you think the chair has impact on your working technique today?
Circle the number that best fits!

Very negative   Not at all   Very positive
        1   2   3   4   5   6   7   8   9   10

20. How do you experience your posture at work today?
 Circle the number that best fits!

Very poor   Average   Very good
        1   2   3   4   5   6   7   8   9   10

21. Do you have a raise and adjustable desk today?
□ Yes □ No (If no, skip question 22)

22. How often on average have you changed your table/desktop to change
between sitting and standing for a day the last six weeks?

□ Never
□ 1-2 times per day
□ 3-5 times per day
□ more than 5 times per day

23. Do you presently feel relaxed in your body during computer work?
□ Yes □ No

24. Have you space to relieve the forearms on the desk for computer work today?
□ Yes □ No

25. Can you place the controller / computer mouse within your shoulder
width today?
□ Yes □ No

26. Can you sit in front of the computer screen today?
□ Yes □ No

27. Can you get close to the work table when you sit in your chair today?
□ Yes □ No

If no:
□ armrests are bumping into the table
□ legs are bumping into the table
□ Upper body is bumping into the table

Evaluation of Ergonomics in Office Chairs

Chalmers University of Technology and Ergonomhuset in Gothenburg are performing a research project on office chairs and the effects of long-term sedentary work.

We have got the opportunity to perform a study at your workplace during weeks 45-51, 2011. We hope that you can help us raise awareness about the effects of sitting office work and development of chairs. After the study, each participant will receive two movie tickets as a gift.

You will be divided into a number of experimental groups and some of you will get a new office chair during the study, others will retain its current chair. Once a week, during six weeks, you should fill in a questionnaire about chair preferences, comfort and work performance. The form takes up to 10 minutes to complete and it is done during working hours. A person from the research team will advise here. Before the test starts, you will also fill out a form about your physical work situation today.

All information you provide is anonymous and you are identified only by a number. You have the option to cancel your participation without motivation whenever you want. When you fill out the form each week, it is important that you make a judgment entirely based on your own opinions and feelings. In the spring of 2012, you will be able to take part of the results.

If you have any questions about the scientific part of the project please contact Anna-Lisa Osvalder. For practical issues regarding the implementation of the study, please contact Susanne Hedin or coordinator Catrine Jonseth on Ergonomhuset at info@ergonomhuset.se.

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CHALMERS

ergonomhuset

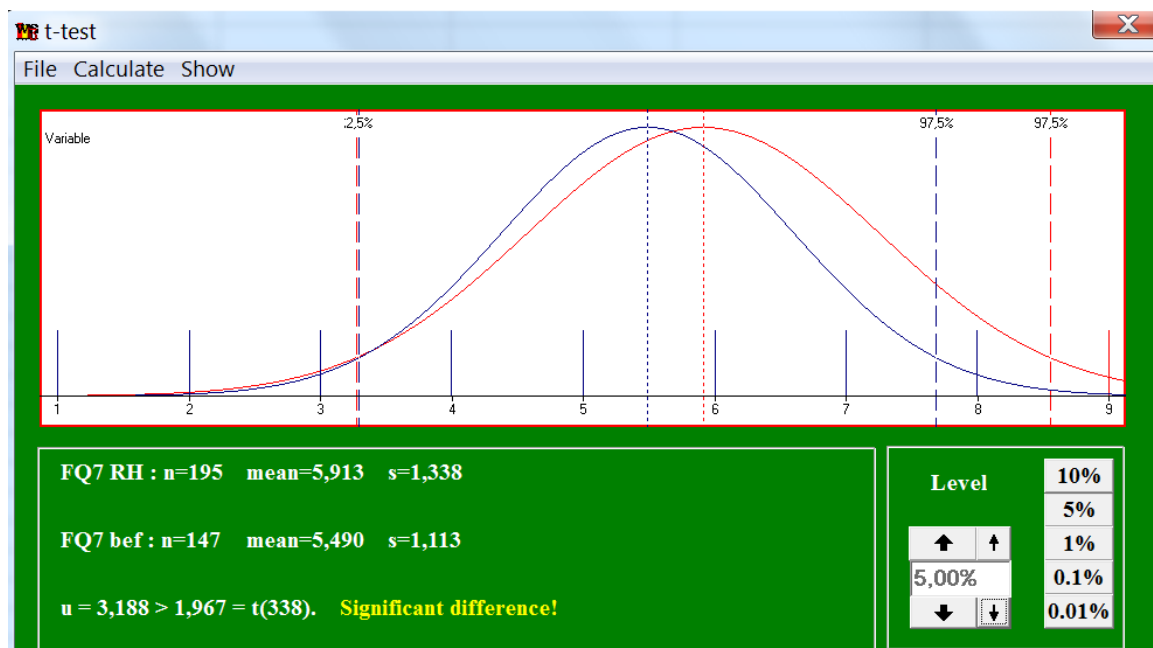## The RH chair's impact on work situation and work techniques

Figure 1: Estimation of the chair's impact on the working conditions of all who have used the RH-chair (195 observations) compared to the estimate for all using the existing chair (147 observations). Student's t-test was used for comparison of group means at a significance level of 5%. The result shows that there is a significant difference that the chair has influenced the work situation more favorable for the group with the RH.
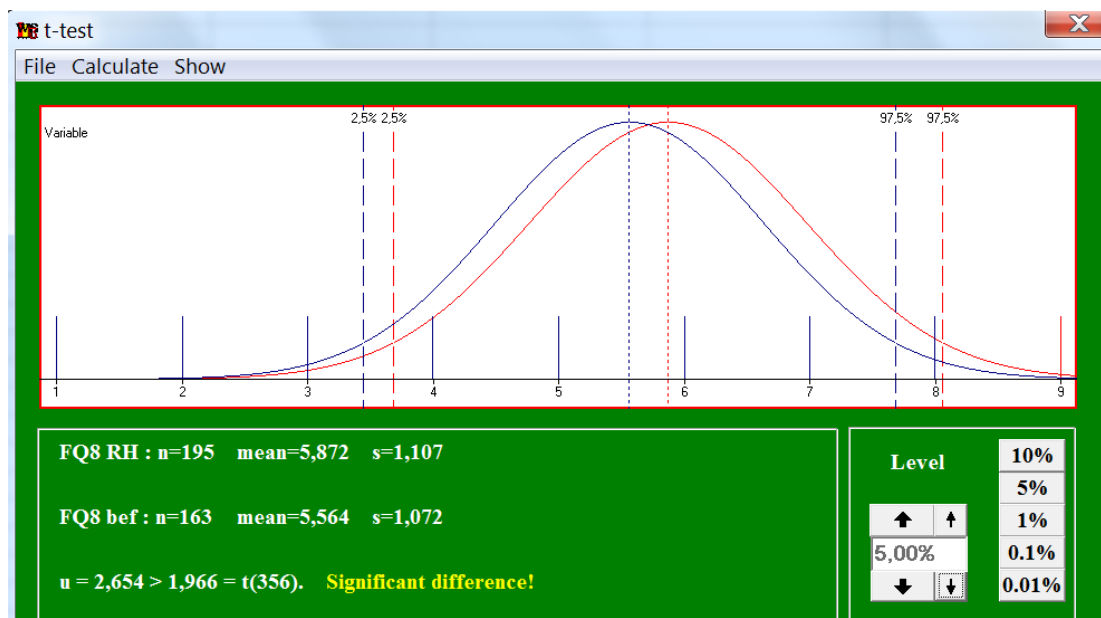
Figure 2: Estimation of the chair's impact on working techniques of everyone who has an RH-chair (195 observations) compared to the estimate for all using the existing chair (163 observations). Student's t-test was used for comparison of group means at a significance level of 5%. The result shows that there is a significant difference that the chair has affected working technology more positive for the group with RH chairs.
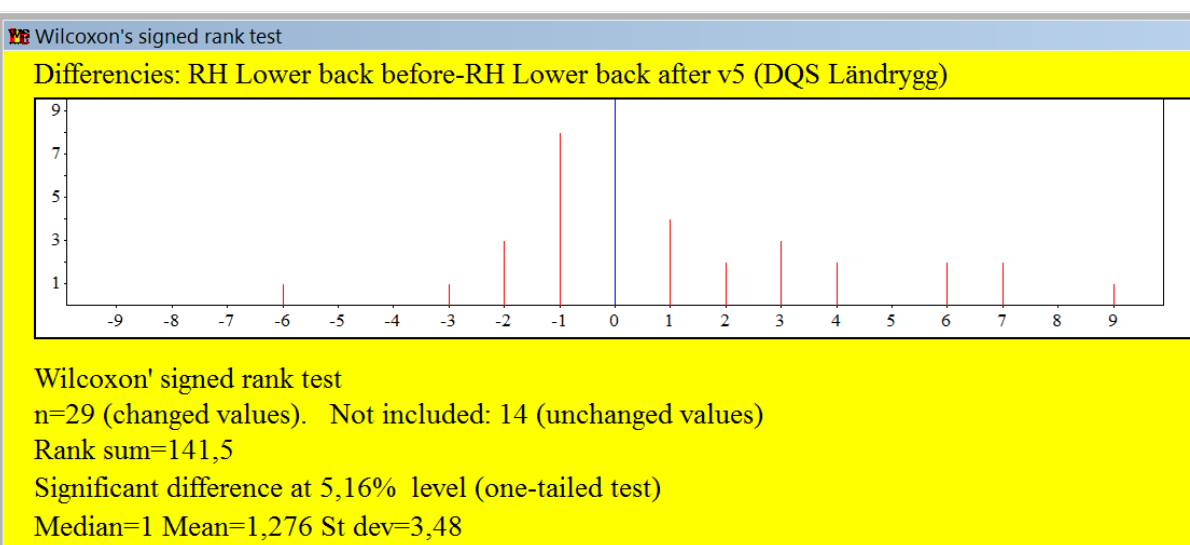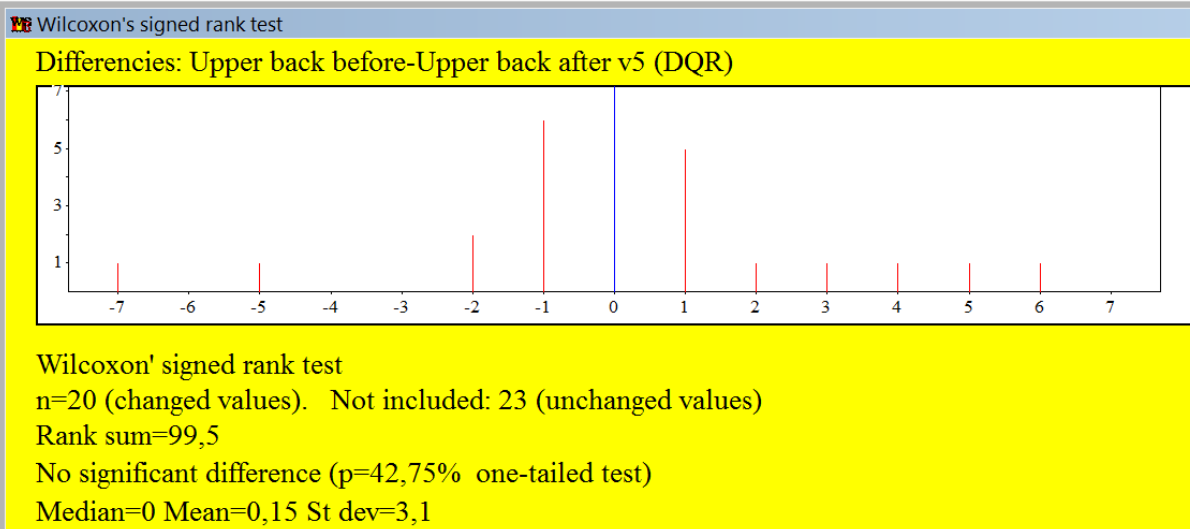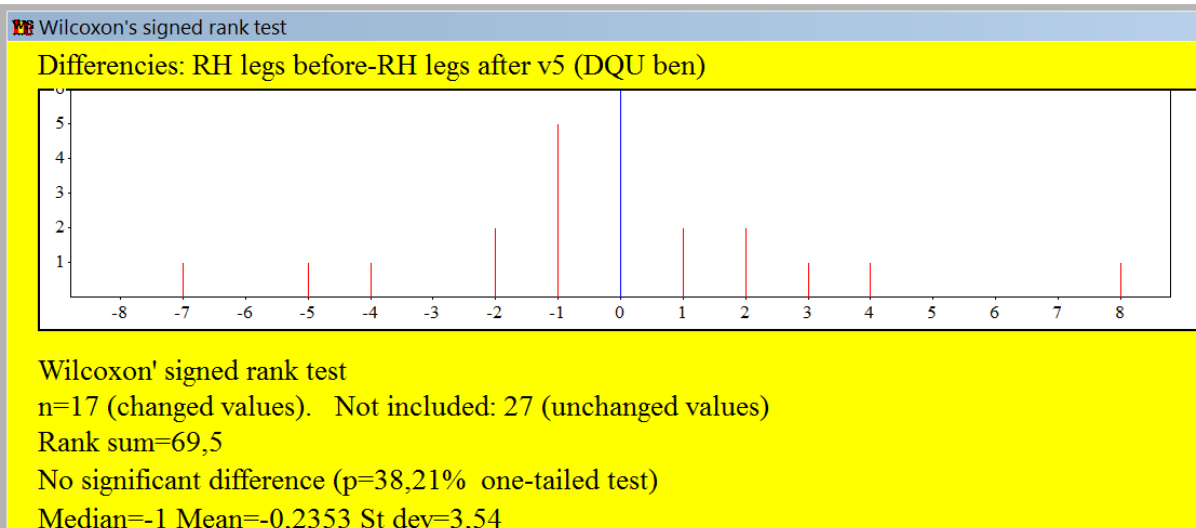
The RH chair's impact on physical complaints

Figure 1: Estimation of the RH-chair's impact on physical complaints of neck, shoulder, upper back, lower back, arms and legs from all participants who have an RH-chair (43 participants in this analysis, group 7 is not included). Wilcoxon sign-test was used for comparison of physical discomfort before and after the study was performed (5 weeks). The level of significance, i.e. the risk of an erroneous conclusion, was calculated exactly in this analysis. A level of 5% or less is considered as a statistically significant difference. In these comparisons the levels were 0.2% for neck problems risk, 1.6% for shoulder problems and no significant difference for upper back pain, lower back pain, arms and legs, i.e. no indications that the latter symptoms have decreased.

Wilcoxon's signed rank test

Differencies: Total RH Neck before-Total RH Neck after v5 (DQE Nacke)

Wilcoxon' signed rank test
n=27 (changed values).   Not included: 16 (unchanged values)
Rank sum=74,5
Significant difference at 0,2419% level (one-tailed test)
Median=2 Mean=1,333 St dev=2,25

Wilcoxon's signed rank test

Differencies: RH Shoulder total before-RH Shoulder total after v5 (DQE-I Skuldra total)

Wilcoxon' signed rank test
n=33 (changed values).   Not included: 10 (unchanged values)
Rank sum=161
Significant difference at 1,609% level (one-tailed test)
Median=3 Mean=2,909 St dev=8,83

Differencies: Upper back before-Upper back after v5 (DQR)

Wilcoxon' signed rank test
n=20 (changed values).   Not included: 23 (unchanged values)
Rank sum=99,5
No significant difference (p=42,75% one-tailed test)
Median=0 Mean=0,15 St dev=3,1

Differencies: RH Lower back before-RH Lower back after v5 (DQS Ländrygg)

Wilcoxon' signed rank test
n=29 (changed values).   Not included: 14 (unchanged values)
Rank sum=141,5
Significant difference at 5,16% level (one-tailed test)
Median=1 Mean=1,276 St dev=3,48

Differencies: Total RH arms before-Total RH arms after v5 (DQJ-M armarl)

Wilcoxon' signed rank test
n=24 (changed values).   Not included: 19 (unchanged values)
Rank sum=144,5
No significant difference (p=44,42% one-tailed test)
Median=0,5 Mean=-0,8333 St dev=9,19

Exit

Wilcoxon's signed rank test

Differencies: RH legs before-RH legs after v5 (DQU ben)

Wilcoxon' signed rank test
n=17 (changed values).   Not included: 27 (unchanged values)
Rank sum=69,5
No significant difference (p=38,21% one-tailed test)
Median=-1 Mean=-0,2353 St dev=3,54

Median, **mean** and **standard deviation** are calculated on the size of the difference in scale step for each participant's estimate of trouble before and after the test period.