



JÖNKÖPING UNIVERSITY

School of Health and Welfare

How does the height of a chair influence the pressure distribution inside and underneath a transfemoral prosthetic socket whilst seated?

MAIN AREA: *Orthotics and Prosthetics*

AUTHORS: *Jennifer Hägg & Signe Sander Nielsen*

SUPERVISOR: *Sara Kallin*

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Summary

Although sitting is a large part of everyday life the influence of the sitting positions and chair design on pressure and load distribution as well as comfort for transfemoral amputees quite unexplored. The aim of this study was therefore to examine this further.

Two transfemorally amputated females (49 and 57 years old) participated in the study. Three positions were examined for each subject; sitting without foot support and sitting with the knee joints flexed 90° and 105°. The pressure inside the socket was measured by two pressure sensors, placed distally and proximally on the posterior wall inside the socket. The lengthwise pressure distribution and the sidewise load distribution between the socket and the underlying material was measured by a pressure mat. In addition to this, the subjects answered a questionnaire regarding the subjective comfort for each position.

The result showed that the pressure underneath the socket were higher distally than proximally without foot support. The pressure transferred proximally as the knee became more flexed. The most even load distribution sidewise was found when the subjects sat with their knees flexed 105 degrees. Sitting with the knees flexed 90° was ranked as the most comfortable position. No conclusion could be made regarding the pressure inside of the socket. Additionally, according to this study the level of comfort does not have any clear relation with the sidewise load distribution or the longitudinal pressure distribution.

Key Words: Transfemoral amputee, pressure distribution, load distribution, sitting, subjective comfort

Sammanfattning

Hur påverkas tryckfördelningen inuti och under en transfemoral proteshylsa av höjden på en stol under sittande?

En stor del av livet spenderas sittandes, men den påverkan som sittposition och stoldesign har på tryckfördelning och komfort för transfemoralt amputerade är ganska outforskat. Studien ämnar därför undersöka detta.

Två transfemoralt amputerade kvinnor (49 och 57 år) medverkade i studien. Tre sittpositioner undersöktes för varje testperson; sittande utan fotstöd samt sittande med knäleden i 90° respektive 105° flexion. Trycket inuti hylsan mättes med hjälp av två trycksensorer, som placerades distalt och proximalt på den bakre hylsväggen. Tryckfördelningen i längsriktningen och lastfördelningen i sidled mellan hylsan och underlaget mättes med en tryckmatta. Förutom detta svarade testpersonerna även på ett frågeformulär angående den subjektiva komforten för varje position.

Resultatet visade att trycket under hylsan var högre distalt än proximalt när inget fotstöd användes. Trycket förflyttades proximalt då knät böjdes. Den mest jämna lastfördelningen mellan sidorna påträffades när knät var flekterat 105°. Enligt frågeformuläret var den mest bekväma positionen den med 90° i knäleden. Ingen slutsats kunde göras angående trycket inuti hylsan. Ingen tydlig relation kunde heller inte hittas mellan den subjektiva komforten och tryck- eller lastfördelningen.

Nyckelord: Transfemoralt amputerade, tryckfördelning, lastfördelning, sittande, subjektiv komfort.

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Introduction

Sitting is generally a large part of everyday life, it is therefore important to consider the influence of the posture and chair. This concerns transfemoral amputees in particular, since a prosthetic socket could result in excessive tissue loads or have a negative influence on the biomechanical situation.

The subject of sitting for transfemoral amputees is fairly unexplored and little is known about the sockets influence on the residual limb during sitting. The purpose of this study is therefore to get a better understanding of how the pressure distribution inside the socket and between socket and seat is affected by different chair heights. The clinical relevance of having this knowledge is hopefully to increase the comfort and reduce the risks connected with high pressure for prosthetic patients by recommending chair heights that minimizes these risks.

Our hypothesis is that different chair heights distributes the pressure in different ways, so, by adjusting the height of a chair would it be possible to decrease the peak pressure, and thus decreasing the risk of pressure ulcers. This could be beneficial for transfemoral amputees who regularly uses a prosthetic socket.

Forssén and Larsson (2014) and Thomasson and Johansson (2015) have previously conducted their bachelor thesis on the subject of sitting with transfemoral sockets, thus the current study could be considered an independent continuance of their work.

Background

Literature review

Problem definition

Hagberg and Brånemark (2001) have presented findings that show reduced quality of life after having a non-vascular transfemoral amputation. The two main reasons for this is pressure ulcers or shaving from the socket and the increase of heat which leads to sweating (Hagberg & Brånemark, 2001). However, it is well known that many amputees do suffer from vascular diseases, the most common is diabetes (Colgecen, Korkmaz, Ozyurt, Mermerkaya, & Kader, 2016; Vandelanotte et al., 2013). This makes it even more important to be aware of pressure ulcer and wounds in general, since ulcers in the worst case scenario can lead to a reamputation (Vandelanotte et al., 2013). It is therefore interesting to examine what can be done to reduce the risks of ulcers by adjusting the sitting positions.

Sitting

In general people tend to spend a great amount of time sitting, exactly how much is of course dependent on different aspects of life such as profession, interests and health. Bennie and colleagues (2013) report that Europeans on average spend 5-6 hours every weekday sitting down. Another study by Miller and Brown (2004), that examined the level of activity for several professions over a long period of time, found that the average of sitting each day is 9.4 hours. People who worked with management or administration sat even longer (Miller & Brown, 2004), these must be considered low active jobs. A Dutch study by Schoppen and colleagues (2001) have shown that Dutch lower limb amputees often switched to a less physically challenging job after the amputation. This could possibly be true in other European countries as well.

Vandelanotte et al. (2013) has shown that the unemployed people sit way more on average during a day compared to employed people. In consonance with this, a large group of amputees with skin problems on the residual limb are unemployed (Colgecen et al., 2016). A return to gainful employment is, from both a social and medical point of view, one of the main challenges of rehabilitation (Fernández, Isusi, & Gómez, 2000). However, this is extremely difficult due to both social and physical limitations (Vandelanotte et al., 2013). It is not certain that they can return to their original job even if they start working again.

Larsson, Aaro, Normelli and Oberg (2002) reported that uneven weight bearing can lead to discomfort when sitting, and for people with limited sensation can it lead to pressure sores. Treating these soars also comes with an economical cost (Hobson, 1992), this is an additional reason for preventing uneven load distribution.

It should also be stated that there is a difference between sitting and sitting with a socket. Transfemoral amputees that have used both socket and osseointegration rapport that one of the benefits of not having to use a socket is the increased sitting comfort (Lundberg, Hagberg, & Bullington, 2011). Hagberg, Häggström, Uden and Brånemark (2005) also rapport that it is common for prosthetic socket users to experience discomfort when sitting, moreover they rapport that the discomfort decreases when the hip flexion is more than 90 degrees. The active range of motion in the hip joint is significantly reduced when wearing a transfemoral socket (Hagberg et al., 2005). Which makes it particularly interesting to examine transfemoral amputees.

Pressure and pressure distribution

Pressure is defined as force per area and is measured in pascal (Pa), where 1 Pa equals 1 N/m² (Nationalencyklopedin, 2016). A high pressure on a small area increases the risk of pressure ulcers on the given area (Ek & Lindgren, 1997). High pressure is therefore sought out to be prevented. Pressure ulcers are defined by the NPUAP as a localized injury as a result of pressure or friction to the skin or underlying tissue (Black et al., 2007). The damage done by the pressure is due to a period of insufficient blood flow, which leads to a deficiency of oxygen in the cell tissue (Ek & Lindgren, 1997).

Forssén and Larsson (2014) found that the pressure distribution relation between the socket- and the healthy side was 30/70. Inconsistently the participants in the study experienced that the pressure was distributed evenly which led to the theory that the pressure inside the socket could be distributed in a different way. One possible explanation considered by Forssén and Larsson is that some load is taken up by the socket and transferred through the prosthesis to the floor. This led to the recommendation for future studies to examine the pressure inside the socket. Furthermore they found that the angle of the knee may affect pressure distribution as one of the participants had a prosthesis with dissimilar leg length (Forssén & Larsson, 2014).

In this field of knowledge, there is still very little research regarding the amount of pressure inside a transfemoral socket. However Zhang, Zhu, Shen and Zheng (2013) uses a finite element method to analyze the stress in the interface between a transfemoral socket and the residual limb during walking. Zhang and colleagues found a calculated normal stress between 50-80 kPa on the distal end of the stump and between 90- 120 KPa on the ischial bearing areas during the gait cycle of an average male amputee.

Research done on wheelchair users have explored the effects on pressure displacement between the buttocks and seat for tilted positions (Giesbrecht, Ethans, & Staley, 2011) and inclinations of backrest and seat (Chen et al., 2014; Hobson, 1992). The theory was that tilting the chair can change the orientation of the gravity in relation to the body, which changes the areas of peak pressure on the tissue (Giesbrecht et al., 2011). This is an interesting theory and indicate that the position is an important aspect to consider when researching the pressure when sitting.

Measurements and methods used by previous studies

According to the literature review made by de Looze, Kuijt-Evers and van Dieën (2013) have some studies reported a significant correlation between pressure distribution and comfort, others only showed an association and some found no clear connection between these, moreover, the associations can currently only be attributed to certain types of seats. A pressure mat has been used for measuring pressure when sitting in a wheelchair in different positions (Chen et al., 2014; Giesbrecht et al., 2011; Lung et al., 2014). Previous studies by students regarding sitting with a prosthesis have also used a pressure mat to investigate either load distribution or maximum pressure of transfemoral amputees when seated (Forssén & Larsson, 2014; Thomasson & Johansson, 2015). Pressure distribution seems to be the objective measurement that best reflects a subjective ranking of seating comfort (de Looze, Kuijt-Evers, & van Dieën, 2003).

Other methods such as electromyography (EMG), measuring the load on the spine or analyzing the subjects posture were not associated as clearly to the subjective rankings, nor were these associations statistically significant (de Looze et al., 2003). This indicate that measuring the pressure distribution is an accurate way to investigate the sitting comfort of transfemoral amputees. Correspondingly, subjective evaluations may to some extent reflect the pressure distribution.

Biomechanical reasoning

Some biomechanical reflections were done concerning various sitting positions, in order to develop a method that could examine the consequences regarding pressure, of altering chair heights for transfemoral amputees.

The authors expect that when a transfemoral amputee sits without foot support the pressure on the residual limb will increase anteriorly/distally. This hypothesis is based on the fact that the weight from the prosthesis not supported by the seat will create a vertical downward force, which affects the distal end of the socket. It is assumed that the distal force will increase the angle between femur and the socket, since expected that the femur bone will remain in an almost horizontal position, while the distal end of the socket will be inclined slightly forward. This should theoretically lead to pressures on the residual limb located anteriorly/distally as well as posteriorly/proximally. It is, however, assumed that the distal downward force on the socket will create a more distal pressure between the socket and chair.

The most equal distribution of distal and proximal pressure inside the transfemoral socket is expected to be found when the amputee sits with the knee flexed 90°. In this scenario it is assumed that the pressure will be distributed almost evenly over the posterior inner side of the socket. The authors are aware that it is not realistic to get an even distribution, since the density and shape of the residual limb is not constant throughout the socket. An even distribution would also require that the posterior wall is parallel to the chair and has no edges. The proximal edge of the socket is often rounded in order to raise comfort for the amputee. This gives an increased posterior/proximal force when sitting, which could affect the bone to flex inside the socket and give an anterior and distal pressure. It is assumed, however, that this force rather compresses the soft tissue than affects the bone.

When transfemoral amputees sit on a lower chair with the knee flexed more than 90° the foot support will create a vertical upward force, provided that the prosthetic lower leg is vertical, this affects the distal end of that socket to be pushed upwards. As this happens the gravity will influence the residual limb to move downwards. This theoretically leads to a higher pressure on the residual limb posteriorly and distally as well as anteriorly/proximally.

Justification of the current study

There is, to our knowledge, a shortage of peer reviewed articles on the subject of sitting with a transfemoral prosthetic socket. The majority of studies concerning transfemoral amputees mainly focuses on gait and prosthetic components. It is unclear how the pressure inside the socket is distributed and how this affects the residual limb. The article by Zhang and colleges (2013) who uses the finite element method is one of the few who approaches the pressure in the interface for transfemoral amputees, however it only addresses walking. Furthermore the 3D-modell created in this study were based on several assumptions and compromises, which lowers the validity.

However, no previous studies have examined how the height of a chair influence the pressure distribution inside and underneath a prosthetic socket whilst seated. Nor is it confirmed that high pressure between the socket and seat equals a high pressure inside the socket. Therefore we found it interesting to examine the pressure of the interface between socket and residual limb.

The placement of the sensors is essential when measuring the pressure inside the socket and the procedure is more circumstantial than measuring the pressure between socket and chair. A confirmed relation between these could make it easier to conduct future studies on this subject since they could then use only the pressure mat. Thus is a comparison between the results from the pressure mat and the sensors inside the socket motivated.

Amputees, like all people, spend a large part of their lives sitting as seen in the literature. Therefore is it important that the conditions are as good as possible to avoid discomfort and pressure related problems. Position is according to Hobson (1992) important to research further when discussing pressure-management regimes. By reducing the maximum pressure, the risk of pressure ulcers is lowered (Ek & Lindgren, 1997). To achieve reduced pressure inside the socket more information surrounding the aspects of sitting is required. One way to modify the situation when seated is to adjust the height of the chair. This is easy to implement in everyday life and in the workplace by using an ordinary office chair. A

seating device to heighten for instance the toilet seat is a common aid used by amputees according to Olsson and Axtelius (2008).

Arbetsmiljöverkets författningssamling (AFS 2012:2 5 §) states that the employer should arrange the workplace so that the working posture is as beneficial as possible for the employees. Thus knowledge of what is a beneficial position could improve the workplace for the amputees, which, as mentioned, is important for the rehabilitation process.

There is a need to examine the internal and external pressure for the socket, regarding sitting for transfemoral patients in different positions in order to get more information on how to prevent excessive pressure on the tissue and improve comfort.

Aim

The primary aims of this study were to examine how the height of a chair influence the pressure distribution in the longitudinal direction of femur, both inside a transfemoral socket as well as between the socket and chair. Furthermore to compare the results of these measurements.

The secondary aims were to examine if the load distribution between the amputated- and the healthy side is affected when the height of the chair is altered, and to investigate how the height of a chair influence the subjective comfort whilst seated.

Research questions

1. How will the posterior pressure move in the proximal/distal direction underneath and inside a transfemoral socket when the chair height is altered?
2. For which chair height will the pressure be most evenly distributed in the longitudinal direction of femur?
3. Is it possible to compare the pressure inside and underneath a transfemoral socket?
4. How does the load distribution between the left and right side differ when the chair height is altered?
5. How does the height of the chair influence an amputee's subjective comfort?

It was expected by the authors that both the pressure inside the transfemoral socket and the pressure between the socket and underlying material would be most evenly distributed when the knee joint was flexed 90 degrees, because then the thigh and socket would be parallel to the surface of the chair. In theory, lifting the distal end of the socket should influence the external proximal peak pressure to increase and the distal pressure to decrease.

Differences in amount of pressure inside the socket is assumed to be lower than the external pressure. This is based on the theory that even if the socket is lifted from one part of the seat the socket still contain the residual limb and some pressure should be registered.

A low chair could be uncomfortable for amputees, as many losses the range of motion in the hip (Hagberg et al., 2005), and it requires considerable flexion. It is also difficult to sit down that low with a prosthetic knee since it does not have any voluntary control. On the other hand a high chair, where the feet does not reach the ground, could be uncomfortable due to the fact that the weight of the prosthesis is not supported through the foot.

Methods

This was an experimental study where the subjects were given three interventions. Each subject served as its own control. Repeated measurements were made and results were compared between the studied conditions.

Subjects

The participants in this study was recruited through contacts of the Department of Rehabilitation at the University of Jönköping. Two subjects participated in this study, both were transfemoral amputated females. The two participants will be referred to as subject X and subject Y throughout the rapport. Subject X and subject Y have respectively been amputated due to cancer and trauma. More information regarding the participants can be found in "Results".

Inclusion and exclusion criteria

The inclusion criteria were unilateral transfemoral amputees, who was using a prosthetic socket, regardless of design and other components. The subjects should be over 18 years old and should be able to stand up and sit down repeatedly with ease. They should also be able to DON/DOFF the socket themselves and be able to flex the hip- and knee joint 105 degrees bilaterally.

The exclusion criteria were; osseointegration, exuding ulcers on the residual limb or subjects that were dissatisfied with the fit of the prosthetic socket, since poor fit could indicate risk of movement inside the socket, which could affect the trustworthiness of the results. People with cognitive impairment, reduced sensibility in the lower extremities or other pathological conditions that affects the ability to participate in this study were also excluded.

Equipment

Clinical examination

For the clinical examination a goniometer was used to measure angles, a tape measure was used for all length measurements and a scale was used for measuring the bodyweight and the weight of the prosthesis.

Pressure measurement systems

Two different systems were used for the data collection. Tekscan CONFORMat was used for the measurement between the socket and the seat. The CONFORMat provides information on pressure distribution, by using a 30 x 30 grid of specially designed sensors. The Pliance system from Novel was used for the measurement between the residual limb and the socket. The Pliance sensors used contains 4 x 4 pressure transducers on an area approximately 30 by 30 mm. The default frequencies of each software are used, 10 Hz for Tekscan and 50 Hz for Novel.

Chair

The chair used in this study is an ISOMed dynamometer. It is possible to adjust the inclination of the backrest as well as moving it forwards and backwards over the seat. The seat and backrest is flat and relatively firm, which the authors consider ideal when using the pressure mat. The same chair was used for all measurements in order to minimize the amount of independent variables, for example cushioning material, design and inclination. To simulate a chair with different heights a footstool and planks were used to adjust the distance to the footrest. These were secured using tape in order to make it safe for the participants.

Questionnaire

A modified questionnaire from a previous study (Donnelly, Callaghan, & Durkin, 2009) was used to acquire quantitative data, to help classify the level of comfort the subject experienced during three different positions. The questionnaire uses a 10 cm scale on which the participants marks the level of experienced discomfort for different parts of the sitting area. The whole questionnaire have been validated. However, this study only include two small section of the original questionnaire. The original questions 13-20, will in this study be referred to as Part 1. It concerns the placement on the body that is in contact with the seat and subjective experienced discomfort. Part 2 consists of the questions 4-6 from the original questionnaire, which concerns discomfort from the chair design, together whit a question where the participants ranked the three positions from most comfortable to least comfortable. The modified questionnaire can be found in Appendix 1.

Data collection

The subjects sat in three different positions whilst the pressure was measured by two different systems simultaneously. Five measurements were carried out for each position, resulting in a total of 15 recordings. Each system measured the general pressure distribution as well as the distal and the proximal peak pressure. For each recording 15 seconds of data were collected.

Clinical Examination

All subjects were examined before participating in the experiment. During the examination it was confirmed that all subjects complied with the physical inclusion and exclusion criteria by investigating the range of motion and looking for ulcers. Additionally measurements were taken. The leg length,

length of the remaining limb, bodyweight, the weight of the prosthesis and the distance between knee center and plantar surface were documented. Any apparent differences between the prosthetic and sound leg were also noted.

Sitting positions

Three positions were chosen to be examined (Figure 1). These positions will be referred to as position a), b) and c) throughout the rapport.

- a) No foot support, legs relaxed.
- b) Footrest that ensures 90 degrees of flexion of the knee.
- c) Footrest that ensures 105 degrees of flexion of the knee.

It was decided that the angel regulations should be for the knee as it is easier to measure reliably according to the authors.

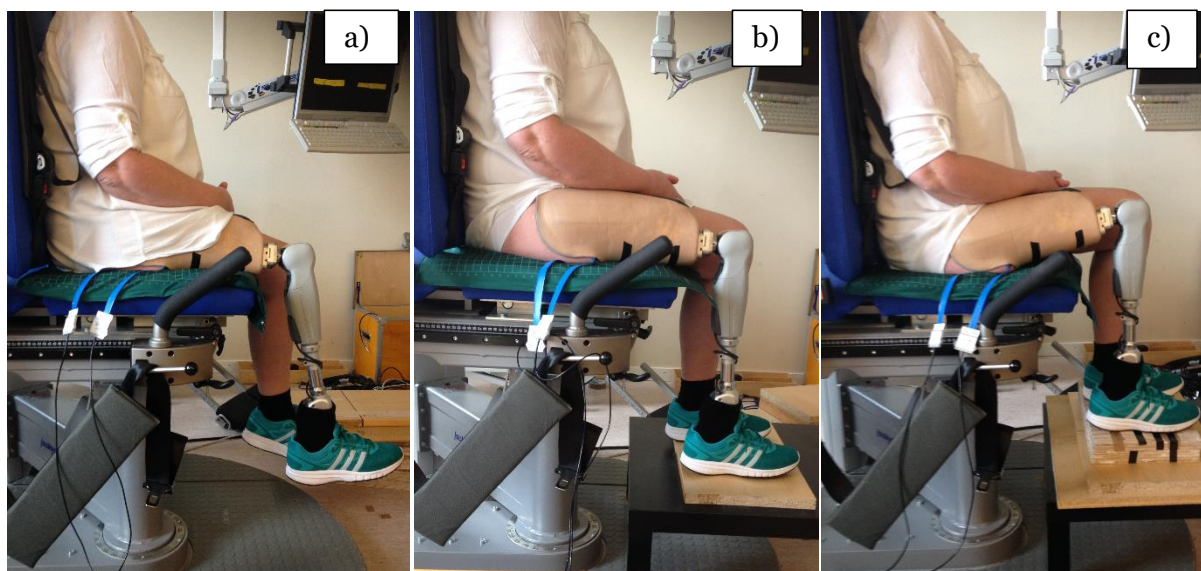


Figure 1: Positions examined during the experiment

All experiments were carried out with the following regulations: Hands comfortably resting on the lap, to avoid movement and to ensure that the hands were not pressed against the mat, and torso against backrest. The backrest was perpendicular to the seat and the ankle joint placed directly below the knee joint to minimize the effects of shear forces. Shear forces are difficult to measure without affecting the interface properties (Lung et al., 2014), and even though it is impossible to totally prohibit sliding and shear forces, it is desirable to have it contribute as little as possible.

The participants were seated from the height which was intended to be measured, with support if needed. For position a) the foot support was removed before each recording. The distance between the knees were not controlled. This was done in order to get a situation that was as true to life as possible.

The reasons for examining these specific positions were to get one fairly neutral position and two more extreme positions that is independent of body height. One of the three most common sitting positions observed by Kamp, Kilincsoy and Vink (2011) at semi-public leisure situations was a combination of head away from backrest, torso against backrest, arms not on the armrest and both feet on the ground. This is fairly similar to the neutral position (position b) in this experiment, presumably with exception from the inclination of the seat. Even though the study was not specific to amputees it shows that the position studied is relevant to every day sitting. Position a) is equivalent to sitting on a high chair where the feet cannot reach the ground. Position c) is equivalent to sitting on a low chair.

To significantly relocate the pressure when only tilting a wheelchair and not changing the position in relation to the chair a tilt of 30 degrees was needed (Giesbrecht et al., 2011). When changing the inclination of the seat and backrest smaller changes, around 20 degrees, were needed to get significant differences between the conditions (Chen et al., 2014). It is however plausible that changing the position

in relation to the chair has a bigger impact than just tilting a chair, it was therefore expected to get results by the angle changes used in this study.

Pressure measurements

The pressure mat was placed on the seat of the chair. Two Pliance pressure sensors were placed posteriorly inside the socket, one distally and one proximally (Figure 2). The proximal sensor was placed where the socket began to have continuous contact with the seat after the edge. This was made to ensure co-occurrence between the pressure mat and the sensors. In order to decide where to place the distal sensor, so that it at all time was in contact with the residual limb, the participants were asked about the distal fit of the socket when sitting. The location of the sensors were marked on the outside of the socket using tape.



Figure 2: Placement of the Pliance sensors

In the beginning of each measurement the position of the Pliance sensors in relation to the pressure mat were transferred by pressing the end of a whiteboard-marker next to the sensor, which gave a pointed pressure that indicated the position of the sensors. This part of the recording was excluded from the analysis and not included in the 15 seconds of data. The location of the sensors were only identified in the longitudinal axis of femur, due to difficulties locating the sensors in the lateral/medial direction.

Procedure

The participants were given instructions of the procedure before the experiment began. The participants were able to ask questions during the whole experiment and the instructions were repeated when needed.

To be able to observe if the socket rotated when sitting down a reference mark was placed vertically over the knee center in the frontal plane when standing. If the reference mark was not in the frontal plane when the subject sat down it indicated a rotation, which was taken into account when placing the sensors. During the experiment photos of the positions were taken to have the opportunity to look at the implementation in retrospect. The participants were allowed to wear loose fitting shorts, to allow room for the measuring equipment and to enable the researchers to see the marks.

The order of the positions were b), c), a). This order were chosen because the alterations and the use of the foot support made it the safest for the participants without prolonging the procedure.

The data collection began when the participants appeared relaxed. The participants were not allowed to see the computer screens during the data collection to prevent correction of posture. Between each measurement the participants stood up before sitting down again. The reason was to avoid that repeated measurements were taken in an unrepresentative position.

After each position the participants answered part 1 of the aforementioned questionnaire. After all three positions were finished part 2 was answered.

Data analysis

The recordings were controlled in order to find potential artifacts to verify the collected data. The five measurements from each position were compared, in order to avoid anything that seemed incorrect.

The results were not normalized to body weight or height since the intention was to only compare the results within the subject.

Proximal-distal pressure between socket and chair

The area representing the location of the Pliance sensors were manually chosen using the pointed pressure from the marker, creating a mask of the pressure area of interest. The sequence of the recording that included the additional pressure from the marker were excluded from the analysis. In addition to this the left and right sides were manually, by approximation, separated into masks for further analysis (Figure 3). In the medial-lateral direction the masks were ensured to include all the pressure recorded from the socket.

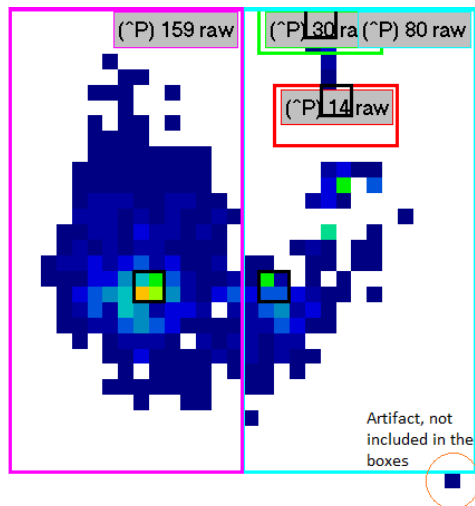


Figure 3: The masks made in the Tekscan system. Red= placement of the proximal sensor. Green=placement of the distal sensor. Purple=left side. Blue=right side

For each measurement, a sequence range of 15 seconds were collected. The sequence was checked for artifacts. If artifacts were found they were not included in boxes, as seen in Figure 3. 15 seconds of data corresponded to approximately 150 frames. All values calculated were based on an average of these frames. The mean pressure and peak pressure were calculated, using the software system, for both the proximal and the distal areas chosen

Proximal-distal pressure inside the socket

The data collection for the Plance system were started and stopped at the same time as the Tekscan measurement. The results from the two sensors were separated using masks, as seen in Figure 4. The mean results over time were calculated. The force, the mean pressure (calculated over the whole sensor area) and the peak pressure (both mean and maximum) were documented. The differences between the proximal and the distal values for the three positions were compared within each person.

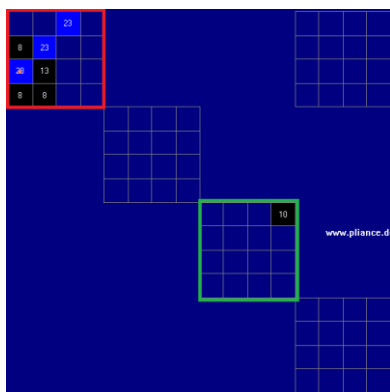


Figure 4: The masks made in the Plance system. Red=proximal sensor. Green= distal sensor.

Medial-lateral load distribution

The load distribution was collected from the same recordings as for the proximal-distal pressure between the socket and chair. The load distribution between the left and right side were calculated using the percentage of force on each side.

Questionnaire

The results from the questionnaire were compiled by measuring where, on the 10 cm line, the subjects made a marking. The three positions were non-statistically compared to each other for each subject individually.

Comparison between measurements

The differences of the means for the distal and proximal pressure were compared between the systems, within the same position and person. Additionally the experienced comfort was reported in the questionnaire compared to the results from the pressure measurements.

Statistical tests

IBM SPSS Statistic 21 were used for the statistical analysis of the data from the measurement systems. For all test a significance level of $\alpha=0.05$ were used.

Two options for statistical tests were given to examine if the differences between the distal- and proximal data for the three positions respectively, were statistically significant. In case of normal distribution a Two-way-ANOVA were used, since this test allows comparisons between two or more variables for repeated measurements. Bonferroni's post hoc. test was used in order to compare the means of the locations to each other within a position. In case of non-normal distribution the nonparametric method, Friedman's test, were used repeated times. Bonferroni were then used to compensate for the effects on the significance level.

To examine the differences of the sidewise load distribution between the positions One-way-ANOVA was used, if the data were normal distributed. This is due to the fact that the data contains repeated measurement for three observations. The reason for using One-way instead of Tow-way is because the percentile of load distribution on the right and the left side is proportional with each other, this means that the test only need to include one side. In this study the healthy side was tested. In case of non-normal distribution Friedman's test were used.

Ethical considerations

The study was approved by the course coordinator at the Department of Rehabilitation, School of health and welfare, Jönköping University. The participants were given information about the study and a letter of consent to sign before participating in this study (Appendix 2). The participants were informed both in writing and verbally that participation was voluntary and could be terminated by the participant without any explanation at any time.

Reflections regarding the safety for the participants were made. The risks were considered low in regards to injuries related to the equipment, injuries while conducting the experiment and the patients being upset or otherwise negatively affected by the questionnaire. The medical care of the patients were in no way affected by participating in this study. There are potential benefits with this study for transfemoral amputees as it increases the overall knowledge about sitting whit a prosthetic socket.

Results

The following section presents the results from the data collected. Thus the following contains the relevant clinical findings as well as the statistical results from pressure measurements, which should provide clarification on the research questions. The test results are presented in the same order as the structure of the aim.

Subjects

By the clinical examination both participants were found suitable for the study according to the inclusion and exclusion criteria. However subject X was wearing an adhesive plaster near tuber ischiadicum. The subject explained that the adhesive plaster was used preventive, and it was checked that there was no ulcer underneath. The subject confirmed that she was satisfied with the socket despite the use of plaster. Thus it was decided to let the subject continue participating in the study.

The shape of the residual limbs were categorised as cylindrical for both participants, the stump lengths were ordinary and the solidity were soft according to the standards made by Persson and Liedberg (1983). Subject X had an especially soft stump due to the fact that femur was much shorter than the residual soft tissue.

Information about the participants can be found in Table 1. Both subjects were using a Marlo Anatomical Socket (MAS). However, subject X had a total contact suspension whereas subject Y was using a vacuum suspension with a seal-in liner with three rings.

Table 1: Information regarding the subjects.

Subject	X	Y
Age [Years]	49	57
Amputated side	Right	Left
Socket design	MAS	MAS
Body weight [kg]	76	52
Weight of prosthesis [kg]	3.4	1.7
Length of residual limb [cm]	22	25
Leg length [cm]	89	82
Distance from intact knee joint to floor [cm]	49	44
Distance from prosthetic knee centre to floor [cm]	49.5	46

Proximal-distal pressure between socket and chair

The pressure values described in this section refer to the values between the chair and the socket.

Some visible difference occur in between the positions. An example of the pressure distribution in each position can be seen in Figure 5. For position c) there was no pressure registered by the equipment distally. In contrast to this, the distal pressure underneath the socket was relatively high for position a).

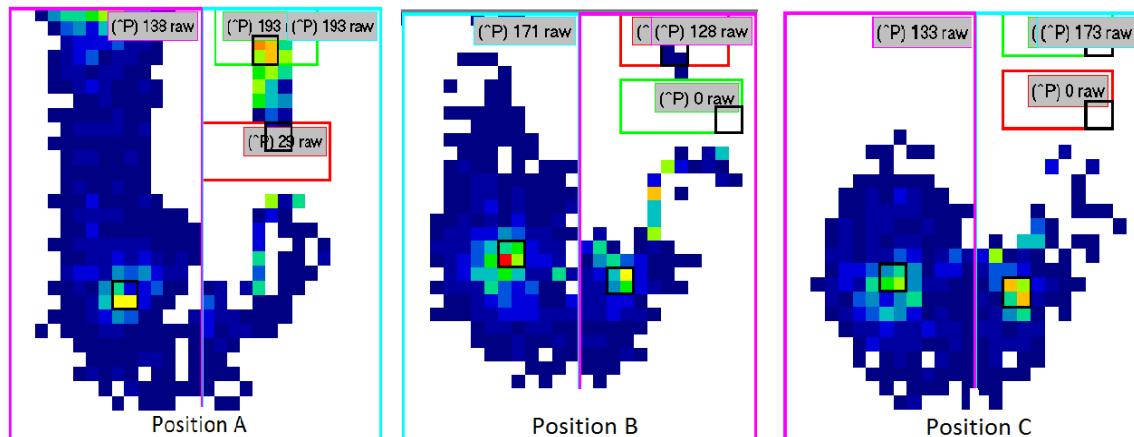


Figure 5: An example of the pressure distribution between the socket and chair.

The mean- and peak pressure data from all three positions for both the proximal and the distal masks were normally distributed, and Two-Way-ANOVA was used for the statistical tests. The sphericity were checked using Mauchly's Test of Sphericity. For subject Y was one p-value for the sphericity lower than 0.05, this was compensated for by using Greenhouse-Geisser since the ϵ -value was lower than 0.75.

Table 2 shows that both the distal mean pressure and the distal peak pressure were higher than the proximal pressures in position a) for both subjects. For subject X the distal pressures was higher than the proximal in position b) and there were no pressures registered at all in position c. For subject Y no pressures were registered in the distal masks in neither position b) nor c).

There were statistically significant differences between the means of the distal and proximal pressure underneath the socket for the mean and peak pressure with exception to the peak pressure in position a) for subject Y (Table 3). For subject X the biggest differences between the proximal and the distal area was found in position a), where the distal mean pressure was more than five times bigger than the proximal mean pressure. The distal peak pressure was more than double of the proximal peak pressure. For both subjects the greatest pressure values appears distally in position a). For subject X the distal mean pressure is almost four times bigger in position a) than b). It was not possible to make pairwise comparisons for subject X in position c) since there were no recorded pressures.

Table 2: Mean values for the mean pressure and peak pressure between the socket and the chair in position a), b) and c).

Position	Location	Subject X		Subject Y	
		Mean Pressure (S.D) [kPa]	Peak Pressure (S.D) [kPa]	Mean pressure (S.D) [kPa]	Peak Pressure (S.D) [kPa]
a)	Proximal	32.2 (8.34)	107.8 (84.3)	69.5 (3.9)	158.0 (36.6)
	Distal	171.2 (15.1)	236.0 (20.5)	95.3 (13.5)	242.6 (68.3)
b)	Proximal	9.2 (5.4)	10.2 (6.1)	55.5 (15.2)	107.0 (46.9)
	Distal	45.4 (24.0)	71.8 (33.9)	0.0 (0.0)	0.0 (0.0)
c)	Proximal	0.0 (0.0)	0.0 (0.0)	85.0 (51.7)	98.2 (43.2)
	Distal	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)

The mean pressure is calculated over the contact area, the area on the pressure mat that has registered any pressure within the limited masks.

Table 3: Pairwise comparisons of the mean and peak pressure for both subjects

Table 3. Pairwise comparisons of the mean and peak pressure for both subjects							
Position (I) Location (J) Location			Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
						Lower Bound	Upper Bound
Pairwise comparisons of the mean pressure between the different locations for each position, or subject X.							
a)	Distal	Proximal	139,000*	8,983	,000	114,058	163,942
b)	Distal	Proximal	36,200*	9,937	,022	8,611	63,789
c)	Distal	Proximal	,000	,000	.	,000	,000
Pairwise comparisons of the peak pressure between the locations for each position, for subject X.							
a)	Distal	Proximal	128,200*	33,589	,019	34,941	221,459
b)	Distal	Proximal	61,600*	13,963	,012	22,833	100,367
c)	Distal	Proximal	,000	,000	.	,000	,000
Pairwise comparisons of the mean pressure between the different locations for each position, or subject Y.							
a)	Distal	Proximal	25,820*	5,536	,010	10,450	41,190
b)	Distal	Proximal	-55,460*	6,791	,001	-74,314	-36,606
c)	Distal	Proximal	-85,000*	23,139	,021	-149,245	-20,755
Pairwise comparisons of the peak pressure between the locations for each position, for subject Y.							
a)	Distal	Proximal	84,600	36,062	,079	-15,524	184,724
b)	Distal	Proximal	-107,000*	20,981	,007	-165,252	-48,748
c)	Distal	Proximal	-98,200*	19,335	,007	-151,882	-44,518

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Proximal-distal pressure inside the socket

During the measurements on subject X no pressure were recorded inside the socket. No technical defects were found on the equipment. It is assumed that the pressure did not reach the lower threshold for registration, which was 7.5 kPa.

The outcome for the pressure measurements for subject Y shows that the peak pressure is considerably greater than the mean pressure (Table 4). There was only one recorded measurement saved for each position due to technical difficulties.

Table 4: Subject Y's mean values in peak pressure and mean pressure between the socket and residual limb in position a), b) and c).

Position	Location	Peak pressure (mean) [kPa]	Peak pressure (maximum) [kPa]	Mean pressure [kPa]
a)	Proximal	27.407	27.500	6.357
a)	Distal	9.675	10.000	0.605
b)	Proximal	16.080	17.500	2.874
b)	Distal	14.979	15.000	0.936
c)	Proximal	26.976	27.500	5.338
c)	Distal	17.490	17.500	1.093

No statistical tests were done on the data collected inside the socket, because of the lack of usable results. However the intention were to make the same procedure as for the data collected between the socket and chair.

Load distribution

The percentage of load between the sides was normally distributed for both subjects. One-way ANOVA were therefore performed for each participant to determine if there were any significant difference between the positions. Since the percentile of load distribution on the right and the left side is proportional, the differences between the positions were only compared for the healthy side. According to the One-way ANOVA there was a significant difference between some of the position for each subject. The mean load percentage for the healthy sides is shown in Figure 6 and 7 for subject X and Y respectively.

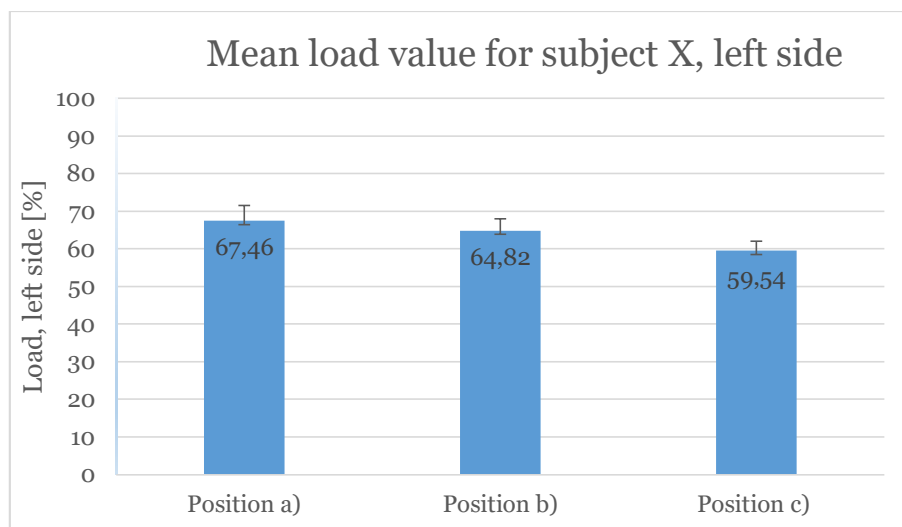


Figure 6: Mean load value for subject X, left limb

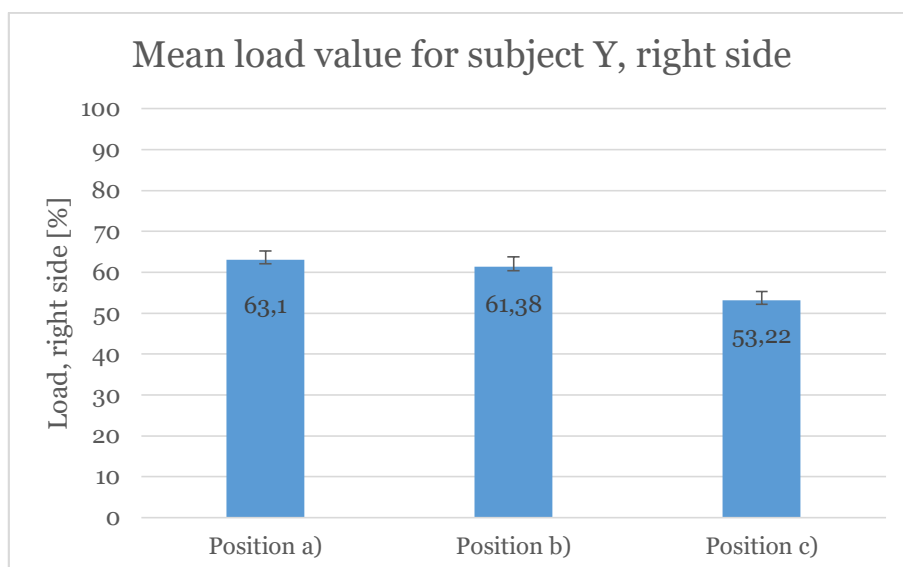


Figure 7: Mean load value for subject Y, right limb.

The difference between the means of the load in subject X were only statistically significant for position a) and c). For subject Y were the differences of the means statistically significant between position a) and c) and between position b) and c) (Table 5).

Table 5: Level of significance for the load distribution between the positions

Positions compared	Significance for subject X	Significance for subject Y
a) and b)	0.007	0.000
b) and c)	0.685	0.734
c) and a)	0.078	0.000

Questionnaire

Part 1

The questions from part 1 in the questionnaire concerns the experienced level of comfort in the different parts of the sitting surface. The division can be seen in Figure 8. The results show that subject X experienced more discomfort in position c) (Figure 9). In contrast it shows that subject Y experienced position a) as least comfortable (Figure 10).

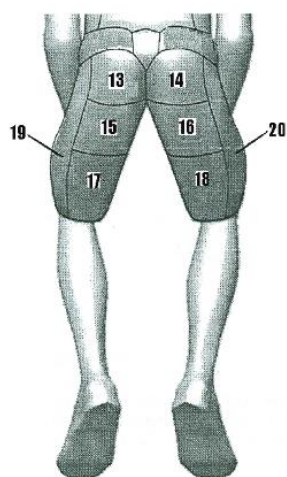


Figure 6: The sitting surface divided into areas, which were evaluated in the questionnaire.

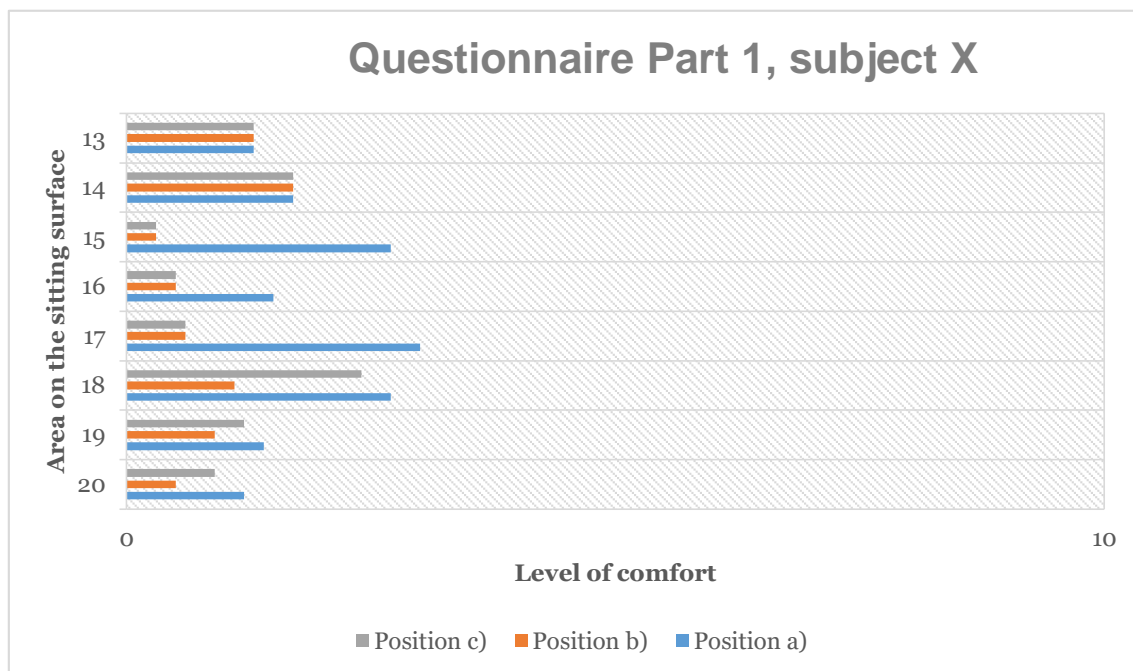


Figure 7: Level of comfort in different areas of the sitting surface for subject X. 0 = “no discomfort” and 10= “extreme discomfort”. The values on the x-axis refer to the numbered areas seen in figure 8

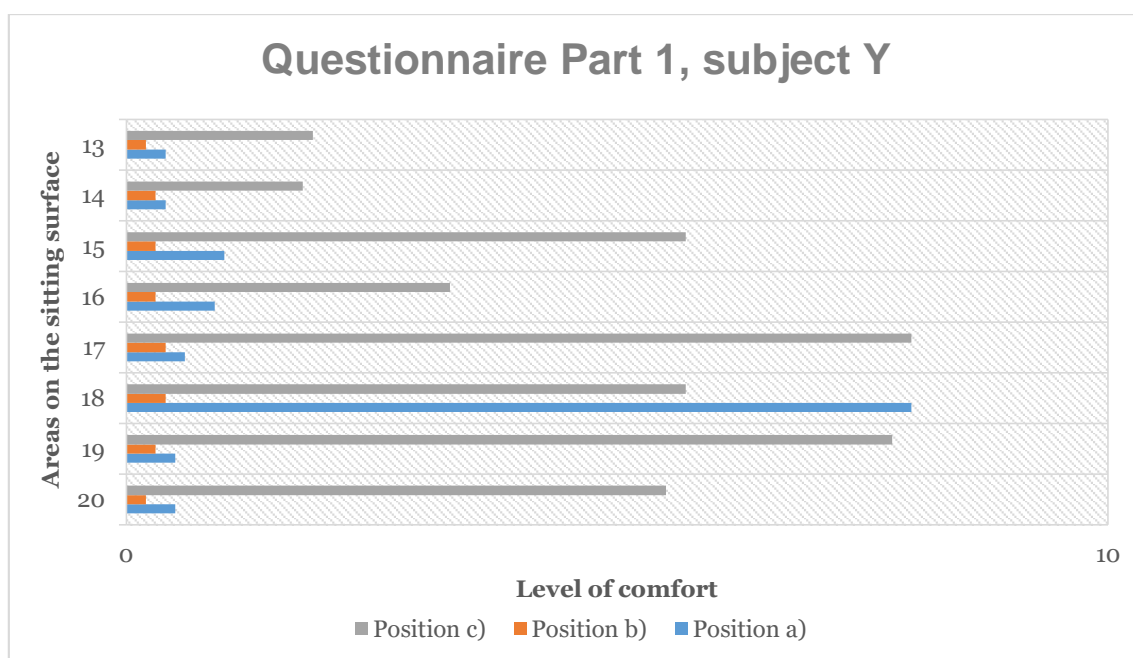


Figure 8: Level of comfort in different areas of the sitting surface for subject Y. 0 = “no discomfort” and 10= “extreme discomfort”. The values on the x-axis refer to the numbered areas seen in figure 8

Part 2

Subject X reported discomfort because of the depth of the seat (5.9/10) and a small amount of discomfort from the firmness of the seat (1.5/10). No discomfort were reported because of the width of the seat. Subject Y reported no discomfort due to any of the three design factors. Both subjects ranked the neutral position as the most comfortable (Table 6).

Table 6: Subjective ranking of the positions.

Position	Participant X	Participant Y
a)	2	3
b)	1	1
c)	3	2

1=most comfortable, 3=least comfortable.

Discussion

Comparison between the proximal and distal pressure

Pressure measurements between the socket and chair

According to the result the pressure distribution between the socket and underlying material seemed to differ in the longitudinal direction of femur. It appears on the pictures in Figure 5, that the total load is moved proximally when the feet are supported and the knees are flexed. Using the center of pressure, instead of the peak pressure location, was considered by Lung and colleagues (2014) since it was difficult to find significant displacement of peak pressure in their study regarding different angles on wheelchair seats. It is presumable that the translocation of pressure in between the positions would have shown more clearly, if the center of pressure had been calculated in this study. This could for example be relevant for position a) for subject Y, as no significant result was found for the peak pressure.

The pressure was as expected primarily located proximally for position c). For subject X the socket was raised enough distally to loose contact with the areas measured. For position a), however, the mean pressure was higher distally. This in accordance to the biomechanical reasoning done in the background section. However, since this meant that both the proximal and distal results were zero, and therefore the same, the research question regarding the evenness of the distribution is invalid.

The standard deviation for the peak pressures were relatively high and varying. The mean values however were more constant. This could be a result of small variations in position of both the socket and posture that occurs when standing up and sitting down. However the general load seemed to be fairly consistent. Lung et al. (2014) highlights that the peak pressure, in contrast to mean pressure, can be unreliable and unrepeatable, based on the article by Hobson (1992) who points out that peak pressure in some cases can give more precise information.

Pressure measurements inside the socket

The Pliance system did not yield any results for subject X. No defects were found on the equipment. The minimum pressure that the system records is 7.5 kPa. One possible explanation is therefore that a good socket-fit and a soft residual limb have contributed to an equal distribution of the interface pressure, lower than the minimum value. The fact that the sensors were placed on a curved surface, the surface inside a socket, could decrease the force on the sensor. This is due to the fact that the normal forces on the sensor no longer are parallel to the direction of gravity, and thereby provide less force.

There was only recorded one measurement inside the socket for each positions and only for one subject, due to lack of experience with the software, which of course decrease the dependability. However, the authors suggest that much of the pressure registered was a result of the vacuum suspension and not the sitting position. The proximal sensor was placed so that it had contact with the seal in the rings. This is assumed to have an influence on the mean pressure and peak pressure. This makes the data unreliable and no clear tendency in the pressure distribution was found. Furthermore, it was noticed that the vacuum inside the socket were reduced between each measurement. To remain the suspension the

subject had to increase the vacuum by standing on the prosthetic side. This may have resulted in a varying amount of vacuum, and thus a variation of pressure, if the authors' assumptions are correct.

The few available results could indicate that a higher peak pressure occurred proximally in position a) and position c). This is as expected for position a). However, according to the earlier presented biomechanical reasoning, position c) should provide an increased distal pressure. Thus, the expected and measured results are in conflict with each other. This suggests that the biomechanical reasoning is incorrect or that the increased proximal pressures for both positions were not provided by the femur but have a different explanation. As previously mentioned the proximal sensor was in contact with the vacuum rings on the seal-in liner. It is assumed that the rings have provided an increased pressure on the sensors, and furthermore it is suggested that the high-friction material of the rings exposed the sensor for shear forces in the positions where the liner is not horizontal, which were true for position a) and c).

Comparison between the pressure measurements

It was not possible to draw any final conclusion about any relation between the pressure inside and underneath the socket, due to the lack of results from the Plance-system.

As shown in the method section, it was attempted as far as possible to take any rotation of the socket into consideration. This was done pursuant to place the Plance sensors parallel to the pressure mat. So that the measurements would be in the same plane. However, it was not possible to control any movement of femur within the socket. Considering that both subjects had a very soft stump, it is conceivable that femur might have abducted while sitting. Subject X had a short femur bone compared to the length of the remaining tissue, this increases the likelihood that femur had been abducted. The inevitable conclusion is that the measurements are made in the longitudinal direction of the socket and unlikely in the direction of femur as intended, since the sensors were placed on the socket and not on the residual limb. It is difficult to tell the consequences of this, however it is possible that the pressure could be slightly higher under femur compared to under the soft tissue.

Load distribution

The load distribution for the neutral position were 65/35 and 61/39 between the sound and amputated side respectively. This could be compared to the result from the bachelor thesis by Forssén and Larsson (2014), which were 70/30 for the subject wearing a MAS (Marlo Anatomical Socket). This study never intended to compare the participants within this study or to other results, since the small number of participants make it difficult to determine whether any differences are caused by individual deviation or the surroundings, such as chair design.

For both subjects the difference between the left and right side were for position c) smaller than a). One theory for this could be that, since the distal end of the socket and thigh is lifted the load is moved proximally in position c). Thus less load is taken up by the socket and more directly by the body. Which would create a situation more like a non-amputee sitting. This is according to Forssén and Larsson (2014) closer to evenly distributed. An even distribution is preferable to prevent discomfort and pressure sores (Larsson et al., 2002), however, it should be kept in mind that in this study is the distribution between the sides not the only factor, but the height varies too. The fact that the thighs are lifted decreases the total weight bearing area, which increases the pressure.

Questionnaire

Subject X experienced more discomfort when sitting in position a) compared to the other positions, especially on the back of the thighs. Subject X ranked position a) to be the least comfortable in accordance with this. Subject Y however reported more discomfort when sitting in position c) for all areas in the survey except for the posterior/distal part of the thigh of the sound leg. This also coincides with the ranking question. The increased discomfort on the distal end of the thigh could be a result of the pressure being moved towards the edge of the chair, inside the socket. This is the same tendency noticeable by the results from the pressure mat on the prosthetic side.

Both subjects ranked position b) as the most comfortable. However, their subjective experiences of which were the least comfortable positions were different. This could be a consequence of the difference in leg length. The chair design did only allow for the backrest to be moved back to a certain point. This is reflected in the answers from question 2 where subject X reported discomfort because of the depth of

the chair. Having support under a larger percentage of the thigh/socket, during sitting in position a), could have two different biomechanical benefits. One is a reduced pressure as a result of an increased area in proportion to the load. Another could be a shorter distance between the center of the knee joint and the edge of the chair, resulting in a shorter lever to the weight of the shank and thus a reduced momentum.

The result from the questionnaire indicates that an even load between the sides does not directly correspond to a more subjectively comfortable experience, both subjects ranked position b) to be more comfortable. Conversely were the load distribution between the sides less even than for position c).

Limitations of the study

The above discussion suggest that the study have some issues that needs to be addressed. The study have some limitation when it comes to the study design and equipment used. The threshold in the Pliance system is a large limitation for measuring the pressure inside the socket when sitting still. Furthermore the relatively small area of the sensors limits the complete picture of the load distribution. The above reflections on measuring the pressure inside the socket with the Pliance sensors questions if the chosen method is valid and useful for the purpose. However, as mentioned the methods available for measuring pressure inside a socket are limited and none of the alternatives are flawless.

Due to the fact that no sensor was placed anteriorly in the socket can no conclusions be made about the pressure in that area, nonetheless can the probability of an anterior pressure be discussed. Assuming that the soft tissue is evenly distributed on the residual limb and that any pressure is proceed by femur can the anterior pressure be assumed to increase when the posterior pressure decreases and vice versa.

The 90 degree position of the backrest to the seat is not representative of an everyday chair. Hobson (1992) used a inclination of 100 degrees between the backrest and seat as his neural position, this is assumable more common to see in everyday chairs. However, the authors discusses the problems with the difficulties measuring the shear forces earlier.

Since the only socket design available for the study was the MAS, who has a fairly low trim line posteriorly, the distance between distal and proximal location for the sensor is limited. This means that the separation between the measured areas are small and any kind of lever effects are minimized.

The results with and without the foot support are not entirely comparable as some of the weight from the leg and prosthesis is taken up by the foot support. The lack of foot support could therefore contribute to an increased pressure overall. Another difference between these conditions was that subject Y in particular had a noteworthy difference between the length of the prosthetic and remaining lower leg. This is a factor that could influence the load distribution between the sides for the neutral and flexed position.

The results from the questionnaire may had given a more true and fair picture if the subjects had been sitting in each position for a longer time. It could take a longer time to experience discomfort since the pressure inside the socket seems to be quite small. Prolonged sitting in conditions with mechanical forces, increases the risks associated with sitting (Hobson, 1992).

The limited number of subjects made it impossible to compare the results between the participants and between different socket designs. Which could have been in public interest. The restricted number of measurements and subjects limit the conclusions that can be drawn from the statistical tests and this should be taken into consideration when interpreting the results.

Recommendations for future studies

Future studies in this fields should take the above issues into considerations. If the same purpose is to be examined the study design and equipment should be reconsidered. It is also recommended to lay down some requirement for the prosthesis suspension, since it seems that the seal in liner have inappropriate effects on the measurements. It is furthermore recommended that the measurement system used inside the socket has a lower threshold and preferably a larger contact area.

More participants would of course make it possible to compare the results between participants and increase the reliability. The normalization of the body weight and height should be taken into consideration if comparisons between subjects were to be made. A comparison of how pressure is

distributed inside the socket in between various design should also be interesting and be more relevant to a larger population.

It would be interesting to explore the subject of sitting with a transfemoral prosthetic further, since it is fairly unexplored subject. Some suggestions from the authors after conducting this study is to look further on which positions and chair designs is beneficial for transfemoral amputees. Because of the results from the questionnaire it would be interesting to investigate the influence of the depth of the chair in relation to leg length.

During the experiment subject Y notified us that using a wedged cushion helped her reduce back pain by reducing the flexion in the hip joint when seated. According to her explanation the back pain was a result from the socket pushing the residual limb to a more flexed position. Looking into the field of forward inclined chairs for relieving lower back pain is the results somewhat contradictive, some have had positive results (O'Keeffe, Dankaerts, O'Sullivan, O'Sullivan, & O'Sullivan, 2013), other have reported discomfort in other regions such as the lower limbs (Gadge & Innes, 2007). O'Keeffe et al. (2013) also reports that the position of the lean of the trunk could influence the muscle activity which could be related to discomfort. So it would be interesting to experiment with the inclinations of the seat and backrest, especially for transfemoral amputees since the research in this area is restricted.

Whether the chair has an armrest or not is also an interesting factor according to the everyday life of a transfemoral amputee. Another aspect to be examined could be cushioning material and softness, what are the differences between sitting in a couch and on a wooden chair.

The pressure inside the socket, on the locations measured, seems to be quite low whilst seated. It would however be interesting to examine how the pressure inside the socket varies when sitting down and rising up from different chair heights.

Conclusion

It is clear that the position is a relevant aspect to be considered when intending to decrease the pressure when sitting with a transfemoral socket and increasing the subjective comfort. According to this study a chair with no foot support, which imitate a relatively high chair, increases the distal pressure between the socket and the chair. When transfemoral amputees sit with their knees flexed 105 degrees, which imitate a relatively low chair, the pressure between the socket and chair moves proximally. In a neutral position, with the knees flexed 90 degrees, no clear tendency regarding the pressure distribution in the longitudinal direction of femur was found. The intention to measure the pressure inside the socket was unsuccessful, due to the relatively low pressure on the locations measured and methodological artifacts. It was not possible to draw any conclusions regarding the relation between the pressure inside and underneath a prosthetic socket whilst seated. The most equal sidewise load distribution was found when the participants sat without foot support. Thereby we conclude that the height of the chair, according to this study, is able to influence both the pressure under the socket in the direction of femur and the sidewise load distribution. Both subjects found the neutral position to be the most comfortable. It would be interesting for future studies to examine other aspects of sitting posture and chair design for transfemoral amputees.

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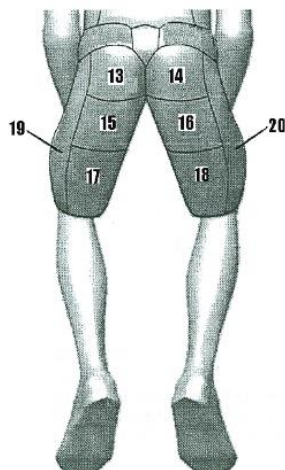
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Appendix 1

Frågeformulär

Del 1: Efter varje test



Markera med ett streck på linjen hur du upplever obehag från sittande i olika delar av kroppen för respektive fall.

a) Inget stöd för fötterna



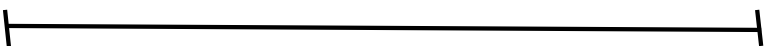
b) Neutral position (knät i 90 grader)

c) Fötterna högt upp (knät i 120 grader)

(v) = vänster, (h) = höger

	Inget obehag	Mycket obehag
13. (v) säte / bakdel		
14. (h) säte / bakdel		
15. (v) övre baksida lår		
16. (h) övre baksida lår		
17. (v) nedre baksida lår		
18. (h) nedre baksida lår		
19. (v) utsida av lår		
20. (h) utsida av lår		

Del 2: Efter alla testerna

	Inget obehag	Mycket obehag
1. Obehag på grund av bredden på sätet:		
2. Obehag på grund av sätets djup:		
3.. Obehag på grund av sätets fasthet:		

4. Rangordna vilken av höjderna som var mest bekväm genom att skriva nummer 1-3 bakom alternativen. 1=Mest bekväm och 3=Minst bekväm.

Inget stöd för fötterna _____

Neutral position (knät i 90 grader) _____

Fötterna högt upp (knät i 60 grader) _____

Appendix 2

Information till deltagare

Hälsö högskolan i Jönköping, Ortopedingenjörsprogrammet

Examensarbete av Jennifer Hägg och Signe Sander Nielsen, med handledning av Sara Kallin

Till den som det berör

Du inbjuds delta i en studie om hur höjden på en stol påverkar trycket på kroppens sittyta för protesbrukare. Mer specifikt är vi intresserade att undersöka hur relationen mellan trycket inuti hylsan och mellan hylsa och stol ser ut samt hur detta påverkas av höjden på stolen. Syftet är att få underlag för hur man kan minska tryck och obehag för transfemoralt amputerade vid sittande.

Du har blivit kontaktad genom uppgifter om frivilliga deltagare från Avdelningen för rehabilitering, Hälsö högskolan, Jönköping University.

Undersökningen beräknas uppta ungefär två timmar av din tid, under denna tid kommer vi först gå igenom experimentet, ta mått (bl. a. benlängd, stumplängd, vikt, protesens vikt) samt prova ut de sittpositioner som kommer undersökas. Därefter kommer vi placera två sensorer i din proteshylsa och du kommer få sätta dig med protesen på en stol som har en tryckmatta på sitsen. Vi kommer göra fem mätningar för respektive scenario: 1) Utan fotstöd 2) Med fotstöd så knät är böjt 90 grader och 3) Med fotstöd så knät är böjt 105 grader. Totalt blir det 15 mätningar. Du kommer ställa dig upp mellan varje mätning. Varje mätning spelar in 15 sekunder data, men det kommer ta något längre tid för att du ska hinna slappna av när du satt dig. Till sist kommer du att få svara på ett kort frågeformulär angående sittkomfort.

Riskerna med att delta bedöms som minimala, då de inte skiljer sig mycket från det dagliga livet. Vi kommer kontinuerligt följa upp hur du uppfattar situationen. Ditt medverkande är frivilligt och du har rätt att avbryta när som helst utan att ange anledning. Information om deltagare kommer hanteras konfidentiellt och insamlad data kommer avidentifieras vid presentation av denna studie.

Studien ingår i ett examensarbete på ortopedingenjörsprogrammet, och kommer att presenteras skriftligt och muntligt på Hälsö högskolan. Studien kommer eventuellt även presenteras i andra forum framöver, som till exempel branschtidningar eller webbsidor. Du som deltagare kommer att få en kopia av den färdiga rapporten.

Om du har några frågor angående studien eller vill prata med någon av oss studenter bör du höra av dig till Jennifer Hägg på 0763-572929 eller Signe Sander Nielsen på +45 29242785.

Jag har läst ovanstående information och samtycker att medverka i studien.

Namn _____

Signatur _____

Datum _____