# The development of a get-up aid

## Standing up from a chair fast and save for elderly people

Bachelor thesis

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# Preface

Before you lies the thesis ''The development of a get up aid''. This thesis had been written to fulfill the graduation requirements of the study Human Kinetic Technology at De Haagse Hogeschool. This research took place from March to October 2017.

The research was undertaken at the request of the company Sillaplus. The first steps of the project were undertaken by a previous student: Jelles Overmeen. It was a big challenge to perform a project from big proportions from literature research to a working model in limited time. The fact that the thesis is written in English lead to an even greater challenge.

I would like to thank my mentors, Daphne Wezenberg and Liz Haverkate, for their guidance and support during this project and Nil Sancho Comasolivas from SillaPlus for the assignment. I also would like to thank Aad Lagerberg for his guidance during the last phase of my project. Besides the mentors from the study there are also some people I would like to thank: the subjects that took part voluntary during (test-) measurements and the people that helped me brainstorming during designing and of the aid.

I hope you enjoy your reading.

Simone Gravesteijn

Den Haag, 27 October, 2017.

# Abstract

Standing up is harder to perform when getting older. The company SillaPlus want to create a physical device that can be attached to already existing chairs and will help elderly people get up from a chair. The company reached out to students who want to help with the development of a get up aid. The first steps to reach this goal were undertaken by student Jelles Overmeen. He investigated the ideal horizontal position of placement of the arms while standing up. Left to investigate were the measurements that the device need to meet and the appropriate height of the armrest.

The aim for this project is to create a physical device that can be attached to different existing chairs that are frequently used in nursing homes that helps elderly people stand up, while maintaining a secure feeling.

The project is divided in phases: an analysis-,design-, construction- and evaluation phase. The first part of the analysis phase consist out of literature research. Found was that muscle quality in the arms is significantly higher than the muscle quality in the legs with increasing age. An users survey is performed by analyzing mentioned pros and cons in product reviews from users from comparable products. For deciding which measurements the device has to meet, dimensions from chairs in nursing homes are measured. Finding the appropriate vertical position for the armrest is investigated by performing EMG measurements on the m. vastus lateralis (VL) and m. triceps brachii lateralis (TBL), while a subject stood up from a chair using different heights of armrests. The armrest height where the least muscle activity is shown in the VL was the height for the subject. The angle of the elbow was measured using videos. By analyzing the average angle of the elbow on this armrest height, and assuming this is the ideal force-length relationship, the armrest height for 90% of the target group can be calculated. The list of requirement and wishes is fulfilled with the addition of the analysis results. For the design phase different methods are applied: brainstorming, clustering with the help of a morphologic map, concept development and rating the concepts with the cardinal method. The construction phase is performed by creating technical drawings and a working model. During the evaluation the final design is discussed with the help of the list of requirements and wishes.

The users survey lead to minimum result. Most pros and cons were already mentioned in the list of requirements and wished. With the dimension measurements from the chairs, a small database is created. At an armrest height of 25 cm the VL showed the least activity in the subject. With this result is calculates that the device needs to be able to vary in height between 20,1 and 25,2 cm. By following the design methods a final design is developed. The device has four legs that are positioned on the floor. It can be attached to the chair with an flexible strap.

The design meets most of the requirements and wishes. However, not all requirements are evaluated yet. During the EMG measurements one subject is used. The subject is younger than 65 year. A large list of requirements followed out of the analysis. It was hard to make sure that the device would meet the requirements, and designing a compact device with a small adjustability's.

## Samenvatting

Opstaan wordt moeilijker wanneer men ouder wordt. Het bedrijf SillaPlus wilt een hulpmiddel ontwerpen dat vastgezet kan worden aan bestaande stoelen wat ervoor zorgt dat oudere mensen gemakkelijker kunnen opstaan uit een stoel. Het bedrijf heeft ondersteuning gevraagd aan studenten die wilden helpen met de ontwikkeling van een dergelijk hulpmiddel. De eerste stappen van het onderzoek zijn ondernomen door student Jelles Overmeen. Hij heeft onder andere de ideale horizontale positie van de handen op de armleuning onderzocht tijdens het opstaan. Wat nog onderzocht diende te worden was de ideale verticale positie van de handen tijdens het opstaan, en de afmetingen waaraan het hulpmiddel dient te voldoen.

Het doel van het project is het ontwikkelen van een op-sta-hulp welke ervoor zorgt dat de gebruikers een veilig gevoel behouden. Het hulpmiddel dient aan bestaande stoelen uit verpleeghuizen vastgezet te kunnen worden.

Het project is opgedeeld in fasen: een analyse-, ontwerp- , constructie- en evaluatie fase. De eerste stap van de analyse bestaat uit een literatuuronderzoek. Hieruit is onder andere gebleken dat de spierkwaliteit in de armen significant hoger is dan de spierkwaliteit in de benen met toenemende leeftijd. Vervolgens is een gebruikersonderzoek uitgevoerd. Hierin zijn honderd productreviews van vergelijkbare producten geanalyseerd. De genoemde positieve en negatieve punten zijn geclusterd en verwerkt in de lijst van wensen. Er een klein onderzoek uitgevoerd naar afmetingen van stoelen door verzorgingshuizen te bezoeken en hier stoelen op te meten. De ideale verticale hoogte is bepaald tijdens een EMG onderzoek. Een proefpersoon is geïnstrueerd op te staan vanuit een stoel, gebruikmakend van verschillende hoogten armleuningen. Tijdens het opstaan is de EMG activiteit van de m.vastus lateralis gemeten (VL) en m. de m.triceps brachii lateralis (TBL). Er werd gezocht naar de armleuninghoogte waar de minste activiteit in VL werd gemeten. Door zijn gemiddelde hoek van de ellenboog uit video's te analyseren en aan te nemen als ideale kracht-lengte relatie is de hoogte voor 90% van de populatie te bepalen. Met de analyse is de lijst van eisen en wensen volledig aangevuld. Tijdens de ontwerpfase zijn de volgende methoden toegepast: een brainstorm, clustering a.d.h.v. een morfologische kaart, concept ontwikkeling, het toetsen van de concepten a.d.h.v. de kardinale methode waaruit vervolgens een eindontwerp is ontwikkeld. In de constructie fase is uitgevoerd door technische tekeningen te vervaardigen en een werkend model te construeren. Tijdens de evaluatie is het eindpontwerp besproken aan de hand van de lijst van eisen en wensen.

Het gebruikersonderzoek heeft beperkt resultaat opgeleverd. De meest genoemde voor- en nadelen waren al toegevoegd aan de lijst van eisen en wensen. Van de opgemeten stoelen in verpleeghuizen is een kleine database opgesteld. Uit het EMG onderzoek bleek 25 cm de ideale armleuninghoogte voor de proefpersoon te zijn. Hieruit is berekend dat het hulpmiddel tussen de 20,1 en 25,2 cm in hoogte dient te kunnen variëren. Door het uitvoeren van de genoemde methoden tijdens de ontwerpfase is een eindontwerp ontwikkeld. Het ontwerp is hulpmiddel met vier poten welke d.m.v. een 'snowboard sluiting' aan de stoel gezet kan worden.

Het eindontwerp voldoet aan de meeste eisen. Het ontwerp is echter nog niet getoetst aan alle eisen getoetst. Voor de EMG meting is maar één proefpersoon is gemeten, en deze persoon is ver onder de leeftijd van 65 jaar. Een grote lijst van eisen beperkte de vrijheid van ontwerpen. Het eindontwerp is een hulpmiddel van groot formaat geworden, met veel instellingen.

# Table of contents

# Abbreviations/Glossary

| | |
|---|---|
| BoS | Base of support. When standing in upright position the BoS are the feet, and the space between the feet. |
| CoM | Center of mass |
| EMG | EMG is the abbreviation for electromyography. With EMG it is possible to measure the activity from muscles. |
| TBL | musculus triceps brachii lateralis |
| VL | musculus vastus lateralis |
| StS | Sit-to-stand |

# 3. Introduction

Standing up from a chair is an common daily activity, where most people don't pay much attention to. When getting older it becomes harder to perform this activity. A solution would be desirable to make this activity easier when getting older. The company SillaPlus, founded by Nil Sancho Comasòlivas, is a company that focusses on active aging and healthy living. One of the aims of the company is to create a physical device that can be attached to already existing chairs that helps elderly people to get up from a chair. Nil reached out to the education Human Kinetic Technology to get in contact with students who want to help with one of his projects. Jelles Overmeen was the first student that started off with this project. He investigated the ideal horizontal positions of the hands on the armrest during standing up. His project was aimed on the SpringUp chair (Appendix 2). The results he gathered are also used during this project. What's left to investigate is what the ideal height of the armrest is and which dimensions the device has to meet . The aim for this project is to create a device that fits on the armrest from a range of chairs, used in nursing homes that will help elderly people stand up faster than they do without the device, while maintaining a safe feeling.

In cooperation with SillaPlus the assignment is performed via the ECBT, Expertise Centrum Bewegingstechnologie. The target group for the device are people having trouble with standing up from a chair due to problems caused by aging. This involves  mainly elderly people (65+). At the start of the project a few requirements for the device were already clear.  These were given by the company or are necessary to ensure the safety for future users. These requirements are summed up in table 1.

*Table 1;Pre-known requirements*

| Requirement no. | Description |
|---|---|
| **1** | The device is an add-on device that can be attached to multiple chairs that are frequently used in nursing homes. |
| **2** | The device makes the standing up process faster. |
| **3** | The person feels secure while using the device. |
| **4** | The device is transportable. |
| **5** | The material is water resistant. |
| **6** | The device does not have sharp edges. |

The requirements evolved from the previous bachelor thesis about this topic are shown in table 2.

*Table 2;Requirements previous project*

| Requirement no. | Description |
|---|---|
| **7** | The device doesn't obstruct the person while sitting in the chair. |
| **8** | It has to be easy to attach the device to the chair. (Maximum three tasks before it can be used). |
| **9** | The device has to be able to be used intuitively by a person from 65 year old or older. |
| **10** | The device has to fit on chairs with open armrests. |
| **11** | The device has to be resistant to horizontal and vertical forces. |
| **12** | The person has to be able to pull their self  forward till the end of the seat with their arms followed by  pushing their self-upwards with the hands positioned in the middle of the armrest. |
| **13** | The measurements of the product make the device suitable for at least 90% of the elderly Dutch population. |

Requirement 12 describes the tasks that need to be performed for standing up. As mentioned in the requirement the person needs to pull their self forward to the end of the seat. In this position the person can achieve an upright posture, where the Center of Mass (CoM) can be brought above the Base of Support (BoS) (Figure 1) without repositioning the feet.

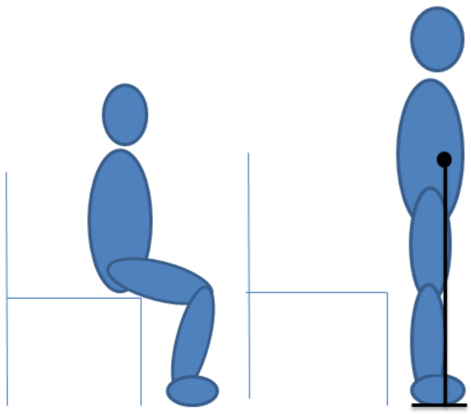


*Figure 1: Standing up without repositioning the feet. The CoM positioned above the BoS.*

The project consist of four main phases: an analysis-,design-, construction- and evaluation phase. The analysis phase will end with an list of requirements and wishes. Based on this list the design is created. The result of the project is a working model and technical drawings constructed in the construction phase.

What's need to be mentioned is that the described devices in this thesis are intended for placing on one side of the chair, but for proper performance of the standing up process two devices (on both sides of the chair) are needed.

# 2. Analysis

The goal of this analysis is to define a list of requirements and wishes as a foundation for designing a suitable device. As mentioned in the introduction, some requirements are already clear and some are presented by the previous student. However, a number of questions still need to be answered. The unanswered questions are as follow:
- What do potential users want from a get-up aid?
- What measurements should the device meet to make it fit on different chairs?
- Does the device needs to be adjustable in height?

As a result of this chapter the list of requirements and wishes will be presented.

These questions will be answered at the end of the analysis phase to fulfill the list of requirements and wishes. The phase will start off with a literature research to substantiate the problem.

## Literature research

Research shows that the amount of elderly people (65 years or older) in the Netherlands is getting bigger. The reason that there are more elderly people is that the life expectancy is increasing (Alders & Tas, 2001). With age, comes increased problems with movements like standing up from a chair. The fact that the group of elderly people is getting bigger, will lead to a greater amount of people that will run into this kind of problems.

Changes in the ability to perform a Sit-to-Stand (StS) movement can lead to institutionalization, impaired functioning and mobility in activities of daily living (Janssen, 2008). The growing group of elderly people creates a demand for a product that helps this group to stand up from a chair. The product should help to stand up in a faster way, while maintaining a good sense of security.

There are several reasons known why elderly people are having more trouble in the standing up process compared to younger people. Elderly people move slower than younger people during standing up The Center of Mass(CoM) velocity of several subjects was analyzed during standing up (Mourey, Grishin, d'Athis, Pozzo & Stapley, 1998). The result shows that the maximal CoM velocity in horizontal axis is lower in elderly persons compared to younger subjects. At the instant of lift off the position of CoM was shifted backwards in elderly subjects (Mourey et al., 1998). This shows that the body is positioned differently in elderly persons. The Range of Motion(ROM) in some joints, like the hip joint, increases during the movement of StS (Nonaka, Mita, Watakabe, Akataki, Susuki, Okuwa & Yabe, 2002). That can be one off the causes of the different positioned CoM. Another influence for the problems is the decrease in muscle strength (Burr, 1997)

Research shows that the muscle quality, in this research defined as peak torque per unit of muscle mass, in the arms is significantly higher than the muscle quality in the legs with increasing age (Lynch, 1999). This fact is used as a basis for the previous thesis about this subject. For the previous project, as well as this one, it will be beneficial that a part of the needed strength during standing up will be moved to the arm muscles.

A normal StS movement can be described in four different phases. The division of these phases are shown in Figure 2.

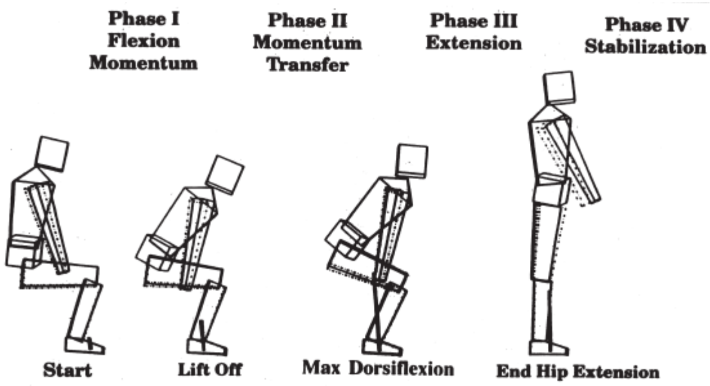



*Figure 2; StS phases*

Phase I is called the flexion-momentum phase. This phase starts with initiation of the movement and ends before there is no contact anymore between the chair seat and the person. Phase II begins when the contact between chair seat and the person ends, at this moment maximum dorsiflexion in the ankles is achieved. Phase III begins after the maximum dorsiflexion is reached and ends when the hips start to extend: included with extension of the legs and trunk. Phase IV is initiated after hip extension is reached and all the motions associates with stabilization are achieved (Schenkman, 1990).

Besides the reasons of elderly people having problems while standing up related to their lack of strength, there are parameters with respect to both the chairs used and the strength applied by the subject that can influence the StS movement. Research shows that the following determinants have influence in standing up: the height of the seat, whether an armrest is used and the position of the foot (Janssen, Bussmann & Stam, 2002). There are spring-loaded or electrically operated chairs that influences one of these determinants: the height of the seat. The problem with this kind of products is that they are expensive and it is not easy to take a product like this with you.

As concluded in the research from the previous student the device needs to be resistant to horizontal and vertical forces. The maximum force that will be applied on the device in vertical direction is when the user of the device will put his complete weight on one device. As mentioned in the requirements 90% of the complete elderly (Dutch) population has to be able to use the device. The heaviest person from this elderly population group weights 92 kilograms (Dined Anthropometric database, 1998). So the device needs to be resistant to a vertical force from 920 Newton. The maximum horizontal force will be applied when strongest user from the group will apply his maximum pulling force when pulling himself to the end of the seat. The maximum pulling force is 507 Newton(Dined Anthropometric database, 1998).

*Conclusion*
The literature shows that the muscle quality stays of the arms better at a higher age compared to the muscle quality of the legs. A part of the needed strength for standing up can be shifted from the legs to the arms as a possible solution. For performing EMG measurements the described phases in the literature research are going to be used. Followed out of the force research rrequirement 11 will be adjusted as follow: the device has to be resistant to a horizontal force from maximum 507N, a maximum vertical force from 920N and transversal forces.

## Users survey

To cater to the wishes of the future users an users survey was performed. This survey is performed to be able to use the good qualities from the existing products, and to prevent that the same mistakes as in comparable devices. The results of this survey will be processed in the list of wishes.

*Method*

The users survey is performed by collecting reviews written by people who bought comparable products. The comparable products in this research were devices that are sold as products that help people standing up from a chair or bed (Appendix 1). Hundred reviews are analyzed. The comments from the users were divided in pros and cons. The pros are used in the design of the product. The negative feedback is used to prevent performing the same mistakes in this project.

*Results*

Figures 3 and 4 show the result of the analysis about the wishes from the target group. The most mentioned pros are the following: easy assembly, sturdy and stable. The most mentioned cons: stuck/broken, not steady/stable/sturdy, not for every chair, does not feel safe, not adjustable (enough).

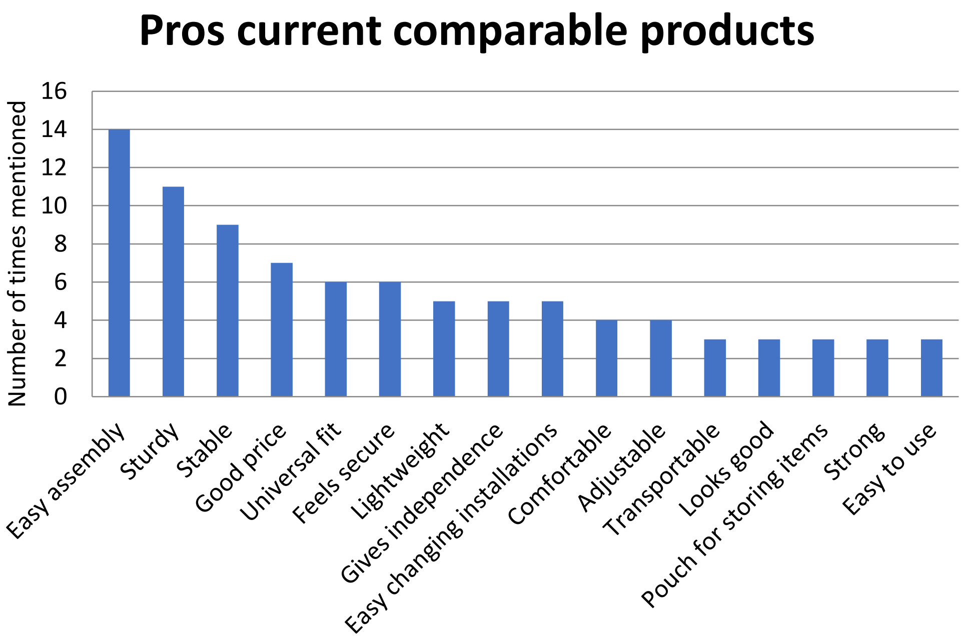



*Figure 3; Pros comparable products (Appendix 1)*

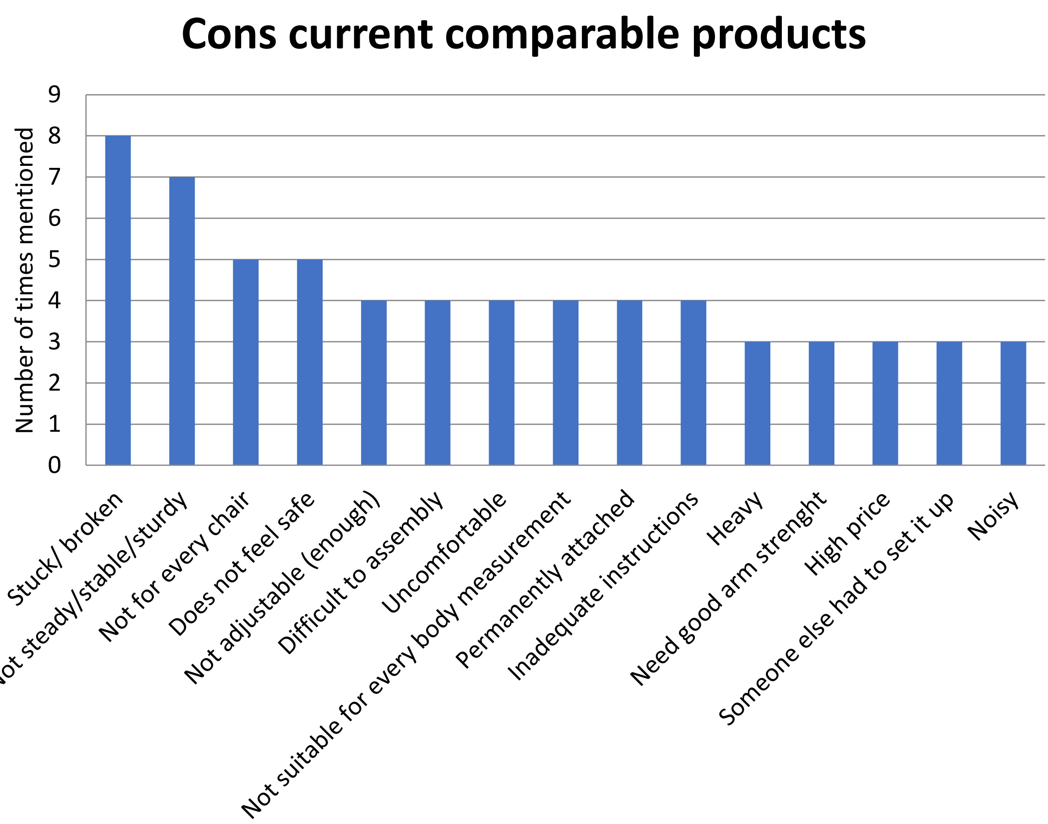



*Figure 4; Cons comparable products* (Appendix 1)

*Conclusion*
It is noticeable that most feedback is already included in the requirements that are mentioned before. Feedback about the price of the product are excluded from the requirements because a price indication will not be part of the project. One new wish is added to the list of wishes: 'The parts that are going to be touched while using the product, do not feel cold,' (table 4). This wish is added because of the comfort that is mentioned by several people.

## Chair measurement database

It must be demarcated which measurements the device needs to have to make the add-on device fit on several chairs. To achieve this a small database about measurements from chairs is created.

*Method*
As mentioned before the product use environment will be nursing homes. Therefore, the measurements are performed in nursing homes and on the SpringUp chair from Springq B.V. (Appendix 2). The measurements that are needed for designing the device are the length, breadth and width from the armrest to make the device fit on the armrests. These measurements are shown in Figure 5.

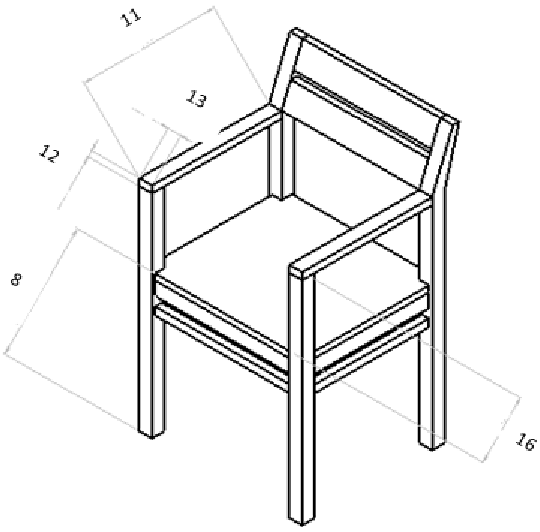



*Figure 5; Measurement numbers.*

The chairs used for the database are shown in Figure 6.Chair A is the SpringUp chair, chair B is a chair from a caring home for people with a mental and physical disability and chairs C, D and E are found in caring homes. A margin of 5% was added to the measurements to make the product suitable for even a larger range of chairs.


*Figure 6; the chosen chairs found in nursing homes*

*Results*

Table 3 shows the average measurements plus a five percent margin from the chairs. All measurements from the chairs are shown in appendix 4.

*Table 3; measurements chairs*

| **Dimension no.** | ***Minimum measurement +5% margin (in cm)*** | ***Maximum measurement +5% margin (in cm)*** |
|---|---|---|
| 8: Height seat, from floor to top seat | 41,8 | 50,4 |
| 11: Length armrest | 44,7 | 54,6 |
| 12:Height armrest | 1,9 | 3,7 |
| 13:Width armrest | 1,9 | 6,3 |
| 16: Height armrest, from top seat to top armrest | 16,2 | 21 |

Now that the dimensions of the chairs are clear, the first dimension of the device can be determined. As found in the chair measurements all armrest are about the same length as the depth of the seat. The armrest needs to be extended to be able to pull forwards and push upwards when positioned on the end of the seat. There will be assumed that the user will pull their self forward until the angle between the upper- and lower arm is $90^{0}$. The underarm length for the group with the largest dimensions is 36,9cm. As the person is positioned at the end of the seat, the torso will be positioned about halfway at the end of the seat (see black dotted vertical line in Figure 8). The depth of the torso for P95 is 37,4 cm.

37:2 = 18,8 cm
(Depth torso:2)
36,9-18,8= 18,1 cm
(Length lower arm- half torso)

*Figure 7: calculation positioning pulling part device P95*

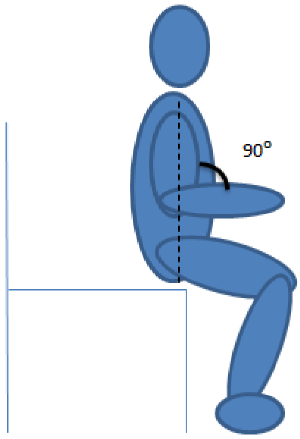



*Figure 8: Position after pulling forward*

The suitable position for the pulling handle will be maximum 18 cm in front of the existing armrest. For the smallest group the position in front of the leg will be as shown in Figure 9:

36:2 = 13 cm
(Depth torso:2)
29,3-13= 16 cm
(Length lower arm- half torso)

*Figure 9:calculation positioning pulling part device P5*

However: this group would be able to reach the pulling part when sitting against the backrest of the chair.. The smallest group has an arm length of 62,3 cm. That is 7,7 cm in front of the chair with the largest armrest length. The pulling handle needs to be positioned 7,7 cm in front of the existing armrest to make the pulling bar reachable for the smallest group (P5). The pulling part needs to be adjustable between 7,5 and 18 cm in front of the existing armrest.

*Conclusion*
The added requirements are as follow: 'the device fits on an armrest with a width between 1,9 and 6,3 centimetres', ',the device fits on an armrest with a height between 1,9 and 3,7 centimetres', 'the device fits on an armrest with a length between 44,7 and 54,6 centimetres' and 'The pulling part needs to be adjustable between 7,5 and 18 cm in front of the existing armrest'. The added requirements are also shown in table 4.

## Experimental study into the ideal height of the armrest

The previous student performed and EMG measurement to determine the ideal horizontal position of the armrest. The conclusion from his research was that the person must pull himself forward on a chair until the person is positioned at the end of the seat, followed by a push upwards while the hands are positioned parallel to the body. At this moment, no research is done concerning the vertical position of the armrest. To answer the question what the ideal height of the armrest will be, an experimental study was performed where a subject stands up from a chair while measuring the EMG activity from the m.vastus lateralis (VL) and the m.triceps brachii lateralis (TBL). As mentioned in the literature research the quality of the muscles of the arms stay better at a higher age compared to the muscle quality from the legs. The aim of this study is to find the most favorable height of the armrest. Most favorable will be defined as: the moment when the average activity in the VL has the lowest value while standing up.

*Method*

*Figure 10; Screenshot measuring arrangement*

Figure 10 shows the measuring arrangement that is used to perform the measurements. The subject is positioned in the chair with his hand placed on a predetermined position. On the VL and the TBL EMG electrodes are attached. The subject received instruction to stand up in two phases: rise until the buttocks lifts from the seat (phase 1) and to the position that the arms are extended fully (phase 2). On the EMG hardware a LED-marker was connected. The marker was turned on when the subject was at phase 1 and turned off when the subject was at phase 2.

To be able to imitate different armrest heights a mock-up was constructed which contained different heights. These heights, from the top off the seat to top of the armrest were as following: 30cm, 25 cm, 20 cm and 15 cm. For the measurements the SpringUp chair (Appendix 2) is used.

For each height three measurements were performed. The obtained results are processed using Matlab (MathWorks, Natick ,USA). The data is filtered and cut so only the data from when the LED marker was on is left. To be able to conclude the amount of activity from the muscles the surface beneath the graph was calculated. When the surface is bigger, more activity is performed by the muscle. All data is presented on a time frame of 101 samples, to allow for proper integration by surface calculation. As result graphs are creates where the surface beneath the graph is an average from the different trials on the same level. Parallel to the EMG measurement video recordings were made needed for finding the average angle from the elbow at the favorable height.

*Results*

Figures 11 and 12 show the results of the EMG analysis. The Figure shows the activity of EMG for the different height levels of the arm chair. The first graph shows the activity from the TBL and the second from the VL. When using the armrest positioned on 25 cm, the least activity in the VL is shown.

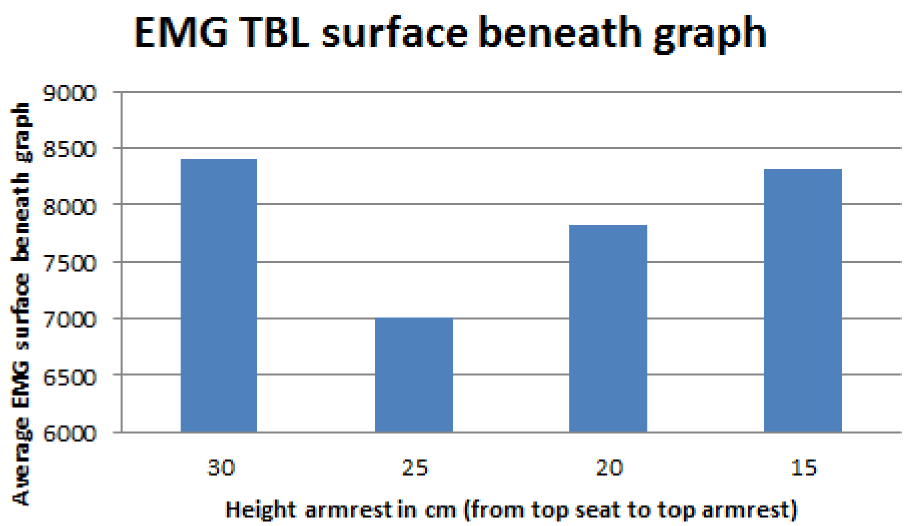



*Figure 11; EMG TBL during standing up*

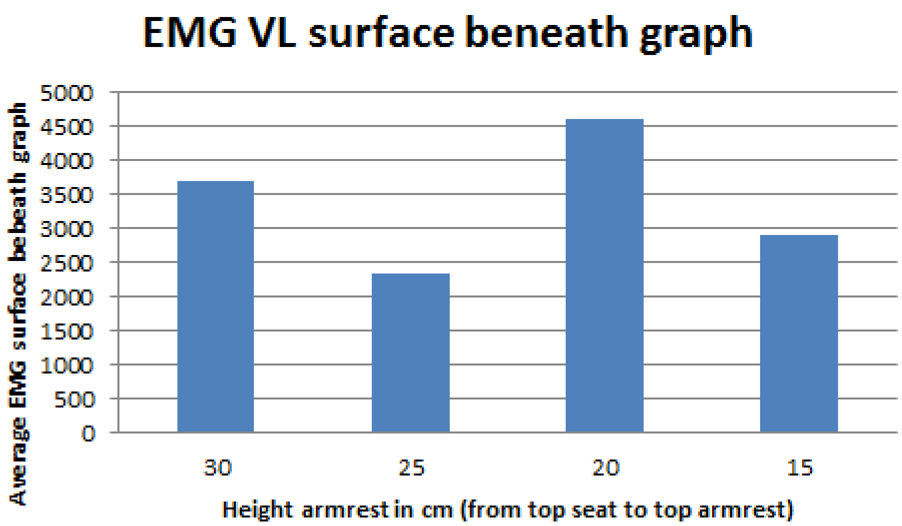



*Figure 12; EMG VL during standing up*

As the height of 25 cm turned out to be the most ideal height of the four, this position in further analyzed. For this analysis the video recordings were used. When the subject was in relaxed position, with his underarm fully placed on the armrest his elbow angle is measured. This is shown in appendix 4. The average angle from the three measurements was $99^{0}$. As muscles have a certain relationship in force-length (Binder, M.D., Hirokawa, N., Windhorst, U. & Hirsch, M., 2009)), the most ideal found relationship in this case was apparently at this angle. By this result will be concluded at which height the armrests has to have for P5 and P95 when their elbows are also positioned in the same angle.

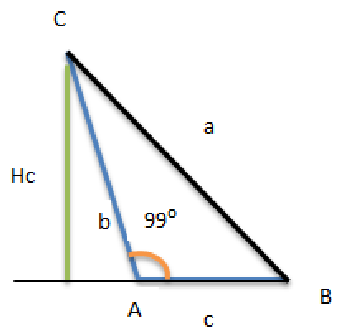



*Figure 13; Reproduction arm position*

As the arm lengths and angle between the upper arm and forearm are known data, the height (Hc in Figure 13) from the ideal armrest can be calculated. In appendix 5 these calculations can be found. The height of the armrest for P5 has to be 20,1 cm from top of seat to top of the armrest. For P95 the most ideal height is at 25,2 cm.

*Conclusion*

Concluded in the database research, measurement 16 in appendix 4, is that the armrest height varies between 16,2 and 21cm. That means that the difference between the lowest armrest and P95 is 9 cm. The lowest armrest has to rise 9 cm. The difference between the highest armrest and P5 is 0,9cm. This minimal difference will be neglected. This means that the device needs to be adjustable in height. To keep the usability the height adjustment will also be performed in maximum three tasks and a height indicator is preferred. The added requirements are as follow: 'The device has to be adjustable from at least 20,1cm to at least 25,2 cm from the top of the seat', and 'there are maximum three tasks needed to adjust the height of the device'. To the wish list the following is added: 'The device has an indicator which shows the user what the ideal height of the device is for their length' These requirements and wish can also be found in table 4.

# 3. List of requirements and wishes

In table 4 all the requirements and wishes are put together. This list is going to be used for the designing of the device.

*Table 4; Final list of requirements and wishes*

| Requirement | Description |
|---|---|
| **1** | The device is an add-on device that can be attached to multiple chairs that are frequently used in nursing homes. |
| **2** | The device makes the standing up process faster. |
| **3** | The person feels secure while using the device. |
| **4** | The device is transportable. |
| **5** | The material is water resistant. |
| **6** | The device does not have sharp edges. |
| **7** | The device doesn't obstruct the person while sitting in the chair. |
| **8** | It has to be easy to attach the device to the chair. (Maximum three tasks before it is attached). |
| **9** | The device has to be able to be used intuitively by a 65 year old. |
| **10** | The device has to fit on chairs with open armrests. |
| **11** | The device has to be resistant to a horizontal force from maximum 507N, a maximum vertical force from 920N and transversal forces. |
| **12** | The person has to be able to pull his/herself forward with their arms and push his/herself upwards with the hands positioned parallel to the body. |
| **13** | The measurements of the product make the device suitable for at least 90% of the elderly Dutch population. |
| **14** | The device fits on an armrest with a width between 1,9 and 6,3 centimetres. |
| **15** | The device fits on an armrest with a height between 1,9 and 3,7 centimetres. |
| **16** | The device fits on an armrest with a length between 44,7 and 54,6 centimetres. |
| **17** | The device has to be adjustable from at least 20,1cm to at least 25,2 cm from the top of the seat. |
| **18** | The pulling part needs to be adjustable between 7,5 and 18 cm in front of the existing armrest. |
| **19** | There are maximum three tasks needed to adjust the height of the device. |
| **Wish** | **Description** |
| **1** | The parts that are going to be touched while using the product, do not feel cold. |
| **2** | the device has an indicator which shows the user what the ideal height of the device is for their length. |

# 3. Designing

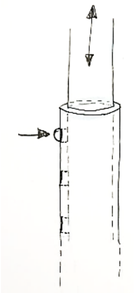
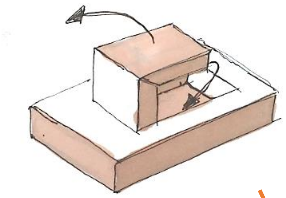
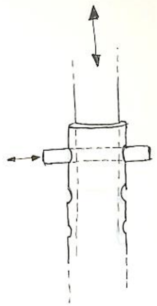
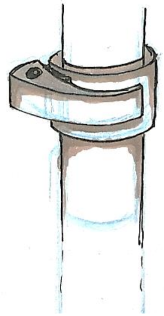
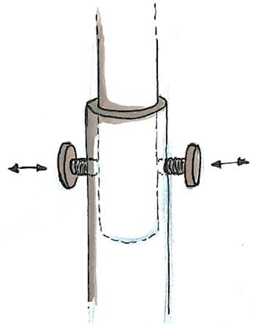
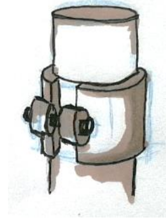
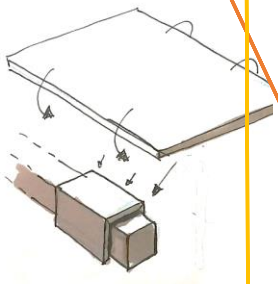
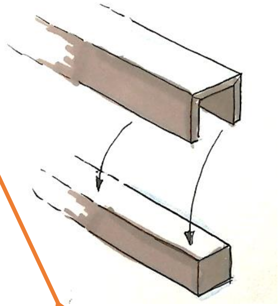
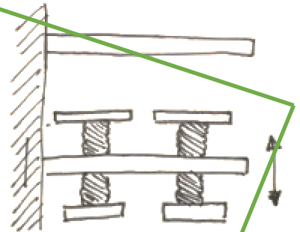
As mentioned before the list of requirements and wishes is a crucial part for the design phase. All concepts must meet all the requirements and preferably all wishes. During this chapter the design phase of the device will be explained. The design phase consists out of several sub phases.

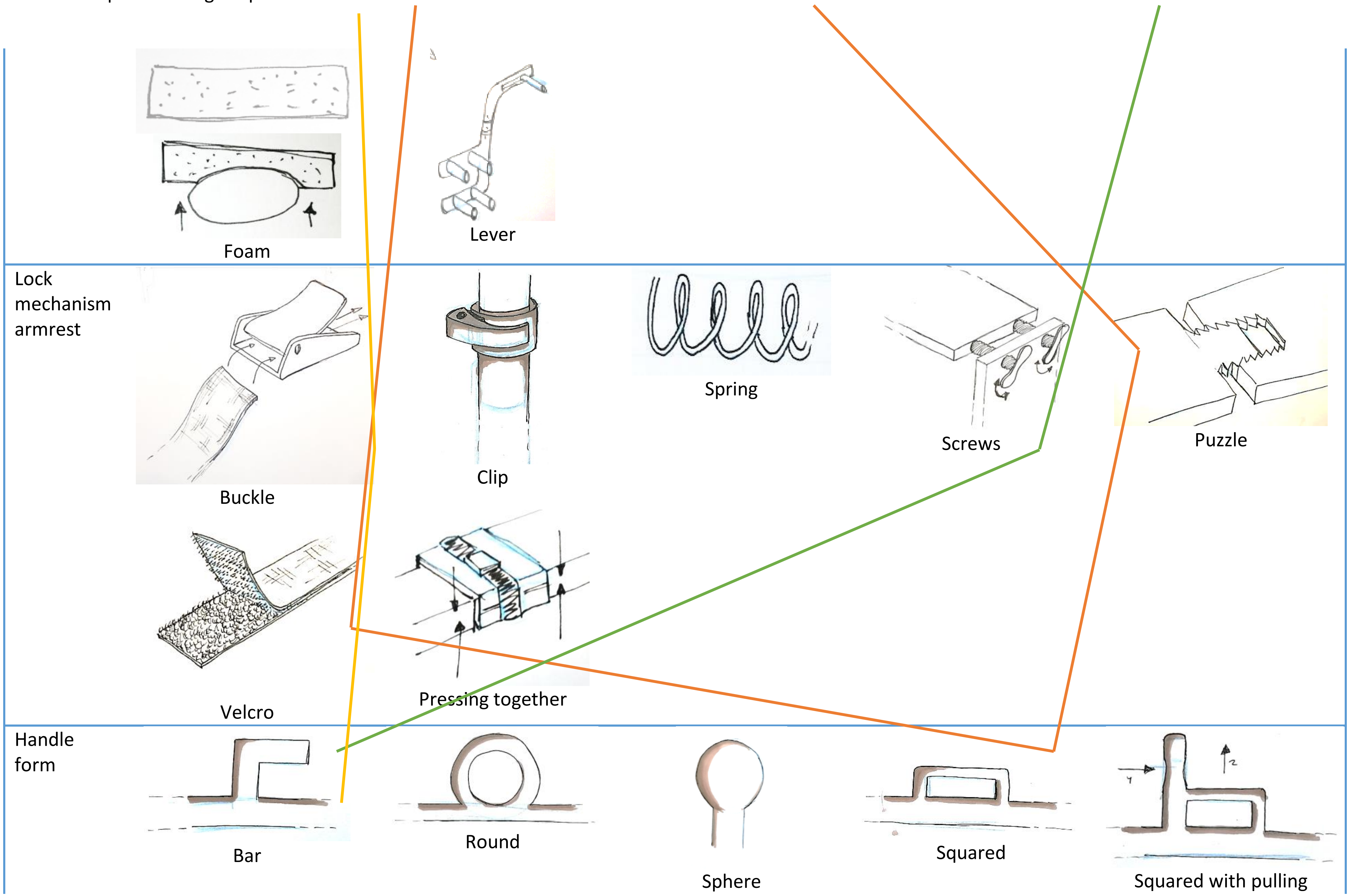
*Brainstorm*

The first step from the design phase is the brainstorm. During the brainstorm a lot of ideas are created by making a mind map, sketches, debating with different people and looking at other products. During the brainstorm it's not necessary that the ideas are feasible, but still are focused on the main goal. The mind maps and sketches are shown in appendix 6.

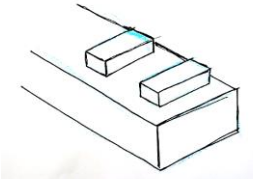
*Clustering*

Following is the clustering. The found solutions during the brainstorm are going to be clustered by comparable functions. This is achieved by the help of a morphologic map. This map is shown in table 5.

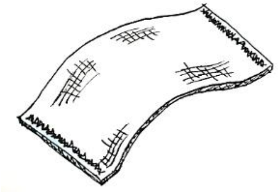
| Part | Option A | Option B | Option C | Option D | |
|---|---|---|---|---|---|
| Adjustment mechanism height |  Button<br> Foldable |  Pin |  Clip |  Screw |  With Pin |
| Formfitting armrest |  Reformable plastic |  Slip-over |  Modular |  Flexible fabric |  By screws |


Foam
Lever
Lock
mechanism
armrest
Buckle
Clip
Spring
Screws
Puzzle
Velcro
Pressing together
Handle
form
Bar
Round
Sphere
Squared
Squared with pulling

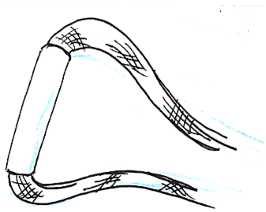
handle



Bars



Flexible strap



Pulling rope

*Table 5; Morphologic map*

*Design phase*

Creating the morphologic map is followed by the design phase. From this phase on it's necessary that the concepts are feasible. In the morphologic map different suitable functions are combined. With the help of the created combinations a range of concepts is created. The three most promising concepts are chosen. These concepts are shown in Figures 14, 15 and 16.

*Concept 1*

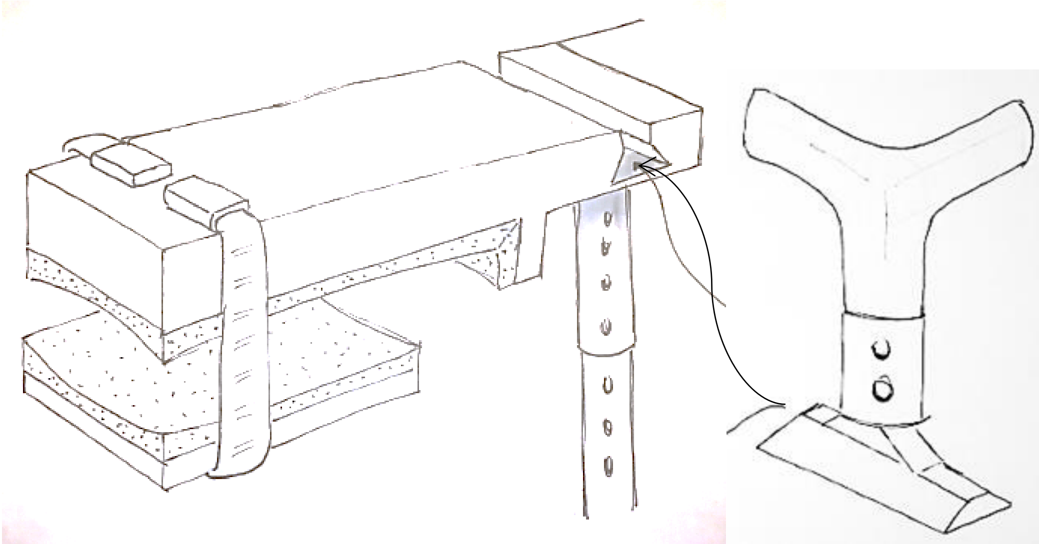


*Figure 14; Concept 1*

Concept 1 (Figure 14) is based on the yellow line in the morphologic map. It is a compact concept that is attachable to the armrest of a chair by pressing the two parts together. Between the two parts foam is applied to let the product form to the shape of the armrest and create grip. The straps around the device are the same as used on snowboard shoes. They can be adjusted depending on the size of the armrest. Because the straps are flexible the design is suitable for all widths of armrests. The handle can be attached on the device and can be put away when the person wants to slide the chair under a table or just want to position the arms on the armrest. This device has modular handles. The handles that are most suitable for the persons length can be chosen upfront purchasing the product. The handle exists out of two different directions of handles. One for pulling yourself forward and the pushing up handle can be chosen.

*Table 6; Pros and cons concept 1.*

| Pros | Cons |
|---|---|
| Compact | Device is possibly going to rotate |
| Easy to use | Little space for the hands between the handle and add- on part |
| Handles in different directions | Possibly big momentum arm |
| The handles can be put away | |

*Concept 2*

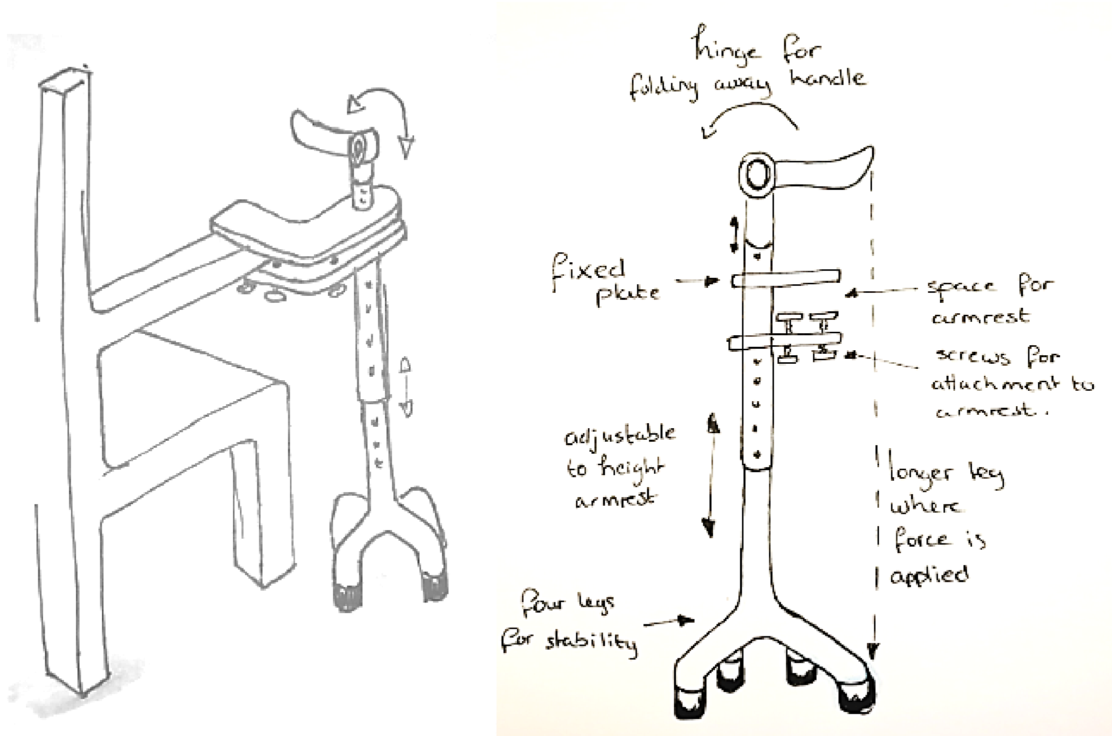



*Figure 15; Concept 2*

Concept 2 is inspired by a four-leg crutch. This concept is based on the green line in the morphologic map. The height of the handle is adjustable by a button system, also similar to a crutch. The device is added on the chair by pressing the armrest between two plates. The lower plate has screws which are used to fasten the product. The handle can be turned by a hinge to give the user the possibility to push them self-up the way they like.

*Table 7;Pros and cons concept 2.*

| Pros | Cons |
|---|---|
| Weight of the person is going to be positioned above the legs | Bulky |
| Possible to place the underarms on the armrests | Cannot be put in a handbag |
| The handle can be put aside | |
| Looks recognizable for a lot of people | |

*Concept 3*

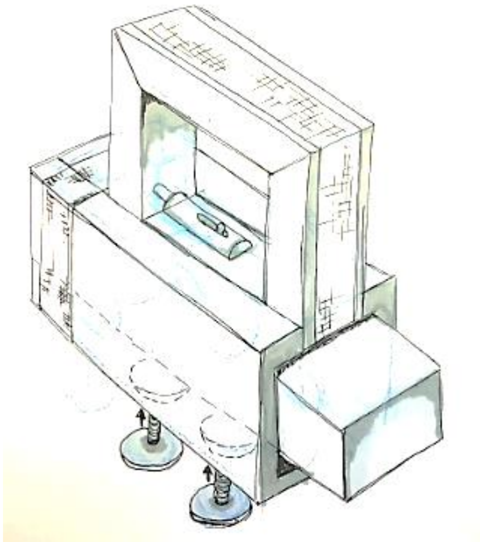


*Figure 16; Concept 3*

Concept 3 is based on the orange line in the morphologic map. The orange line is divided in two direction because multiple functions are combined in this device. Figure 16 shows the device when it's being used. The bar is folded so the user can pull them self forward and push them self-up. The stability of the bar is ensured with the lock. The product consists of two parts that can be put together with a puzzle-like system and Velcro around it. A screw system provides that the device is locked on the armrest. When the device is not in use the bar can be put down as can be seen in the Figure 16. The separate bars stay together by a flexible strap on top of the bars.

*Table 8; Pros and cons concept 3.*

| Pros | Cons |
|---|---|
| The bar can be put down when not in use | Hard to attach the device to the armrest |
| Compact | Not easy to understand how the device works |
| | Consists out of several parts |

*Cardinal method*

The best concepts are compared with each other with the help of the cardinal method (Table 9). Despite the fact that all concepts meet the requirements, there is made a division in safety, design requirements and user-friendliness. Safety and design requirements receive the weight factor 5 and user-friendliness factor 3. In the cardinal method is reviewed how high the possibility is that the requirement can be achieved optimal. The highest score in an 5, the lowest 1. The concept with the highest total score, will be the best option. The best concept will be elaborated into a final design.

*Table 9; Cardinal method*

| Description | **Weight factor** | **Concept 1** | **Concept 2** | **Concept 3** |
|---|---|---|---|---|
| The device is an add-on device that can be attached to multiple chairs that are frequently used in nursing homes. | 5 | 5 | 5 | 3 |
| The device makes the standing up process faster. | 5 | - | - | - |
| The person feels secure while using the device. | 5 | - | - | - |
| The device is transportable. | 5 | 5 | 3 | 5 |
| The material is water resistant. | 5 | - | - | - |
| The device does not have sharp edges. | 5 | 3 | 3 | 3 |
| The device doesn't obstruct the person while sitting in the chair. | 3 | 4 | 4 | 4 |
| It has to be easy to attach the device to the chair. (Maximum three tasks before it can be used). | 3 | 3 | 2 | 2 |
| The device has to be able to be used intuitively by a 65 year old. | 3 | 3 | 4 | 3 |
| The device has to fit on chairs with open armrests. | 5 | 5 | 5 | 5 |
| The device has to be resistant to a horizontal force from maximum 507N, a maximum vertical force from 920N and transversal forces. | 5 | 2 | 4 | 2 |

| | | | | |
|---|---|---|---|---|
| The person has to be able to pull his/herself forward with their arms. | 5 | 3 | 4 | 3 |
| The measurements of the product make the device suitable for at least 90% of the elderly Dutch population. | 5 | - | - | - |
| The device fits on an armrest with a width between 1,9 and 6,3 centimetres. | 5 | 5 | 5 | 4 |
| The device fits on an armrest with a height between 1,9 and 3,7 centimetres. | 5 | 5 | 5 | 4 |
| The device fits on an armrest with a length between 44,7 and 54,6 centimetres. | 5 | 5 | 5 | 5 |
| The device has to be adjustable in height from at least 20,1cm to at least 25,2 cm from the top of the seat. | 5 | 2 | 4 | 2 |
| The pulling part needs to be adjustable between 7,5 and 18 cm in front of the existing armrest. | 5 | 4 | 4 | 3 |
| There are maximum three tasks needed to adjust the height of the device. | 3 | 5 | 2 | 5 |
| | | | | |
| The parts that are going to be touched while using the product, do not feel cold. | 1 | 5 | 5 | 5 |
| The device has an indicator which shows the user what the ideal height of the device is for their length. | 1 | 5 | 5 | 1 |
| **Total** | | 275 | 281 | 243 |

Concept 2 came out as best concept. This concept is developed further, with the help of mock-ups and adding measurement to the concept, to a final design.

*Final design*

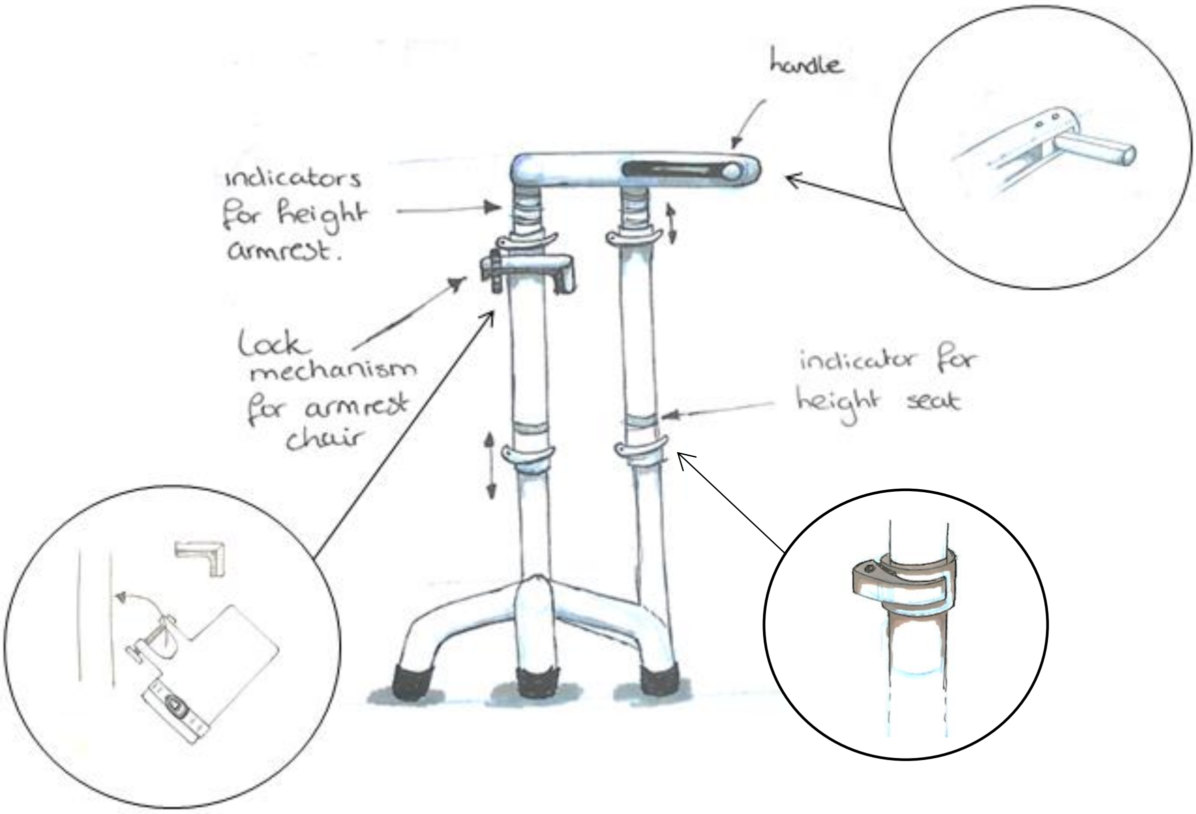



*Figure 17; Final design*

The final design (Figure 17) is an improved version from concept 2. The lock mechanism for the armrest is adjusted with a corner to prevent that the device will shift when the user will pull themselves forward. This corner will also ensure the distance between the device and the pulling handle. The lock mechanism can be attached to the chair with a ratchet buckle.  At the bottom of the lock mechanism foam is applied. The foam prevents that the chair gets damaged, will form to the shape of the armrests and abolish possible space between the floor and device. There is added an extra leg to make sure that the construction can bare the force that will be applied in vertical direction. The leg that is positioned in the same direction as the lock mechanism needs to be positioned behind the front chair leg. There is a height indicator that needs to be positioned on the height of the seat of the used chair. For the height of the armrest are indicators as well. The handle can be used to pull forward and the bar (parallel to the existing armrest) can be used for pushing upwards.

# 4. Construction/materialization

*Technical drawings*

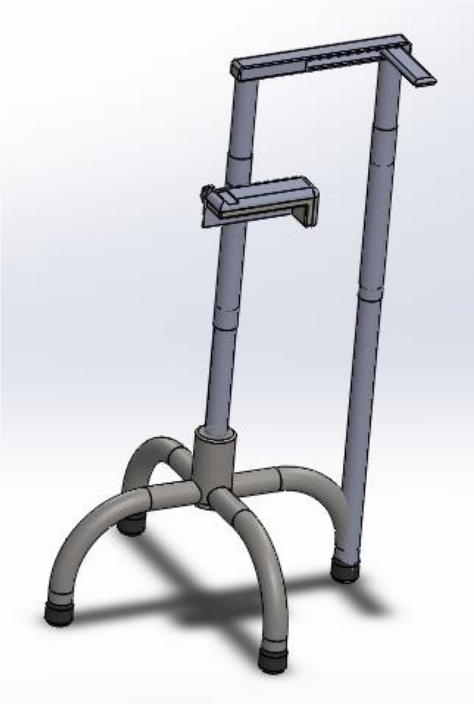


*Figure 18; Technical drawing final design.*

Figure 18 shows a screenshot from the assembly that is created. The technical drawings from the final concept can be found in Appendix 8.

*Working model*
A working model is manufactured that approaches the final design (Figure 19). A legend that will be added to the device for the height indicators can be found in appendix 7.

*Figure 19: Working model on SpringUp chair.*

*Technical drawings*
The technical drawings can be found in Appendix 8.

# 5. Evaluation

The device has to meet all requirements. In table 10 is discussed if the device meets the requirements and wishes.

*Table 10: evaluation requirements and wishes*

| Requirement | Description | Evaluation |
|---|---|---|
| **1** | The device is an add-on device that can be attached to multiple chairs that are frequently used in nursing homes. | This requirement is fully achieved for at least the selected chairs. |
| **2** | The device makes the standing up process faster. | This has not been investigated yet. This will be discussed during the recommendations. |
| **3** | The person feels secure while using the device. | This has not been investigated yet. This will be discussed during the recommendations. |
| **4** | The device is transportable. | This requirement is achieved. The device is transportable by car for example. However, the device cannot been transported in a small bag. |
| **5** | The material is water resistant. | This requirement is achievable for this device. |
| **6** | The device does not have sharp edges. | Achieved. All edges are round from the device. |
| **7** | The device doesn't obstruct the person while sitting in the chair. | Achieved. The device is positioned next to the chair, so it won't obstruct while sitting. |
| **8** | It has to be easy to attach the device to the chair. (Maximum three tasks before it is attached). | Achieved. For the attachment two tasks are needed: positioning the armrest attachment part and closing the flexible strap. |
| **9** | The device has to be able to be used intuitively by a 65 year old. | This has not been investigated yet. This will be discussed during the recommendations. |
| **10** | The device has to fit on chairs with open armrests. | Achieved. |
| **11** | The device has to be resistant to a horizontal force from maximum 507N, a maximum vertical force from 920N and transversal forces. | Achieved. The forces are applied on the model in SolidWorks. |
| **12** | The person has to be able to pull his/herself forward with their arms and push his/herself upwards with the hands positioned parallel to the body. | Achieved. |
| **13** | The measurements of the product make the device suitable for at least 90% of the elderly Dutch population. | Achieved. |
| **14** | The device fits on an armrest with a width | Achieved. |

| | | |
|---|---|---|
| | between 1,9 and 6,3 centimetres. | |
| **15** | The device fits on an armrest with a height between 1,9 and 3,7 centimetres. | Achieved. |
| **16** | The device fits on an armrest with a length between 44,7 and 54,6 centimetres. | Achieved. |
| **17** | The device has to be adjustable from at least 20,1cm to at least 25,2 cm from the top of the seat. | Achieved. |
| **18** | The pulling part needs to be adjustable between 7,5 and 18 cm in front of the existing armrest. | Achieved. |
| **19** | There are maximum three tasks needed to adjust the height of the device. | The tasks needed for adjusting the height are as follow:<br>1. position the device on the right seat height.<br>2. Lock the vertical bars on this height.<br>3. Position the handle on the suitable height.<br>4. Lock the vertical bars on this height.<br>There are more than three tasks needed for the height adjustment. This will be further discussed in the recommendations. |
| **Wish** | **Description** | |
| **1** | The parts that are going to be touched while using the product, do not feel cold. | This is achievable. |
| **2** | the device has an indicator which shows the user what the ideal height of the device is for their length. | Achieved. |

# 6. Discussion

The aim for the project was to create a physical device that can be attached to different existing chairs, that are frequently used in nursing homes, that helps elderly people stand up from a chair while maintaining a secure feeling.

*EMG measurement*

The instructions for the subject before starting the measurement were as follow: sit in a relaxed position, with the lower arm resting on the armrest and the hand and feet positioned on lines that were drawn on the armrest and floor. With these instructions the subject was sitting in the same position for each measurement. The person was positioned with his buttocks to far from the seat. There can still be concluded that the height of the armrest has influence on the activity of the TBL and VL during standing up, but the results may differ when the person is positioned at the end of the seat.

The EMG measurement is performed with one subject with the age of 24 years. For this project was chosen to perform a design process from begin to ending. Because of the limited time per process was chosen for this approach. For now was chosen for a younger subject because of ethical reasons. The person had to offer a lot of time and had to perform the standing up processes in underwear to be able to film all the joints with markers and place the electrodes. It is possible that the measured person does not stand up like an average person, what could influence the result. His age could also be an influence on the performed movements.

*Angle analysis*

The program Kinovea is used to analyze the performed angles by the subject. In this program the body markers in the video are connected by hand. This might cause a few degrees difference compared with reality.

*Final design*

One of the requirements was that the device needs to be transportable. The final design is a bulky design that can be transported by car, but not in a bag for example. There is chosen for a design of big proportions to be able to transfer applied forces to the ground. Possibly there is another solution that can lead to a more compact design.

# 8. Recommendations

*EMG measurement*
To make the research more reliable more subjects need to be used. The person also needs to be instructed to be positioned on the end of the seat. Besides the amount of subjects it is recommended that the age of the subject has to be 65+ years to make the measurement better comparable to the target group.

*Adjustability*
Concepts in earlier stages had buttons to adjust the height of the device. Later on in the process the buttons are replaced with a clip, because it is not user friendly to push two buttons and adjust the device in height at the same time. Unfortunately the possibility exists that clothes can get stuck behind the clips. For further designing it could be interesting to perform further research to height adjustment mechanisms or trying to get rid of one of the legs of the device.

In this design a lot of steps in adjustability are possible. This can possibly lead to unclearness for the user. It could be interesting for further development to try to get rid of a part of the adjustability. For example a design with one vertical bar.

*Size device*
There were two requirements that were interfering with each other. These requirements were the one about extending the armrest and the ability to transport the device. Because the force applied when pushing up is in front of the armrest, a large momentum arm is created. When the person would push him/herself up the possibility exist that the chair come loose from the ground. To solve this problem the final device has legs were the force can be exercised the ground. Unfortunately that means a device from large proportions. The device is still transportable by car, but it is not possible to transport it in a handbag for example. For future research it could be interesting to try to get rid of the legs by shifting the exercised force elsewhere to make the device easier to transport.

*Evaluation*
To make sure that the device meets all requirements a few steps still need to be undertaken. Requirement 2: 'The device makes the standing up process faster' can be tested by measuring the needed time for standing up with and without the working model. The results can be compared to make sure if the requirement is achieved. In Appendix 10 a measurement protocol can be found for performing this measurement.

Requirement 3: 'The person feels secure while using the device' is also not proven yet. A subjective measurement can be performed to make sure if the device meets the requirement. To achieve this a subject with the age of 65+ has to stand up from a chair with the device. The subjects should be asked their opinion if they felt save using the device.  During this subjective measurement requirement 9:' The device has to be able to be used intuitively by a 65 year old' can also be tested by observing if the subject understood the intention of the device without giving instructions how they pull themselves forward and push themselves up with the device.

# 7. Conclusion

To make the device suitable for 90% of the elderly Dutch population the device has to be resistant to a horizontal force of maximum 507N and a vertical force of maximum 920N.
What most users of comparable products like in the devices are: easy to assembly, sturdiness and stability of the device. Most dislike it when it is not steady, when it is not suitable for every chair and feel like the device isn't save.
The are several measurements that the device need to meet. They are as follow: The device fits on an armrest with a width between 1,9 and 6,3 cm, on a height between 1,9 and 3,7cm and on a length between 44,7 and 54,6 cm. The device has to be adjustable from at least 20,1cm to at least 25,2 cm from the top of the seat and the handle needs to be positioned in front of the existing armrest.

The final design is a construction that is based on a four legged crutch which is adjustable in height for five levels. The levels are indicated with different colors to ensure clarity for the users. The handle is positioned in front of the seat so the user can pull his/herself forward and push upwards with the same handle.

As mentioned in the evaluation the device meets most requirements. All requirements concerning the measurements are evaluated with the working model. Not all requirements are evaluated yet.

# Bibliography


1. Alders, M. & Tas, R. (2001). *Lang leven de ouderen.* Retrieved from https://www.cbs.nl/NR/rdonlyres/A1B4D85F-8C92-4199-88F6-4D3DCDFE72B9/0/index1165.pdf
2. Mourey F., & Pozzo, T., & Rouhier-Marcer, I., Didier J. (1998). A kinematic comparison between elderly and young subjects standing up from and sitting down in a chair. *Age and aging, 27,* 137-146, doi: 10.1093.
3. Mourey, F., Grishin, A., d'Athis, P.,Pozzo, T.,Stapley, P. (2000). Standing up from a chair as a dynamic equilibrium task: A comparison between young and elderly subjects. *The Journals of Gerontology, 55,* 425-431, doi: 10.1093.
4. Janssen, W., Bussmann, H., Stam, H. (2002). Determinants of the Sit-to Stand Movement: A Review. *Journal of the American Physical Therapy Association, 82,* 866-879, doi:
5. Schenkman, M., Berger, R.A., P, O'Riley., R.W, Mann, & W.A., Hodge. (1990). Whole-body movements during rising to standing from sitting. *Physical therapy, 70,* 638-651, doi:
6. Nonaka, H., Mita, K.,Watakabe, M., Akataki, K., Susuki, N., Okuwe, T. & Yabe,K. (2002). Age-related changes in the interactive mobility of the hip and knee joints: a geometrical analysis. *Gait & posture, 15,*236-243, doi: 10.1016.
7. Burr, D. (October, 1997). Muscle strength, bone mass and age-related bone loss. *Journal of Bone and Mineral Research, 12,* 1547-1551, doi:10.1359.
8. Janssen, W.G.M. (2008). The Sit-to-Stand Movement. Recovery after stroke and objective assessment. Retrieved from: https://www.researchgate.net/profile/Wim_Janssen/publication/254757523_The_Sit-to-Stand_Movement_recovery_after_stroke_and_objective_assessment/links/0a85e536cdc1d16907000000.pdf#page=15
9. N. A. Lynch, E. J. (1999). Muscle quality. I. Age-associated differences between arm and leg muscle groups. *Journal of Applied Physiology* , 188-194, doi:
10. Binder, M.D., Hirokawa, N., Windhorst, U. & Hirsch, M. (2009). Force-Lenght Relationship. *Encyclopedia of Neuroscience,* 1615-1615, doi: 10.1007.
11. Dined Antropometric database. (1998). *Dutch elderly, gvdd 1998.* [Data set] Retrieved from http://dined.io.tudelft.nl/en/database/tool

## Appendix 1: Comparable products, users survey

| Product name | Figure | Retrieved from |
|---|---|---|
| **Vitility-sta-op-hulp staal** |  | https://www.bol.com/nl/p/vitility-sta-op-hulp-staal/9200000021712046/?suggestionType=typedsearch |
| **SafetySure StandEase** |  | https://www.amazon.com/MTS-Medical-Supply-970-SafetySure/dp/B00QPOL8X8/ref=sr_1_64?s=hpc&ie=UTF8&qid=1489756073&sr=1-64#customerReviews |
| **Golden sta op stoel voor grote personen** |  | https://verpleeg-shop.nl/fit-en-gezond/sta-op-hulpen/golden-sta-op-stoel-voor-grote-personen |
| **ProRise PR001 Seat assist portable lifting device** |  | https://www.amazon.com/ProRise-PR001-Assist-Portable-Lifting/dp/B01NBG6TYD/ref=sr_1_2_a_it?ie=UTF8&qid=1488804226&sr=8-2&keywords=stand+up+assist+from+chair |

| | | |
|---|---|---|
| **Kaboost chair riser** |  | http://www.caregiverproducts.com/kaboost-chair-riser.html |
| **B&B Sta-op stoel Vista** |  | https://verpleeg-shop.nl/fit-en-gezond/sta-op-hulpen/b-b-sta-op-stoel-vista |
| **Careline sta op hulp UpEasy mechanisch** |  | https://verpleeg-shop.nl/fit-en-gezond/sta-op-hulpen/careline-sta-op-hulp-upeasy-mechanisch |
| **Rehastage couch tray** |  | https://verpleeg-shop.nl/fit-en-gezond/sta-op-hulpen/rehastage-couch-tray |
| **Russka bedverhogers** |  | https://verpleeg-shop.nl/zorg/verpleeg-accessoires/russka-bedverhogers-blox-4-stuk |

| | | |
|---|---|---|
| **Able life able tray table – Bamboo swivel TV laptop tray + ergonomic – safety support mobility handle** |  | https://www.amazon.com/product-reviews/B0026IBSUA/ref=pd_sbs_121_cr_17?ie=UTF8&pd_rd_i=B0026IBSUA&pd_rd_r=SY8N8TDF5XD3TMY66QEF&pd_rd_w=rILKU&pd_rd_wg=85lHB&refRID=SY8N8TDF5XD3TMY66QEF |
| **Home solutions premium adjustable bed risers or furniture risers, table risers, chair risers or sofa risers** |  | https://www.amazon.com/Home-Solutions-Premium-Adjustable-Furniture/dp/B01HU42Y5W/ref=sr_1_1?ie=UTF8&qid=1488804080&sr=8-1-spons&keywords=furniture+risers#customerReviews |
| **Stander security pole – tension mounted elderly transfer pole+ bathroom aids to daily living & assist grab bar** |  | https://www.amazon.com/Stander-Security-Pole-Transfer-Guarantee/product-reviews/B0026IBRUQ/ref=cm_cr_arp_d_viewpnt_rgt?ie=UTF8&reviewerType=avp_only_reviews&filterByStar=critical&pageNumber=1 |
| **Able life universal stand assist – Adjustable standing mobility aid+ assist handle for couch, chair & sofa + dual cushioned support handles for fall protection** |  | https://www.amazon.com/product-reviews/B00I45JJRS/ref=acr_arpsims_text?ie=UTF8&showViewpoints=1 |

| | | |
|---|---|---|
| **EZ-Up stand assist – Standing aid for independen t seniors** |  | https://www.amazon.com/EZ-Up-Stand-Assist-Standing-Independent/dp/B00SZO52TM#customerReviews |
| **Standers assist-a-tray standing aid with tray** |  | http://www.caregiverproducts.com/assist-tray.html#tab-2 |
| **Standers security pole and grab bar** |  | http://www.caregiverproducts.com/security-pole-grab-bar.html#tab-2 |
| **My get up and go cane** |  | http://www.ebay.com/itm/NEW-My-Get-Up-And-Go-Cane-Second-Handle-Helps-You-Get-Out-Of-Your-Seat-ASOTV-/162377346731?hash=item25ce71aeab:g:wGsAAOSwImRYj7lO |

| | | |
|---|---|---|
| **Sta op hulp met tafeltje** |  | http://www.orthocor.nl/sta-op-hulp-draaibaar-tafeltje.html |
| **Health smart Quad Cane, Sit to Stand Walker, adjustable Quad Cane** |  | https://www.amazon.com/HealthSmart-Stand-Walker-Adjustable-Black/product-reviews/B009UCE6XG/ref=cm_cr_arp_d_viewpnt_rgt?ie=UTF8&reviewerType=avp_only_reviews&filterByStar=critical&pageNumber=1 |
| **Pakpaal** |  | https://monozorg.nl/product/pakpaal/#reviews |
| **Easy get-up chair support** |  | https://www.amazon.com/JOBAR-INTL-INC-JB7396-Support/dp/B00SNPCVF6/ref=sr_1_51?s=hpc&ie=UTF8&qid=1489755855&sr=1-51#customerReviews |

| | | |
|---|---|---|
| **Sta op hulp** |  | http://www.orthocor.nl/sta-op-hulp.html |
| **Stander PT BedCane – Height adjustable Bedside Assist Handle** |  | https://www.amazon.com/dp/B01N3PFEW4?psc=1 |
| **Stander security pole & curve grab bar- Elderly tension mounted transfer pole+ bathroom assist grab bar** |  | https://www.amazon.com/Stander-Security-Pole-Curve-Grab/product-reviews/B000OR3SYE/ref=cm_cr_arp_d_viewpnt_rgt?ie=UTF8&reviewerType=avp_only_reviews&filterByStar=critical&pageNumber=1 |
| **Duro-Med chair lift, Chair assist, chair lift assist cushion, black** |  | https://www.amazon.com/product-reviews/B000BO9W5O/ref=cm_cr_arp_d_viewpnt_rgt?ie=UTF8&reviewerType=avp_only_reviews&showViewpoints=1&filterByStar=critical&pageNumber=1 |
| **Bed rail advantage by Stander** |  | http://www.arthritissupplies.com/bed-rail-advantage.html#tab-2 |

| | | |
|---|---|---|
| **Black EZ Get-Up seat, extra grip adjustable walking cane** |  | https://www.amazon.com/Black-EZ-Get-Up-Seat-Extra-Grip-Adjustable/product-reviews/B004NEL3ZK/ref=cm_cr_arp_d_viewpnt_rgt?ie=UTF8&reviewerType=avp_only_reviews&filterByStar=critical&pageNumber=1 |
| **Up Easy Lifting Seat Cushion** |  | http://www.arthritissupplies.com/up-easy-lifting-seat-cushion.html#tab-2 |

# Appendix 2: SpringUp chair


| Specifications: | SpringUp Care |
|---|---|
| Colour: | Sunset (orange) |
| Height back: | Height back - 119 cm from ground |
| Height seating: | 44 cm |
| Height top armrests: | 67 cm |
| Width seating (between armrests): | 49,5 cm |
| Seating depth: | 48 cm |
| Weight: | +/- 24 kg |
| Specials: | |

- Wheels
- Locking mechanism

SpringUp chair from the company Springq B.V.

# Appendix 3: EMG measurement protocol

*Materials*

- Electrodes
- Camera
- Camera stand
- Chair
- Mock-up with different armrest heights
- Object with a known measurement.
- Mobi 8 for EMG measurement
- EMG software
- LED marker
- Button for EMG peak
- X-IMU as battery for LED marker
- Body markers
- Tape for marking positions

*Preparation*

*Measurement set-up*

1. Place camera on the camera stand
2. Position chair and armrest mock-up.
3. Position LED marker on chair with tape.
4. Place an object with an known measurement.
5. Place tape on the armrests and on the floor where the subject need to place his hands and feet.

*EMG*

1. Connect the electrodes on the Mobi 8.
2. Make connection via Bluetooth between a computer and the Mobi 8.
3. Make sure that all electrodes work by touching them one by one, and check if the signal is shown on the computer.

*Led-marker*

1. Connect the LED-marker with the X-IMU.
2. Connect the marker with the Mobi 8.
3. Press the button from the LED-marker. Check if a signal shows on the computer.

*Subject*

1. Place markers on the subject on the following joints (only on filmed side): ankle, knee, hip, elbow and shoulder.
2. Attach the EMG electrodes on the VL , TBL and one on the sternum that functions as ground.
3. Let the subject sit in the chair and let the person rise to make sure that no wires get stuck during the movements.
4. Let the person rise to phase 1 and to to make sure that the positions are performed correct.

5. Perform one test round. Make sure that all EMG signals come through, that the LED-marker is shown on camera and that the subject fits in the video frame.

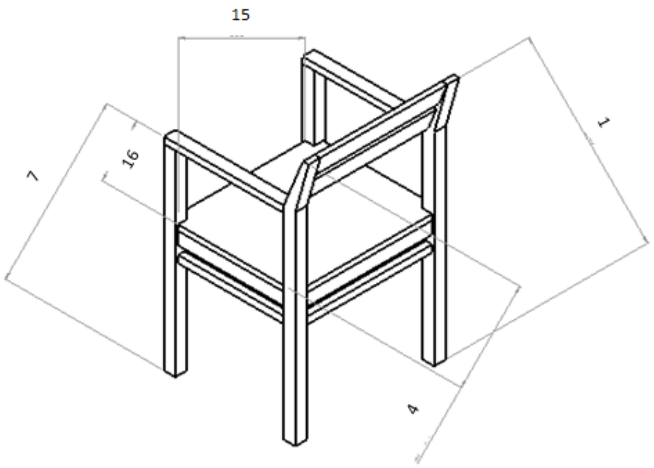
*During measurement*

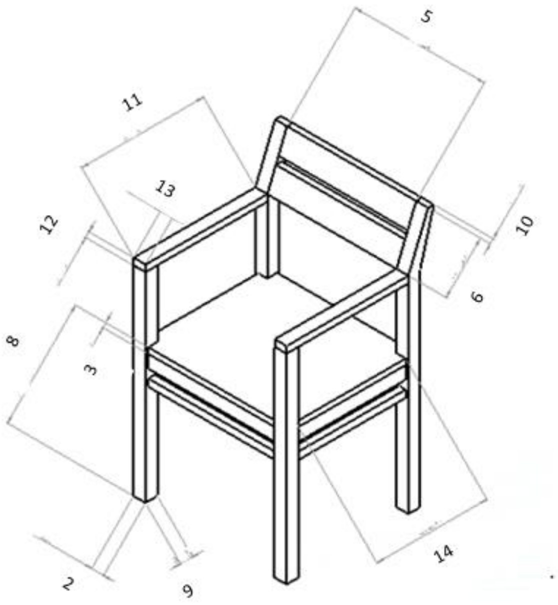
1. Start the video recording.
2. Start EMG measurement.
3. Let the person rise to phase 1.
4. Press the button from the light marker when phase 1 is reached.
5. Let the person rise to phase 2.
6. Press the button from the LED marker when the person reaches phase 2.
7. Stop the video recording.
8. Stop the EMG measurement.
9. Repeat this three times for every armrest level.

*After the measurements*

1. Export and save the EMG as text files.

# Appendix 4: Measurements chairs




*Table….; Complete database chair measurements*

| Measurement no. | Chair 1 | Chair 2 | Chair 3 | Chair 4 | Chair 5 | Minimum (cm) | Maximum (cm) | + 5% margin | Average (cm) |
|---|---|---|---|---|---|---|---|---|---|
| 1: Height chair, from floor to top backrest | 119 | 103 | 85 | 87 | 83 | 83 | 119 | 78,9-125 | 95,4 |
| 2: Width seat leg | 5 | 4,5 (d) | 2,5-3 | 2,5 | 3-4 | 2,5 | 5 | 2,4-5,3 | 3,7 |
| 3: Height seat | 8 | 5 | 12 | 4 | 9 | 4 | 12 | 3,8-12,6 | 7,6 |
| 4: Height from top seat to top | 74 | 56 | 50 | 47 | 42 | 42 | 74 | 39,9-77,7 | 53,8 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| backrest | | | | | | | | | |
| 5: Width backrest | 64 | 46 | 49 | 48 | 45 | 45 | 64 | 42,8-67,2 | 50,4 |
| 6: Height backrest from top armrest to top backrest | 74 | 46 | 26 | 42 | 38 | 26 | 74 | 24,7-77,7 | 45,2 |
| 7: Height armrest from floor to top armrest | 67 | 66 | 68 | 63 | 67 | 63 | 68 | 59,9-71,4 | 66,2 |
| 8: Height seat, from floor to top seat | 44 | 47 | 48 | 46 | 48 | 44 | 48 | 41,8-50,4 | 46,6 |
| 9: Depth seat leg | 2,5 | 4,5 (d) | 2,5-5 | 4 | 3-4 | 2,5 | 5 | 2,4-5,3 | 3,65 |
| 10: Depth backrest | 5 | 4 | 5,5 | 4 | 3 | 3 | 5,5 | 2,9-5,8 | 4,3 |
| 11: Length armrest | 52 | 52 | 50 | 52 | 47 | 47 | 52 | 44,7-54,6 | 50,6 |
| 12: Height armrest | 2,8 | 3,2 | 2-3,5 | 2 | 2,5-3 | 2 | 3,5 | 1,9-3,7 | 2,7 |
| 13: Width armrest | 5 | 5-6 | 3 | 4 | 2-4 | 2 | 6 | 1,9-6,3 | 4,1 |
| 14: Depth seat | 48 | 46 | 52 | 42 | 52 | 42 | 52 | 39,9-54,6 | 48 |
| 15: Width seat | 49,5 | 49 | 50 | 50 | 45 | 45 | 50 | 42,8-52,5 | 48,7 |
| 16: Height armrest, from top seat to top armrest | 18 | 20 | 20 | 17 | 19 | 17 | 20 | 16,2-21 | 18,8 |

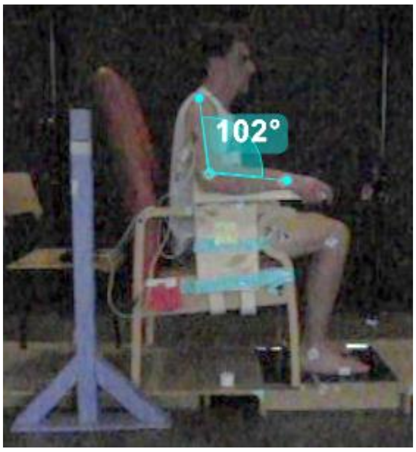
# Appendix 5: Results EMG measurements

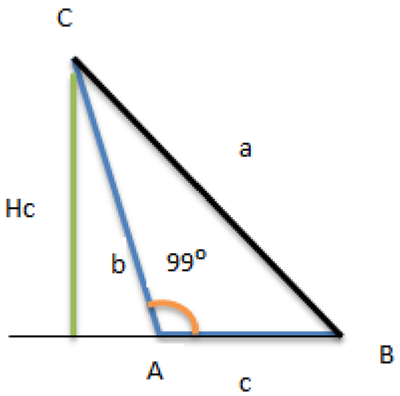
| levels | opp. Trial | opp. Trial | opp. Trial | Average |
|---|---|---|---|---|
| 1 | 8427,261 | 9165,965 | 7631,548 | 8408,26 |
| 2 | 7385,824 | 6464,194 | 7191,539 | 7013,85 |
| 3 | 8317,274 | 7857,744 | 7296,153 | 7823,72 |
| 4 | 9345,565 | 8178,064 | 7417,838 | 8313,82 |

*EMG TBL*

| levels | opp. Trial | opp. Trial | opp. Trial | Average |
|---|---|---|---|---|
| 1 | 2010,394 | 4608,388 | 4403,024 | 3693,94 |
| 2 | 2339,241 | 2438,59 | 2245,567 | 2341,13 |
| 3 | 3801,992 | 4724,616 | 5277,335 | 4601,31 |
| 4 | 1392,872 | 3962,796 | 3347,523 | 2901,06 |

*EMG VL*






Upper Figure shows an upper arm and lower arm, in blue, with the under arm positioned horizontally on the armrest.

For calculating Hc the following calculations are performed:

Hc= b*sin ($99^o$)

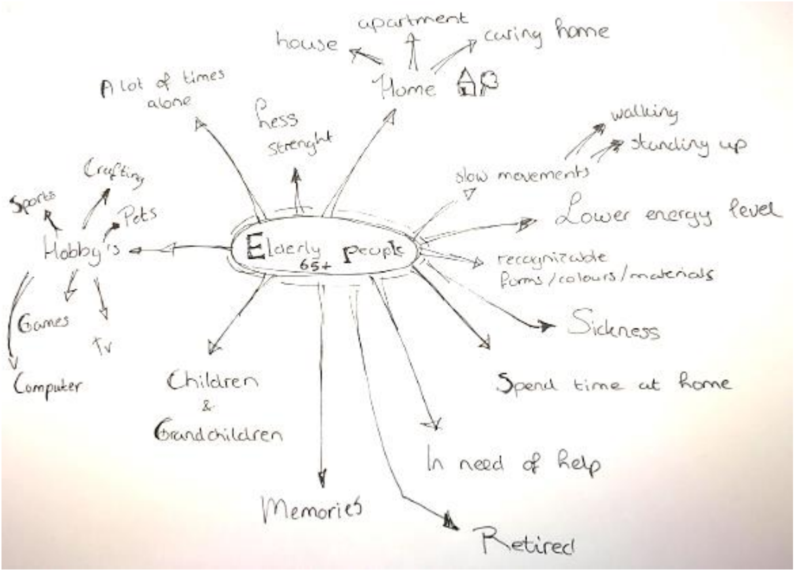
Example with P5:

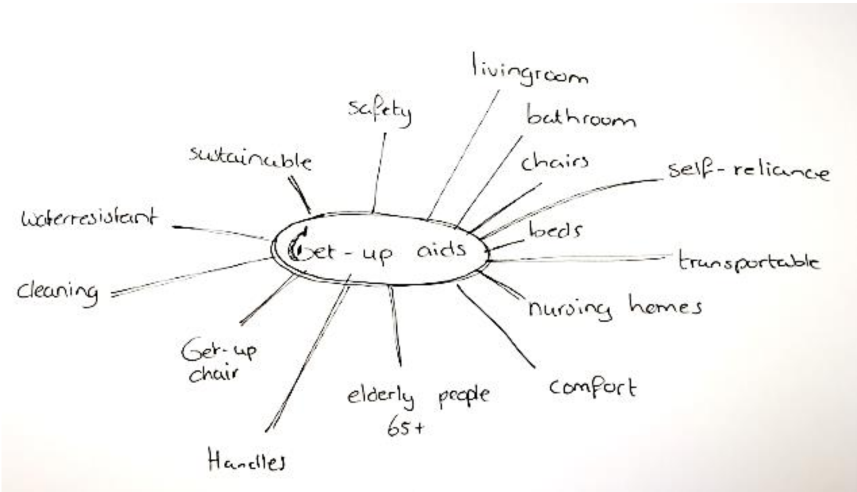
For P5 the upper arm length is 30,2 cm, the underarm length 29,3 cm. The angle between the upper arm and underarm is $99^o$. The height of the top of the shoulder to the armrest is 29,8cm. The length from buttocks to the top of the shoulder for P5 is 49,9 cm.

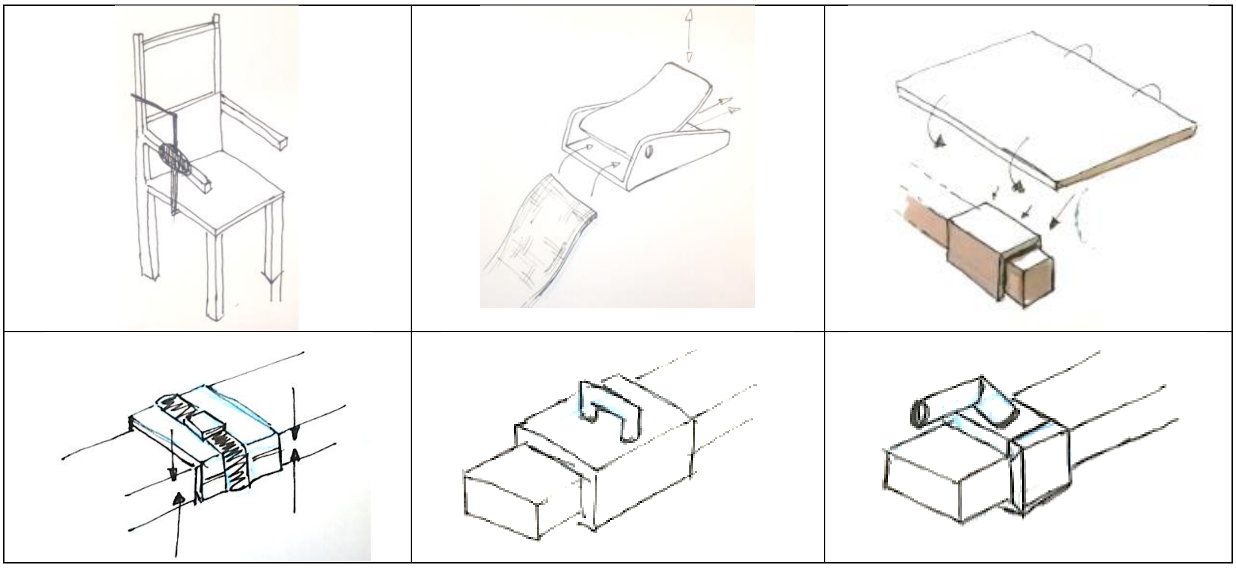
49,9-29,8=20,1 cm.

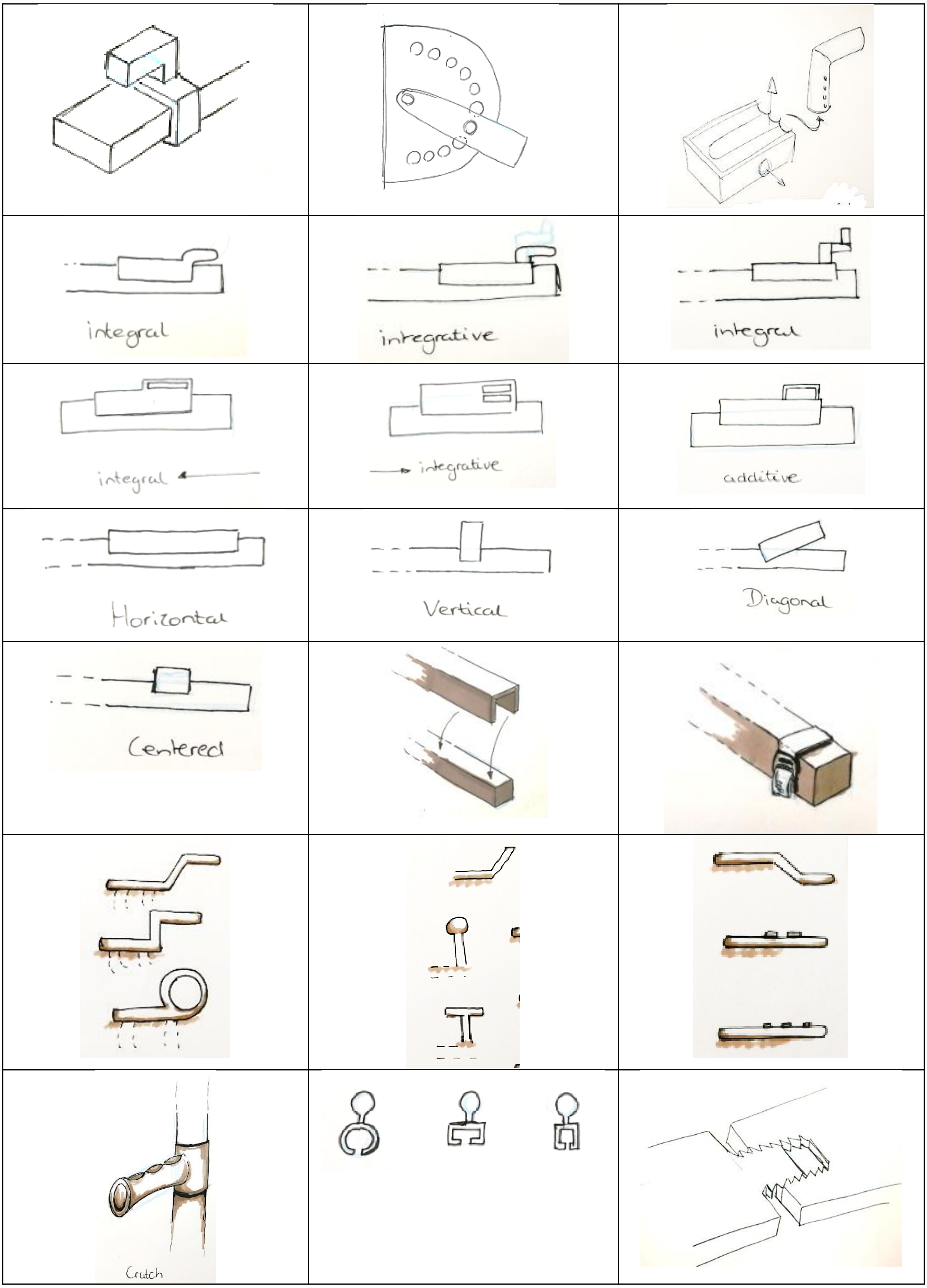
The height of the armrest for P5 has to be 20,1 cm.

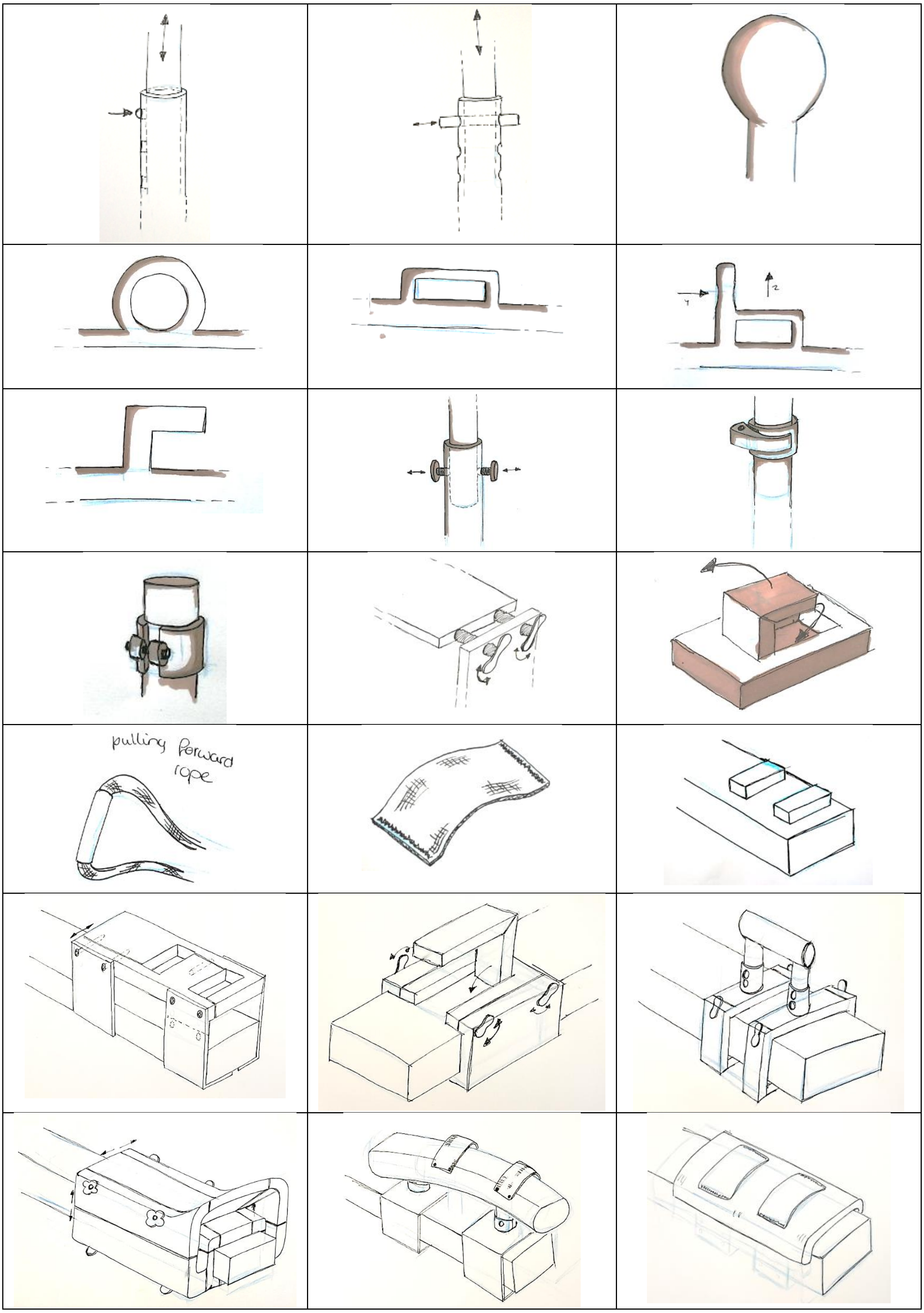
# Appendix 6: Brainstorm

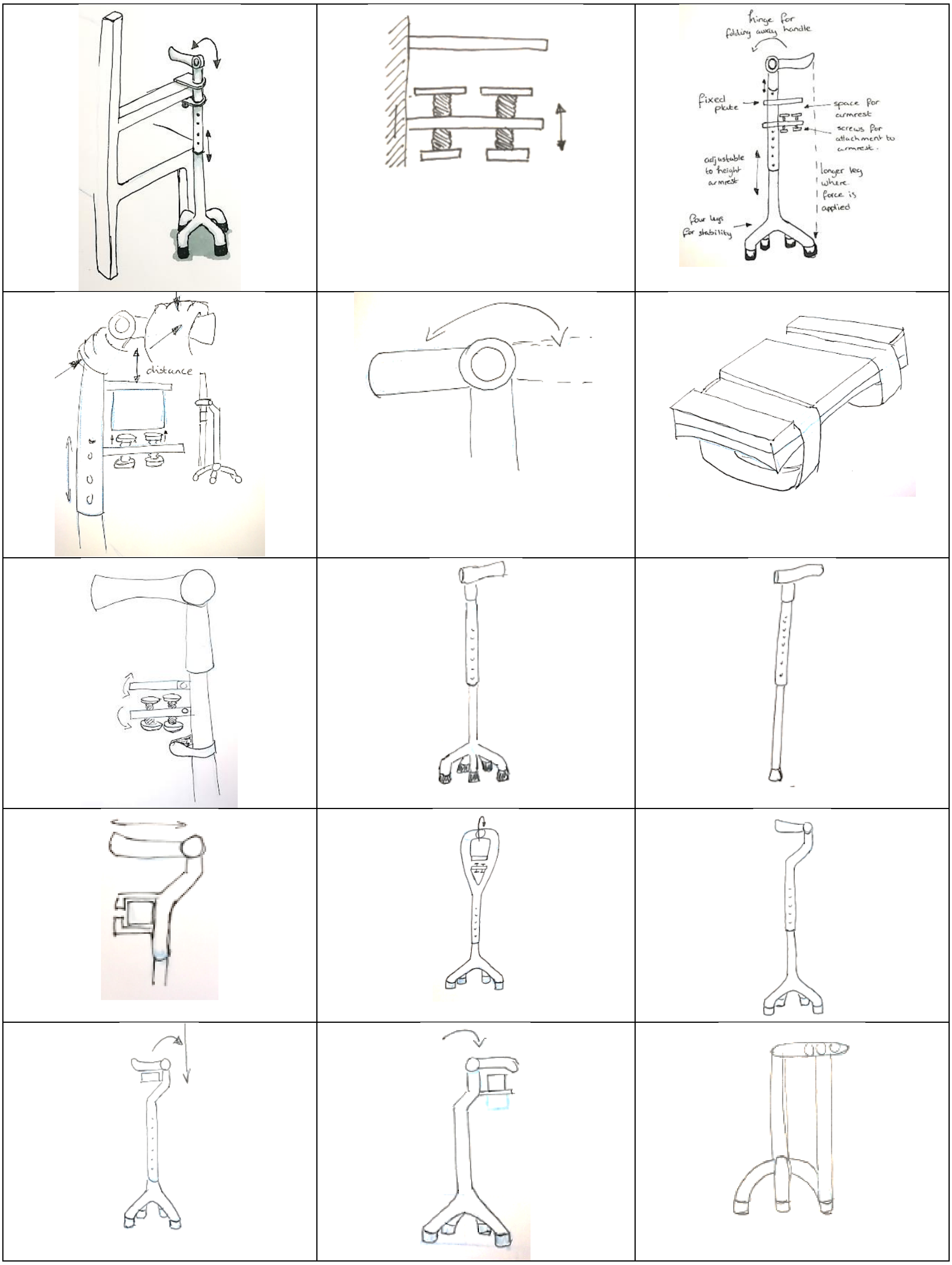


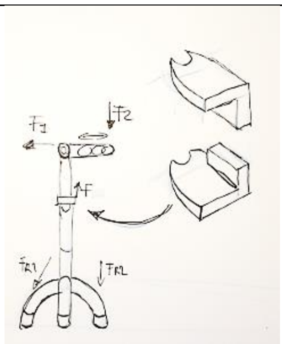



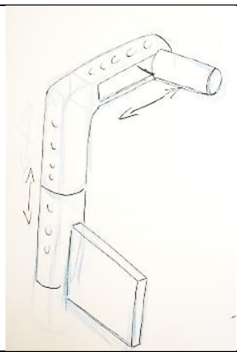



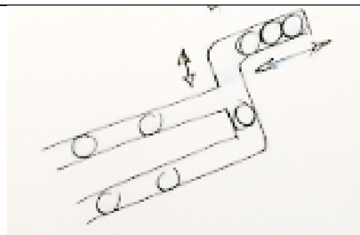

integral
integrative
integral
integral
integrative
additive
Horizontal
Vertical
Diagonal
Centered
Crutch

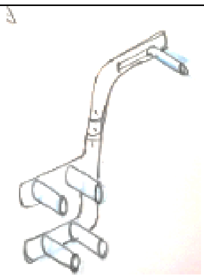

pulling Forward
rope

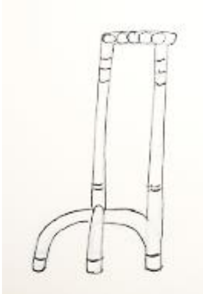

hinge for
folding away handle
fixed
plate
space for
armrest
screws for
attachment to
armrest.
adjustable
to height
armrest
longer leg
where
force is
applied
four legs
for stability
distance

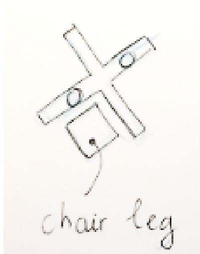


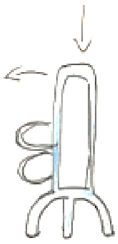









chair leg



# Appendix 7: Device adjustment legend

150 – 156cm

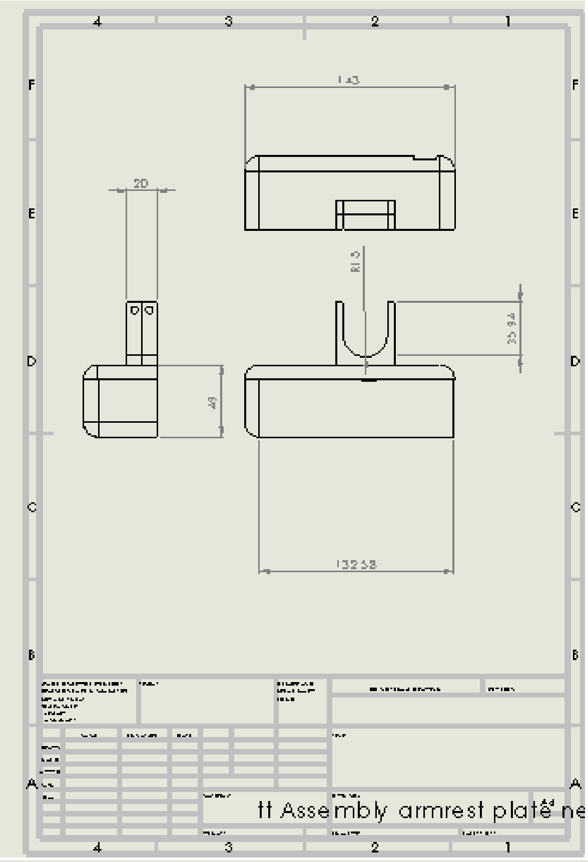
157 -  163cm

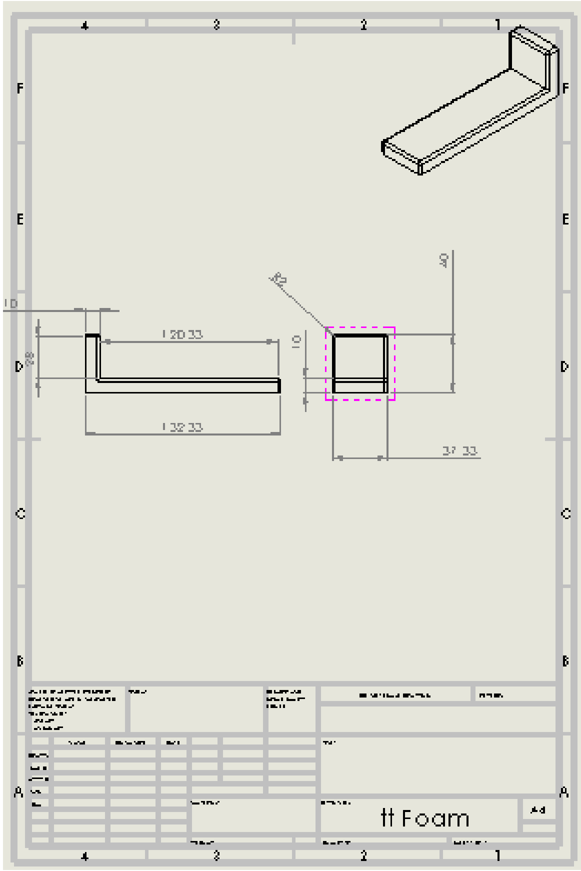
164 – 168cm

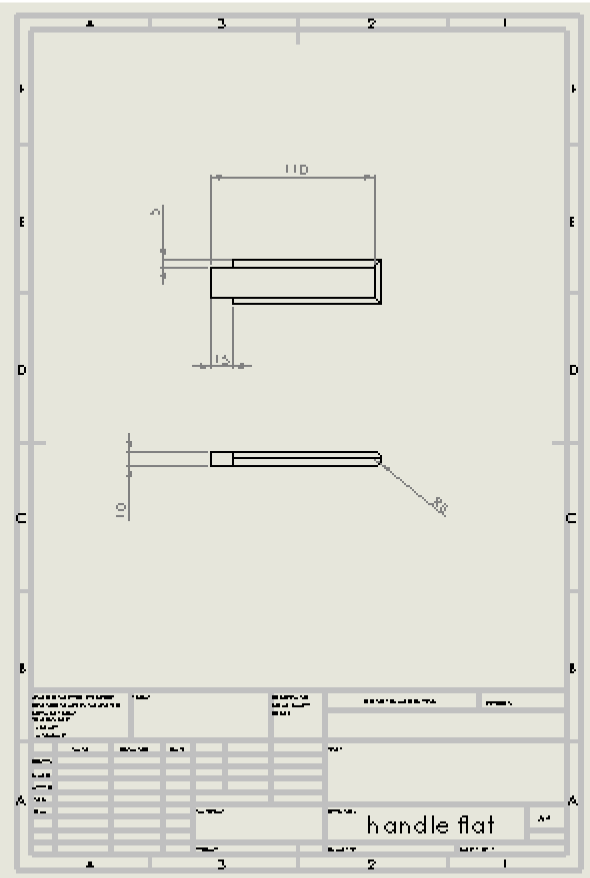
169 – 175cm

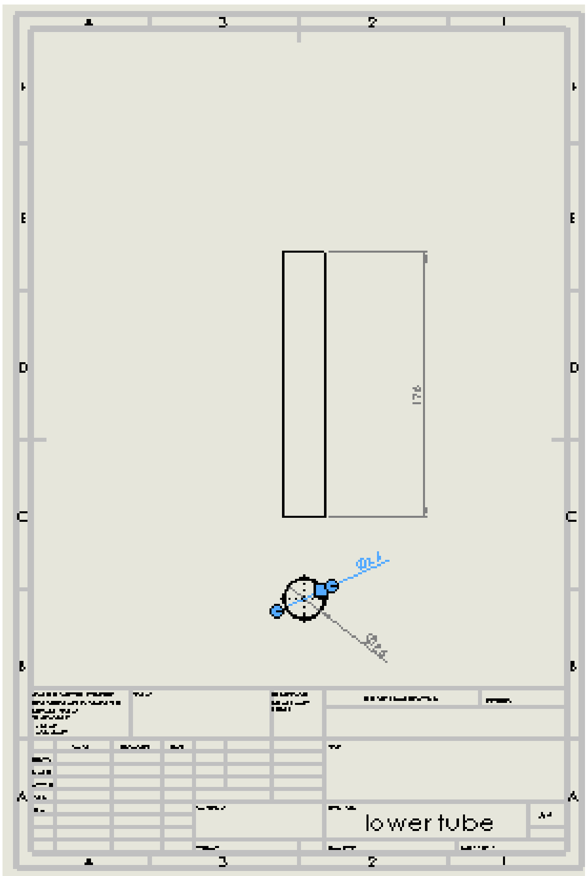
176 – 181cm

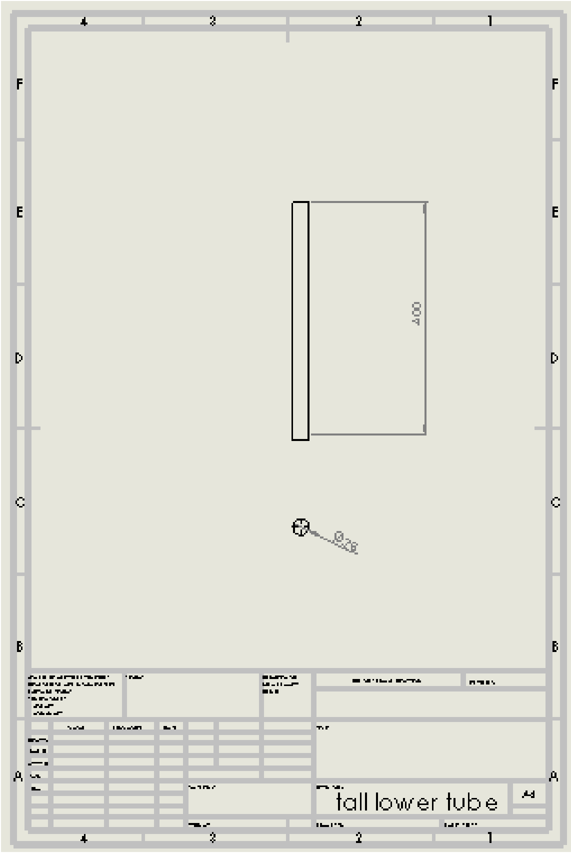
# Appendix 8: Technical drawings

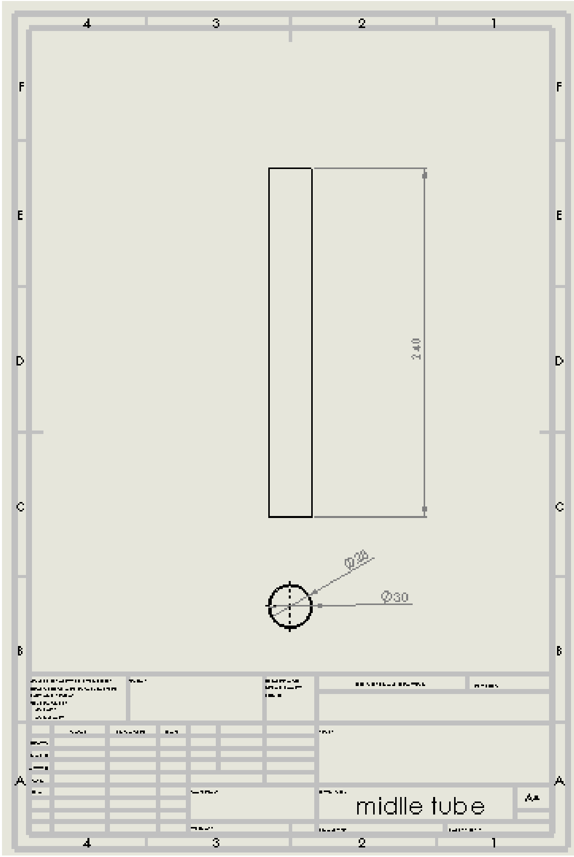


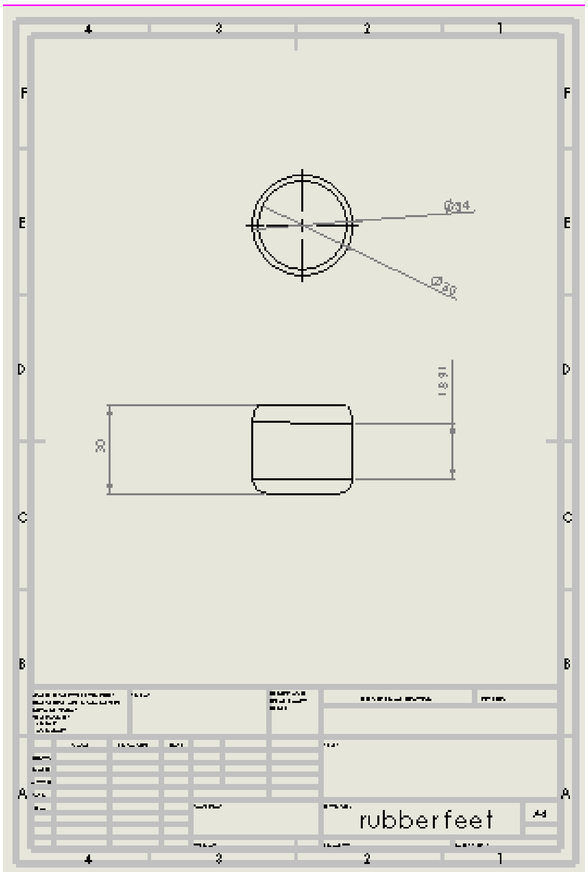



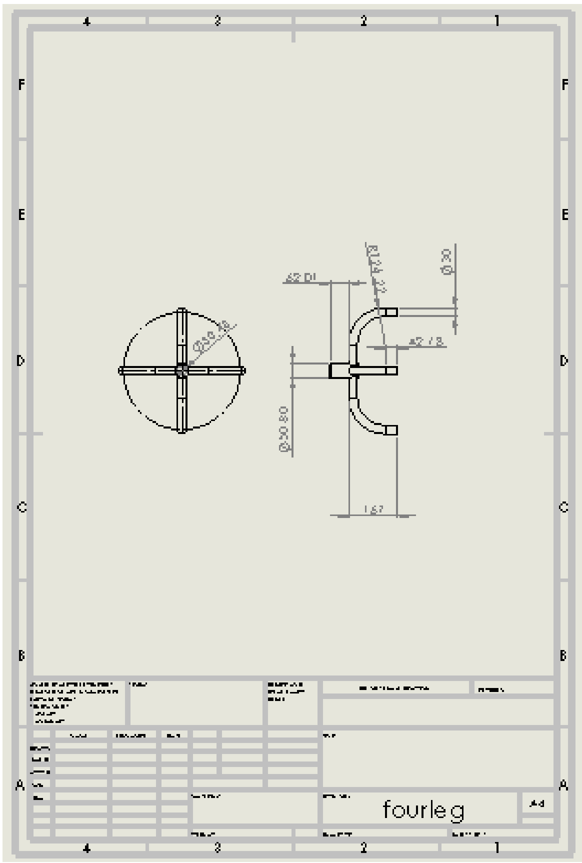



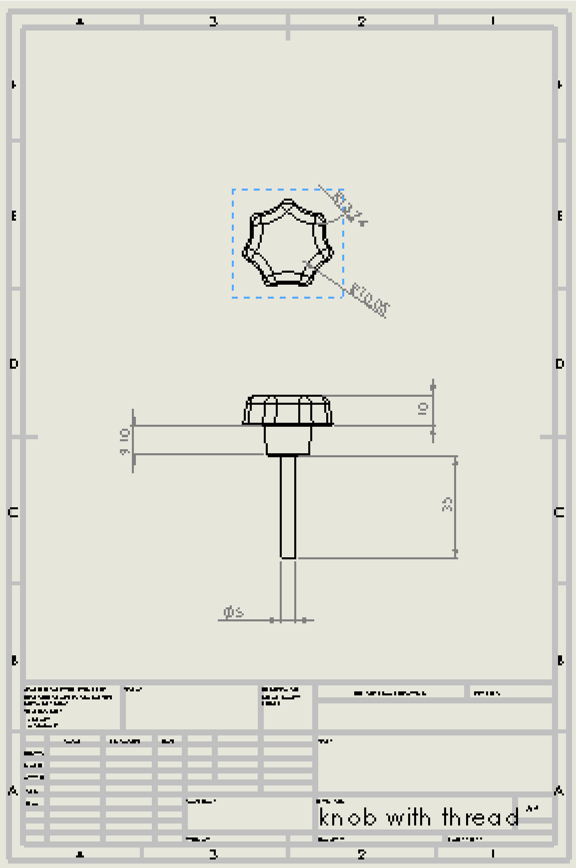



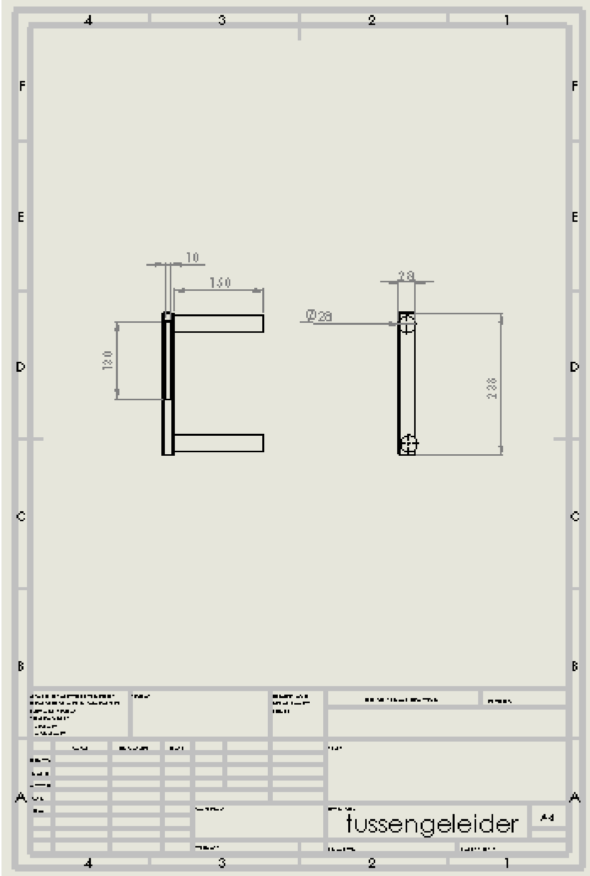

400
tall lower tube

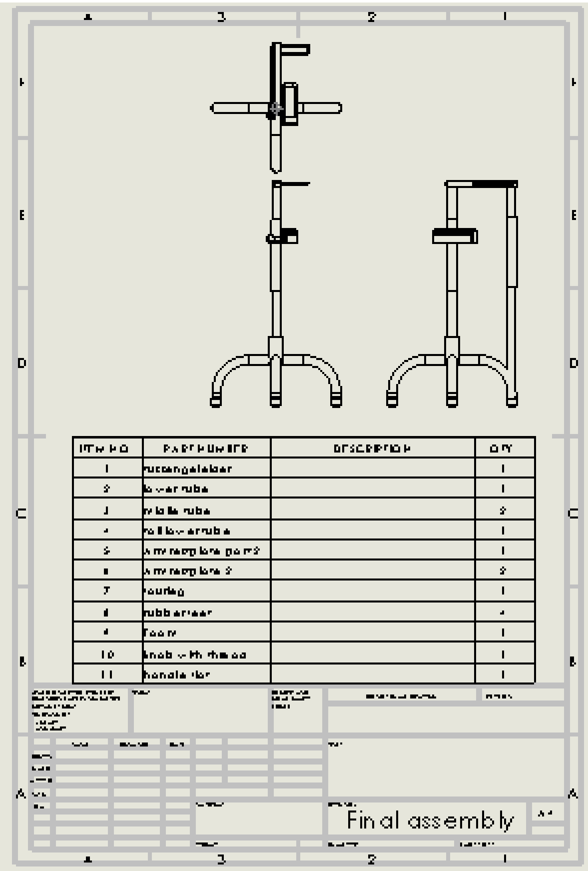

240
Ø30
midlle tube


30
rubberfeet


fourleg


knob with thread
10
35
Ø5


fussengeleider
10
150
120
Ø28
28


Final assembly

## Appendix 9: Questionnaire

**Enquête opstaan met en zonder hulpmiddel**

*Persoonsgegevens*

Geslacht: man/vrouw
Leeftijd:

*Algemene vragen mobiliteit*

Heeft u problemen met het opstaan uit een stoel? Ja/nee

Gaat het opstaan uit een stoel naar u idee langzamer dan het voorheen ging? Ja/nee

*Opstaan zonder hulpmiddel*

Voelt u zich veilig tijdens het opstaan uit een stoel? Ja/nee

Kan u toelichten waarom u zich wel of niet veilig voelt tijdens het opstaan?
…………………………………………………………………………………………………………………………………………
…………………………………………………………………………………………………………………………………………
…………………………………………………………………………………………………………………………………………

*Opstaan met hulpmiddel*

Voelde u zich veilig tijdens het opstaan uit de stoel terwijl u het hulpmiddel gebruikte? Ja/nee

Kan u toelichten waarom u zich wel of niet veilig voelde tijdens het opstaan?
…………………………………………………………………………………………………………………………………………
…………………………………………………………………………………………………………………………………………
…………………………………………………………………………………………………………………………………………

Wat geeft u een veiliger gevoel: opstaan met het hulpmiddel of opstaan zonder het hulpmiddel?
…………………………………………………………………………………………………………………………………………
…………………………………………………………………………………………………………………………………………
…………………………………………………………………………………………………………………………………………

Had u het idee dat u sneller kon opstaan uit de stoel met gebruik van het hulpmiddel?
…………………………………………………………………………………………………………………………………………
…………………………………………………………………………………………………………………………………………
…………………………………………………………………………………………………………………………………………

Zou u dit hulpmiddel aanschaffen als het op de markt verkrijgbaar was? Ja/nee

Kan u toelichten waarom u het wel of niet zou aanschaffen?

# Appendix 10: Test protocol

*Materials*

- Stopwatch
- Two working models
- Chair with armrest

*Preparation*

- Position chair
- Place the models on the armrests
- Install the models on the correct height

*Instruction subject*

- Pull yourself forward, using the handle, until positioned on the end of the seat.
- Push yourself up using the handle until you stand up straight.

*Measuring*

- Measure needed time between: starting the standing up process and standing up straight.

# Appendix 11: Projectplan

## THE DEVELOPMENT OF THE UP&GO

Human Kinetic Technology

## Project plan final thesis

| | |
|---|---|
| Study | Human Kinetic Technology |
| Date | 21-03-2017 |

**Contact information**

| | |
|---|---|
| Name | Simone Gravesteijn |
| Student number | 12106720 |
| E-mail | s.gravesteijn@hotmail.com |

**Study progress**

| | |
|---|---|
| Achieved EC's in modules 9, 10 and 11 | 26 |
| Minor | Product Realization: completed |
| Internship 2 | Completed: waiting on rating |
| Total of EC's besides mandatory program | 9 |
| Outstanding exams (+ module) | Systeemkunde II, module 8 (only written exam)<br>Biodynamica III, module 11 (only written exam) |

**Information final thesis**

| | |
|---|---|
| Title | The development of the Up&Go |
| Work field | Rehabilitation |
| Professional role | Designer |
| External project | SillaPlus via ECBT |
| Contact person | Nil Sancho Comasòlivas |
| E-mail contact person | nilsancho@hotmail.com |

## Table of contents

## Glossary

| | |
|---|---|
| Up&Go | The device that is going to be developed during this project. The aim of this product is to help elderly people stand up from a chair faster and safe. |
| StS | Sit-to-stand |
| RoM | Range of motion |
| CoM | Center of Mass |
| EMG | Electromyography. The electrical activity of the muscle can be measured by this method. |

## Introduction

*Problem description*
Research shows that there are more elderly people right now than there were before. In general by elderly people, people from 65 years and older are intended. One of the reasons that there are more elderly people is that the maximum age that people reach is increasing (Alders & Tas, 2001). With becoming older, increasing problems in ambulation are involved. One of these problems is getting up from a chair. The fact that the group of elderly people is getting bigger, will lead to a greater amount of people that have problems with getting up from a chair.

*Substantiation of the problem*
Getting up from a chair is also known as performing an sit-to-stand(StS) movement. A normal StS movement can be described in different phases. Phase I starts with initiation of the movement and ends before there is no contact anymore between the chair seat and the person. Phase II begins when the contact between chair seat and the person ends, at this moment maximum dorsiflexion in the ankles is achieved. Phase III begins after the maximum dorsiflexion is reached and ends when the hips start to extend: included with extension of the legs and trunk. Phase IV is initiated after hip extension is reached and all the motions associates with stabilization are achieved (Janssen, 2008). As mentioned, standing up from a chair can be a problem for elderly people, the normal StS movement will be adjusted. There are several reasons known why elderly people are having more trouble in the standing up process compared to younger people. Elderly people move slower than younger people during standing up. The Center of Mass(CoM) velocity of several subjects was analyzed during standing up. The result shows that the maximal CoM velocity in horizontal axis is lower in elderly persons compared to younger subjects. At the instant of seat-off the position of CoM was shifted backwards in elderly subjects. (Mourey, Grishin, d'Athis, Pozzo & Stapley, 1998). This shows that the body is positioned differently by elderly persons. The Range of Motion(ROM) in some joints, like the hip joint, increases during the movement of sit-to-stand (StS)(Nonaka, Mita, Watakabe, Akataki, Susuki, Okuwa & Yabe, 2002). That can be one off the causes of the different positioned CoM. Another influence for the problems is the decrease in muscle strength (Burr, 1997)

Besides the reasons that elderly people have problems in getting up that are related to getting older, there are more determinants that have influence on the StS movement. Research shows that the following determinants have influence in standing up: the height of the seat of a chair, if armrest are used and the position of the foot (Janssen, Bussmann & Stam, 2002). There are spring-loaded or electrically operated chairs that influences one of these determinants: the height of the seat. The problem with this kind of products is that they are expensive and it is not easy to take a product like this with you.

Changes in the ability to perform a StS movement can lead to institutionalization, impaired functioning and mobility in activities of daily living, and even death (Janssen, 2008). The growing group of elderly people creates a demand for a product that helps this group to prevent the effects of the problem. The product should help to stand up in a faster way, while having a sense of security by tackling one or more of the summed up causes.

Aim for the project

The company SillaPlus, founded by Nil Sancho Comasòlivas, is a company that focused on active aging and healthy living. They want to create physical devices that can be attached to already existing chairs. They want to facilitate the standing up process, increasing muscle strength, mobility and independence in daily activities. At this moment they are in a start-up phase, they didn't developed products yet. They want to offer a physical product on the consumer market that helps people during the stand-up process, that can be attached on an existing chair. The difference compared to other products they want to achieve, is that the device is easy to carry. By this, the device can be used in different locations by the same user. It can be used in combination with a spring seat, as can been seen in figure 1. For developing such a product they reached out to the study Human Kinetic Technology at the Haagse Hogeschool, to come in contact with students which want to help with the development. Jelles Overmeen is the first student that starts off with this project. Followed by this project, the projects have an overlap of six weeks. The results he gathered in his analyze phase will also be used for this project. The difference in end results of the projects is the product will be suitable for more different sizes of armrests, and thereby suitable for more chairs. His product focusses on one chair, shown in figure 1, that is used a lot in nursing homes. The product for this project will be adjustable so that it is usable for a range of different chairs. The aim of this project is to have a working model and technical drawings of an add-on device that makes the standing up process faster, while having a sense of security. For now the product is going to be called the Up&Go. In cooperation with SillaPlus the assignment will be performed via the ECBT, Expertise Centrum Bewegingstechnologie.

*Target group*

People who have difficulties with getting up from a chair. Mainly elderly people above 65 years.

*Project result*

A design of a physical add-on device, which is usable for a range of chairs, that helps elderly people standing up faster than they do without the device. The device needs to give the users a sense of security.

*Design criteria*

- The product is an add-on device: it will be placed on the armrests of existing chairs.
- The device is focused on the use of the arms while standing up.
- The device can be used by people which experience struggles with standing up from a chair.
- The users has to have arm functions.
- The device can be combined with a spring seat (as can been seen in figure 1).
- The device is not electricity driven.
- The device is transportable.

## Method

The project consist out of four main phases. The phases itself are divided in sub-phases or subjects. Overall a working place and a computer are needed. The working place is available at the ECBT located at de Haagse Hogeschool and a computer is already in possession.

**Analysis**

The first phase of the project consists out of an analysis. The results of the analysis will lead to a list of requirements and wishes. Some requirements are already clear, because these are given by the company or they are already formed by the previous student. The requirements and wishes are needed to design a product suitable for solving the problem. For the analysis different methods are going to be applied:

- Analyzing research ,and obtained results, done by another student.
  The previous student has researched the ideal horizontal position where the hand will be placed on the armrest of the seat. During literature research he found that the leg muscles are the most important during rising from a chair, and also decrease the most in strength during aging (N.A. Lynch, 1999). He performed measurements by using EMG, a forceplate and filming. For the measurements he used a subject which placed his hands in different horizontal positions. He processed the results using the computer program Matlab and Excel. Out of his research he concluded that the most ideal horizontal position for the hand.
- Research about the ideal vertical position of the hand. For this I will use the same methods as the previous student used.
- Anthropometric research using the available data from the TU Delft.
- Own research about the opinion of users from comparable products. Data will be gathered by analyzing the written reviews from comparable products.
- Own research about sale numbers of the most sold chairs worldwide and their dimensions using the internet.

**Designing**

The design phase consists out of several sub-phases:
1. List of requirements and wishes: as result of the analysis phase, the given requirements by the company and the formed requirements by the previous student. Requirements are necessary for the design and wishes are preferable.
2. Brainstorm: finding solutions for the problem, without considering if it is possible to realize the solution and if they meet the list of requirements and wishes. Drawing materials are needed, which are already in possession.
3. Clustering: clustering the found solutions in the past phase. They will be clustered by comparable functions.
4. Designing: with the help of the clustered solutions, several options for a device are going to be designed. Created concepts must meet the requirements.
5. Choose three concepts: the best concepts are chosen with the help of the list of requirements and wishes and own opinion.
6. Form models: for manufacturing form models, foam will be used. The necessary equipment and the foam is available at the study Industrieel Product Ontwerpen. This step is going to be performed to have a realistic reproduction from the concepts. The rating of the cardinal method is going to be easier with models that can be held.

7. Cardinal method & show to company: The cardinal method is going to be performed by giving a certain rate to the wishes. After that, a rating will follow where will be decided which concept does meet the requirements and the wishes the most. Besides this the concepts are going to be shown to SillaPlus with the question to rate the concepts from most favorite to least favorite.
8. Best concept: The combination of the result of the cardinal method and the opinion of SillaPlus will lead to the best concept.

**Construction/ materialization**

Technical drawings will be created by the computer program SolidWorks. SolidWorks is provided by the study itself. The manufacturing of the working model will take place at the study itself and the study Industrieel Product Ontwerpen. Needed machines are available at both places. The needed materials will be purchased.

**Testing/evaluation**

For evaluating the product, two sit-to-stand movements are going to performed by subjects, while filming the movement from a lateral view. One without the device and one while using the device. The filming is going to take place at locations where the subjects live. Materials needed for filming (camera and markers) can be borrowed at the study. The duration of the standing up process will be measured to conclude if the StS movement is performed faster with the help of the device. Besides this angles will be measured with the computer program Kinovea to conclude which situation meets the normal StS movement the most. To be able to measure the sense of security that the subjects experience, an questionnaire will be handed to them. They have to fill this in for the situation without the device and with the device. The results are going to be compared.

## Pre-research

Figure 1 shows a spring chair from the company SillaPlus. This is the chair where the previous student designed his product for. The product that will result out of this product has also have to fit on this chair, besides more chairs.

*Figure 1: Chair with internal spring seat, from the company SillaPlus.*

**Market research**

A market research shows that there are several product available that can be used to make standing up from a chair easier. The function of a market research is to use the positive parts of the design as an inspiration and using the negative parts to get insight what to avoid during designing. The products are categorized and from each category a product is shown in figure 2, the pros and cons are also shown.

| Product description | Figure | Pros | Cons |
|---|---|---|---|
| **Spring seats** |  | + Gives a sense of security of not falling back | - There is no possibility to use the hands while standing up<br><br>- Not easy to carry<br><br>- Probably used in one chair |

| | | | |
|---|---|---|---|
| **Poles** |  | + Hands can be placed in different positions | - Person has to shift to the front of the seat before using the product<br><br>- Needs a lot of space<br><br>- Not easy to carry<br><br>- Probably used in one place<br><br>- Strenght needed in the arms |
| **Support Racks** |  A<br> B | + Person can pull his self to the front of the seat.<br><br>+ Can handle force in different directions<br><br>+ A. Support with both hands<br><br>+ B. can be used with all chairs<br><br>B. light | - Strenght needed in the arms.<br><br>- Not easy to carry<br><br>- A. Can not be used with all chairs<br><br>- B. Support with one hand |
| **Support rack. Help needed** |  | + Light<br><br>+ Support with both hands | - Need help from another person to use the product |
| **Standing up chairs** |  | + Gives a sense of security of not falling back.<br><br>+ Robust<br><br>+ Comfortable | - Usable in one place (not easy to carry)<br><br>- Expensive |

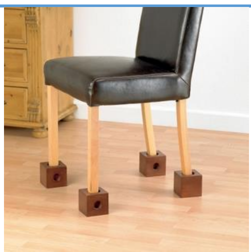
| | | | |
|---|---|---|---|
| **Furniture raisers** |  | + Low costs<br><br>+ Easy to apply | - Probably used in one place<br><br>- No extra support for the hands |

*Figure 2: Market research helping mechanisms standing up from a chair.*

The biggest problem that shows from the market research, as can been seen in figure 2, is that most of the products are not easy to carry because of the size of the products, what means that they will be used in one place most of the time. As SillaPlus did mention, the device needs to be transportable. This is going to be taken in account by processing it in the list of requirements and wishes as a requirement.

## Analysis

*Analyze criteria*

- Literature released before the year 1990 will be excluded from the research.
- Data about the chairs that are sold a lot worldwide can't be older than five years, to make sure that the dimensions of the chairs are still relevant.

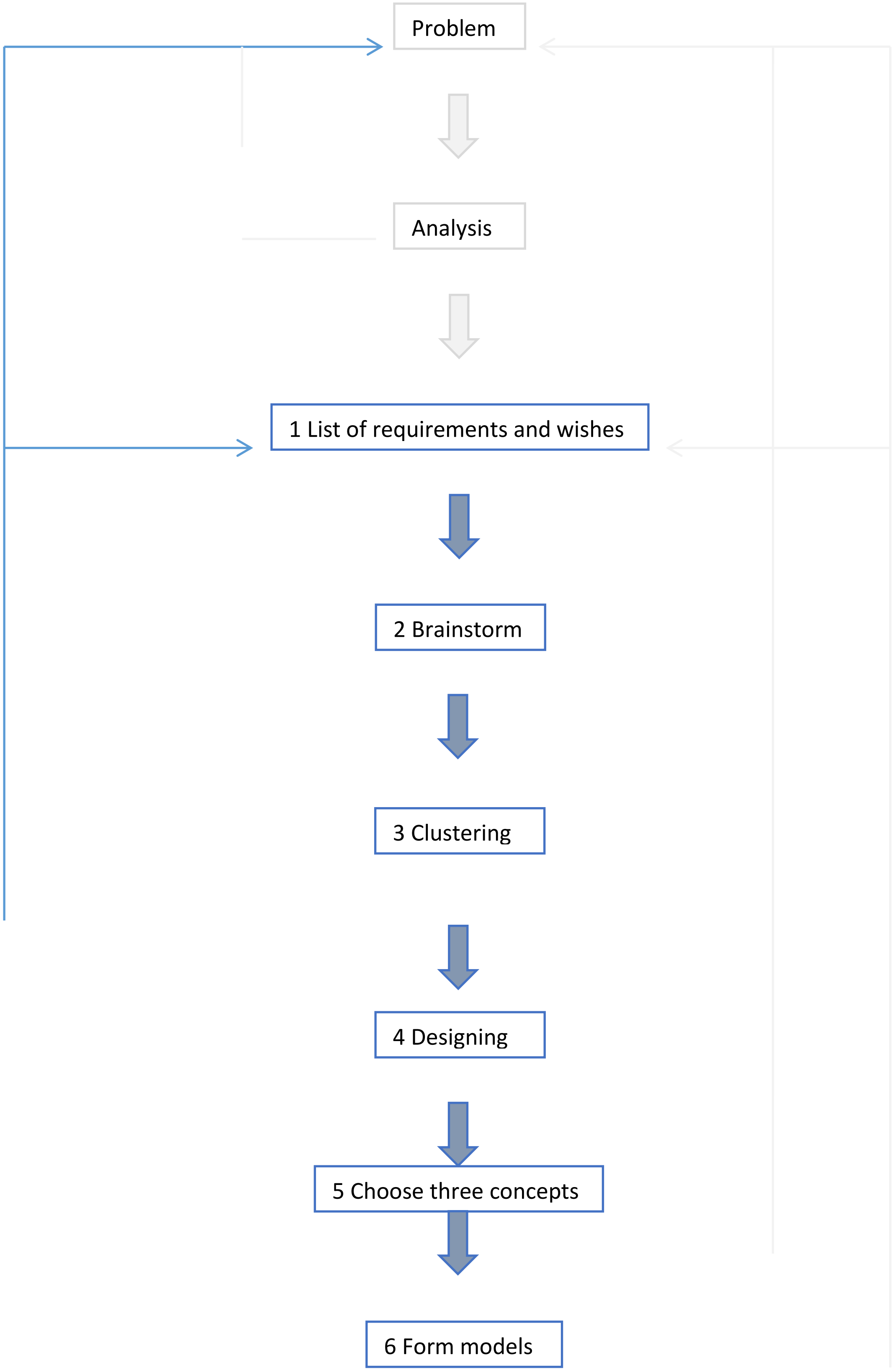
Before a suitable device can be designed, a list of requirements and wishes has to be created which are necessary for a product where all factors have been researched. A list of requirements will follow out of the analysis. Some requirements are already clear, as can been seen in figure 3, because these are told by the company itself. As mentioned before, a big part of the analyze phase is already performed by another student. The results he gathered during his analyze phase will also be used for this project.
The components that will be researched during this phase are shown below, with description how the result will be achieved:

- Which chairs are sold a lot worldwide and what are the dimensions of these chairs?
    - *Action:* perform own research.
    - *Why:* dimensions are needed to determine the measurement of the device.
    - *How:* research using the internet.
- What do people like and dislike about the current comparable products available on the consumer market?
    - *Action:* perform own research.
    - *Why:* to include the opinion from users of comparable products.
    - *How:* this is going to be achieved by analyzing reviews found on the internet written by people which bought comparable products. The most popular results are going to be used to create wishes for the list of requirements and wishes.
- Which muscles are losing strength while aging?
    - *Action:* using the literature research done by previous student.
    - *Why:* to analyze where the difficulties in standing up arises that relates to muscle strength.
    - *How:* analyzing the found literature and results.
- What is the most efficient way to stand up from a chair?
    - *Action:* literature research
    - *Why:* in order to approach the most ideal situation with the device.
    - *How:* literature research
- Which horizontal position of the hand on the armrest of the chair results in the lowest strength needed from the legs?
    - *Action:* using the results of the research done by previous student.
    - *Why:* results are needed to decide how the movements can be improved and are necessary to determine the measurements and placement of the device.
    - *How:* analyzing the research and results and doing literature research.
- Which vertical position of the hand on the armrest of the chair results in the lowest strength needed from the legs?
    - *Action:* own measurements using EMG, a forceplate and filming the standing up process done by a subject. For processing the results the Matlab and Excel script from the previous student will be used.

  - *Why:* to determine what the ideal height for the device is.
  - *How:* performing measurements and processing them. The results will show which positions shows the lowest strength measured in the m. vastus lateralis.
- Which measurements are needed for the device so 98% off the elderly people can use the device properly and comfortably?
  - *Action:* using the results of the research done by previous student, literature research and calculations
  - *Why:* to determine the suitable measurement for a comfortably use of the product for 98% of the population.
  - *How:* analyzing the research and results done by previous student and using anthropometric data available from the TU Delft.
- Which materials are most suitable for this product?
  - *Action:* literature research.
  - *Why:* to decide which materials are the most suitable is for the product.
  - *How:* literature research. A basic research will be done in the beginning of the project. When the final concept is clear, the definitive material will be defined.

## Design

The design phase consists out of several steps. The basic steps are shown in figure 3. The steps are further explained below the figure. The grey parts don't belong to the design phase.



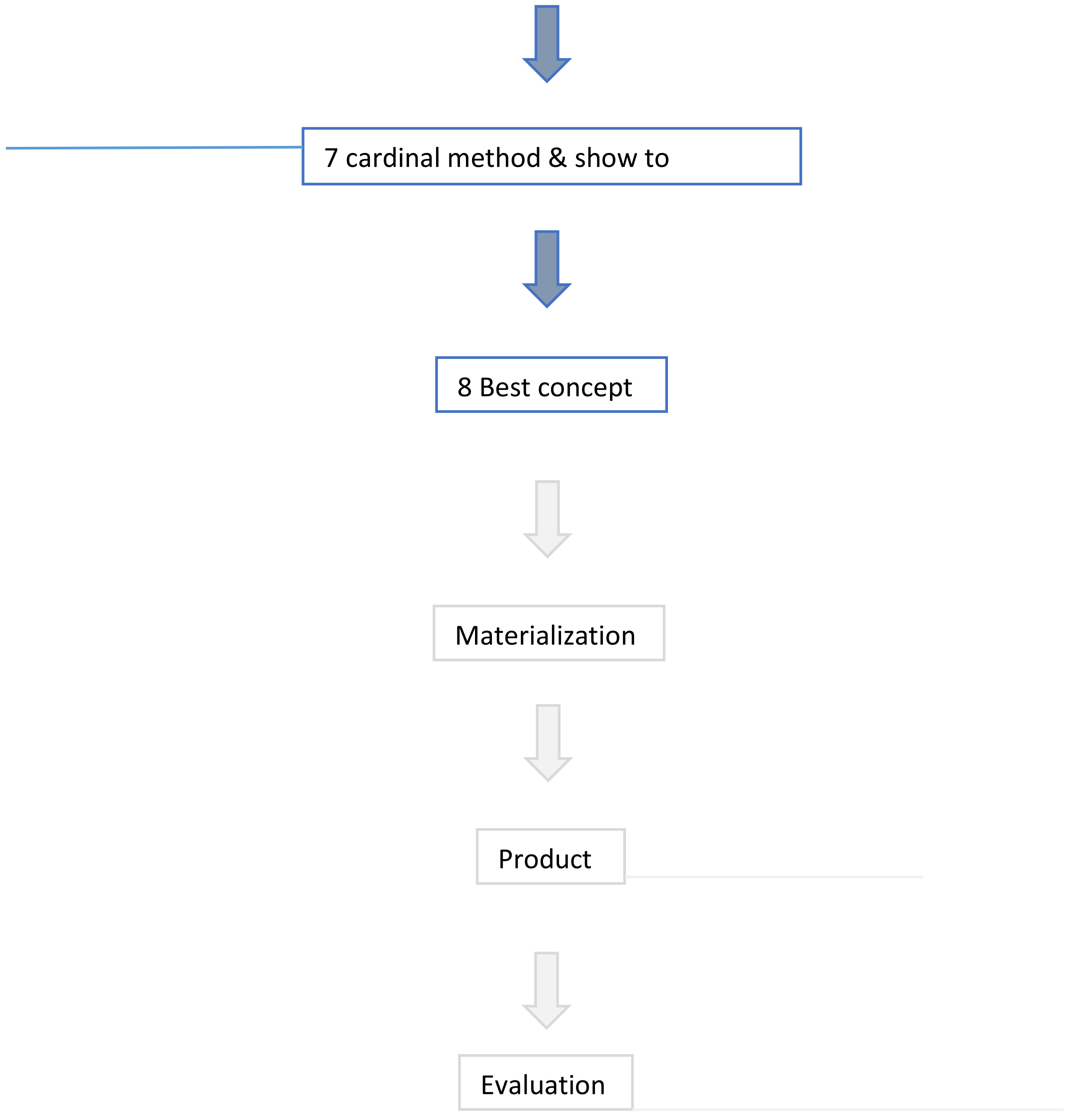



*Figure 3:The design process*

1. *List of requirements and wishes*
   The analysis phase has led to a list of requirements and wishes to design a suitable product. The requirements are most important to the final design. The final product had to meet all the requirements and it is preferable that it will meet as most as possible wishes. Some requirements and wishes are already clear, because these are given by the company. These requirements and wishes are shown in figure 4.

| Number | Requirement |
|---|---|
| 1 | The product is an physical add-on device |
| 2 | The device can be placed on several existing chairs |
| 3 | While standing up with the help of the device, arm strength is used |
| 4 | The device can be used in combination with a spring seat |
| 5 | The device is not electricity driven |
| 6 | The device is transportable |

*Figure 4: Provisional list of requirements and wishes*

2. *Brainstorm*
   In this phase a lot of ideas will be created. In this process there will be no restrictions. If it is possible to realize will be decided in a later phase.
3. *Clustering*
   Parts of ideas will be clustered to create a more specific view and to exclude ideas that are very similar to others.
4. *Designing*
   Using the clustered ideas realistic concepts will be created.
5. *Choose three concepts*
   Out of all concepts the three best concepts will be chosen. This will be based on the requirements and own opinion.
6. *Form model*
   To make sure that it is possible to create to chosen concepts, a model of all the concepts will be created. This will be realized with foam, by this a basic model can be created relatively fast. Suitable equipment for this process is needed. This is available in the workshop of the study Industrieel Product Ontwerpen at de Haagse Hogeschool.
7. *Concepts: Cardinal method & show to the company*
   With the cardinal method will be concluded which concept meets the list of requirements and wishes the most. The concepts are also going to be shown to the company.
8. *Best concept*
   The opinion of the company combined with the result of the cardinal method will lead to the final concept.

As can been seen in figure 3, at some steps in the design process will be gone back to a previously phase to optimize the design.

## Construction

*Technical drawings*
At this point the final concept is clear. The final concept will be drawn using the technical drawing program SolidWorks, which is provided by the study itself.

*Working model*
A working model will be manufactured following the same measurements as the technical drawing. For manufacturing the model suitable equipment is needed. At the study itself and the study Industrieel Product Ontwerpen a workplace is available with most of the equipment.

### Testing and evaluation

The testing phase will be executed using the working model that is manufactured in the process before. For the testing phase are subjects needed, the working model as mentioned, a chair where the product can be attached to and filming instruments. The subjects need to perform a StS movement with and without using the model. By the computer program Kinovea angles will be measured. The difference in angles will be compared with the average angles that are reached during a normal StS movement, to see which situation relates the most to a normal StS movement. The duration of the StS movement will also be measured to be able to conclude if the movement takes less time with the device. The filming will take place by the elderly people at home, this because this is the easiest way for elderly people and the measurement instruments are easy to transport. The data processing will take place elsewhere. To find out whether the subjects are satisfied with the device, and if the device give them a sense of security, the persons have to fill in a questionnaire for both situations.

## Provisional bibliography

1. Alders, M. & Tas, R. (2001, June). Lang leven de ouderen. Retrieved from https://www.cbs.nl/NR/rdonlyres/A1B4D85F-8C92-4199-88F6-4D3DCDFE72B9/0/index1165.pdf
2. Mourey F., & Pozzo, T., & Rouhier-Marcer, I., Didier J. (1997, 31 January). A kinematic comparison between elderly and young sun=bjects standing up from and sitting down in a chair. Retrieved from http://ageing.oxfordjournals.org/content/27/2/137.short#aff-2
3. Mourey, F., Grishin, A., d'Athis, P.,Pozzo, T.,Stapley, P. (1998, 11 August). Standing up from a chair as a dynamic equilibrium task. Retrieved from http://biomedgerontology.oxfordjournals.org/content/55/9/B425.full
4. Janssen, W.G.M., Bussmann, H.B.J., Stam, H.J. (2002, September). Determinants of the Sit-to Stand Movement: A Review. Retrieved from http://ptjournal.apta.org/content/82/9/866
5. Nonaka, H., Mita, K.,Watakabe, M., Akataki, K., Susuki, N., Okuwe, T. & Yabe,K. (2002, June). Age-related changes in the interactive mobility of the hip and knee joints: a geometrical analysis. Retrieved from http://www.sciencedirect.com/science/article/pii/S0966636201001916
6. Burr, B. (October, 1997). Muscle strength, bone mass and age-related bone loss. Retrieved from http://onlinelibrary.wiley.com/doi/10.1359/jbmr.1997.12.10.1547/full
7. Janssen, W.G.M. (2008, October). The Sit-to-Stand Movement. Recovery after stroke and objective assessment. Retrieved from: https://www.researchgate.net/profile/Wim_Janssen/publication/254757523_The_Sit-to-Stand_Movement_recovery_after_stroke_and_objective_assessment/links/0a85e536cdc1d16907000000.pdf#page=15
8. N. A. Lynch, E. J. (1999). Muscle quality. I. Age-associated differences between arm and leg muscle groups. *Journal of Applied Physiology* , 188-194.

## Annex 1: Planning

| Task | project we | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | school week | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | total |
| | date | 6/03-12/( | 13/03-19/ | 20/03-2ε | 27/03-2/ | 3/04-9/0 | 10/04-16/ | 17/04-23 | 24/04-3( | 1/05-7/0ξ | 8/05-14/( | 15/05-21/ | 22/05-2ε | 29/05-4/ | 5/06-11/0 | 12/06-18/06 | | . |
| *Analyse Phase* | | | | | | | | | | | | | | | | | | |
| market research chairs | | | | 5 | 2 | | | | | | | | | | | | | 7 |
| market research current products | | 5 | 4 | | | | | | | | | | | | | | | 9 |
| wishes target group | | 3 | 4 | | | | | | | | | | | | | | | 7 |
| antropometric analysis | | | | | | 3 | 5 | | | | | | | | | | | 8 |
| analyzing project Jelles | | 5 | 3 | 5 | | | | | | | | | | | | | | 13 |
| literature research | | | 5 | 8 | 3 | | | | | | | | | | | | | 13 |
| Analysis placement hands | | | | 10 | 28 | 14 | 5 | | | | | | | | | | | 57 |
| Material research | | | | | | | | | | 5 | | | | | | | | 5 |
| *Design Phase* | | | | | | | | | | | | | | | | | | |
| List of requirements and wishes | | 1 | 1 | 1 | 1 | 1 | 1 | | | 1 | | | | | | | | 7 |
| Brainstorm | | | | | | | 5 | | | | | | | | | | | 5 |
| Clustering | | | | | | | | 4 | | | | | | | | | | 4 |
| Designing | | | | | | | | 10 | | | | | | | | | | 10 |
| Three concepts | | | | | | | | 5 | 4 | | | | | | | | | 10 |
| Foam models | | | | | | | | | 7 | | | | | | | | | 7 |
| Cardinal method | | | | | | | | | 4 | | | | | | | | | 4 |
| Final concept | | | | | | | | | 5 | 7 | | | | | | | | 12 |
| *Manufacturing Phase* | | | | | | | | | | | | | | | | | | |
| Technical drawings | | | | | | | | | | 12 | 30 | 5 | | | | | | 47 |
| Manufacturing working model | | | | | | | | | | | | 22 | 20 | | | | | 42 |
| *Testing and evaluation* | | | | | | | | | | | | | | | | | | |
| Filming | | | | | | | | | | | | | | 21 | | | | 21 |
| Data processing | | | | | | | | | | | | | | 10 | 15 | | | 25 |
| | | | | | | | | | | | | | | | | | | |
| Report | | 1 | 1 | | 1 | 1 | 2 | 1 | 1 | | 1 | 1 | 1 | 2 | 6 | 7 | | 26 |
| Presentation | | | | | | | | | | | | | | 2 | 10 | | | 12 |
| Deadlines! | | | | | | | | 20/04 Tc . | | | | | | | | 14th june Toets B | | . |

## Annex 2:
## Personal learning goals graduating phase

Academic advisor: Jorine Koopman
Signature:
Date: 20-12-2016

| **Personal learninggoals** |
|---|
| **Learning objective 1**:<br>**Perform a complete design process**<br>I'm able to complete a full design process from start to end with a working model and technical drawings as end result. |
| Focus/ Problem:<br>No experience in following a complete design process independently. |
| Cause:<br>Used to perform little parts of the process because of group work and limited time for projects. |
| Symptom:<br>In group projects everyone performs the part of the project they are experienced in. So a lot of times the same activities are executed. |
| Learning goals:<br>- Extend knowledge of a design process.<br>- Extend knowledge in analyze techniques.<br>- Extend knowledge about manufacturing techniques.<br>- Apply manufacturing techniques. |
| Actions:<br>- Gain more knowledge about design processes by reading literature about this topic.<br>- Gain more knowledge about analyze techniques by reading literature about this topic and perform measurements.<br>- Gain knowledge about manufacturing techniques by reading literature about this topic.<br>- Make a sufficient planning where enough time is planned for learning and for the manufacturing.<br>- Manufacture a working model. |

| |
|---|
| **Learning objective 2:**<br><br>**Independence and management**<br><br>I'm able to independently carry out the project. If in doubt, help will be asked from a teacher. I will be able to implement all the components required for the graduation project within the given timeframe. |
| Focus / problem:<br>No experience in having the responsibility to initiate a similar project independently. When in doubt about a particular part of a project, the student may linger longer than is desired. |
| Cause:<br>Inexperienced and insecurity of the student. |
| Symptom:<br>Incur delays in parts of the process. |
| Learning goals:<br><br>- Maintain overview about the project.<br>- Continue to work on schedule.<br>- Ask for help if in doubt from a teacher or another professional. |
| Actions:<br><br>- Create a schedule and continue to work by this.<br>- Take notes after consults.<br>- Ask questions to teachers or other professionals if in doubt. |
| |
| **Learning objective 3:**<br>**Communication**<br>I'm able to communicate properly in English and deliver a report in professional written language. |
| Focus / issue:<br><br>Did not develop professional writing skills. |
| Cause:<br><br>No experience in writing English for study. Only followed college in Dutch. |

| |
|---|
| Symptom:<br><br>Reports written in basic English. The same words are repeated a lot of times because of limited vocabulary. |
| Learning goals:<br><br>- Professional English writing skills. |
| Actions:<br><br>- Write everything in English during the graduation project. Even if the notes are only for myself.<br>- If I don’t know a specific word, I will look this up by internet. |

# Appendix 12: Personal learninggoals

Academic advisor: Jorine Koopman
Signature:
Date: 20-12-2016

| Personal learninggoals |
|---|
| **Learning objective 1**:<br>**Perform a complete design process**<br>I'm able to complete a full design process from start to end with a working model and technical drawings as end result. |
| Focus/ Problem:<br>No experience in following a complete design process independently. |
| Cause:<br>Used to perform little parts of the process because of group work and limited time for projects. |
| Symptom:<br>In group projects everyone performs the part of the project they are experienced in. So a lot of times the same activities are executed. |
| Learning goals:<br>- Extend knowledge of a design process.<br>- Extend knowledge in analyze techniques.<br>- Extend knowledge about manufacturing techniques.<br>- Apply manufacturing techniques. |
| Actions:<br>- Gain more knowledge about design processes by reading literature about this topic.<br>- Gain more knowledge about analyze techniques by reading literature about this topic and perform measurements.<br>- Gain knowledge about manufacturing techniques by reading literature about this topic.<br>- Make a sufficient planning where enough time is planned for learning and for the manufacturing.<br>- Manufacture a working model. |
| Own evaluation:<br>I found this more difficult than expected. It is hard to brainstorm about things with other people while there not that much in the project as I am myself. It was way bigger than I expected. However, I learned a lot during this project. |
| |

| |
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| **Learning objective 2:**<br><br>**Independence and management**<br><br>I'm able to independently carry out the project. If in doubt, help will be asked from a teacher. I will be able to implement all the components required for the graduation project within the given timeframe. |
| Focus / problem:<br>No experience in having the responsibility to initiate a similar project independently. When in doubt about a particular part of a project, the student may linger longer than is desired. |
| Cause:<br>Inexperienced and insecurity of the student. |
| Symptom:<br>Incur delays in parts of the process. |
| Learning goals:<br><br>- Maintain overview about the project.<br>- Continue to work on schedule.<br>- Ask for help if in doubt from a teacher or another professional. |
| Actions:<br><br>- Create a schedule and continue to work by this.<br>- Take notes after consults.<br>- Ask questions to teachers or other professionals if in doubt. |
| Own evaluation:<br><br>It was hard to perform everything on time. Especially because I had a few side projects. It was the first time I worked alone for such a long time. At the end of the project it went way better than the beginning. |
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| **Learning objective 3:**<br>**Communication**<br>I'm able to communicate properly in English and deliver a report in professional written language. |
| Focus / issue:<br><br>Did not develop professional writing skills. |
| Cause:<br><br>No experience in writing English for study. Only followed college in Dutch. |

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| Symptom:<br><br>Reports written in basic English. The same words are repeated a lot of times because of limited vocabulary. |
| Learning goals:<br><br>- Professional English writing skills. |
| Actions:<br><br>- Write everything in English during the graduation project. Even if the notes are only for myself.<br>- If I don't know a specific word, I will look this up by internet. |
| Own evaluation:<br><br>I still have a lot to learn in professional English. I notice I'm faster than I was in the beginning of the project in writing in English. |