

REMOTE WORK & GOOD ERGONOMICS

Degree Project for Bachelor of Fine Arts in Design
Main field of study Industrial Design

By Mette Bruun Bager
Spring 2022



LUND
UNIVERSITY

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2022

ISRN-number - LUT-DVIDE/EX--22/50582-SE

ABSTRACT

Based on the recent years of home working, this project is an examination of our home workplaces, to optimize the human posture and include good ergonomics in future static remote work. With an experimenting approach, I explore the possibilities of designing a dining chair with simple adjustments to transform the chair into a work chair. The purpose is to design a multifunctional chair that increases the risk of developing strain injuries when working remotely in the home.

ACKNOWLEDGEMENTS

This project was carried at the School of Industrial Design at Lund University. Thanks to all of the supervisors, Anna, Charlotte, Claus and Jas. Especially thanks to Claus for supervising and motivating me trough the entire project.

A thanks to all my classmates such as friends and family in Denmark. Without your always postive energy and peptalks this project (and education) would not have been completed.

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BACKGROUND

The past two years we have all been forced to work from home due to the pandemic, Covid 19. The personal motivation for this project has its origins in my own experiences and issues with the remote working. As a human living in a small apartment I have not had the opportunity to install a home office. Due to this, my primary work place has been the dining table, sofa or even the bed. During static work from bad ergonomic furnitures has resulted in physical pain in the lower back and neck.



*Am I the only one experiences these issues?
How will our work flow be in the future?
What is good ergonomic sitting positions?*

The remote working has come to stay. I'm wondering how we in the future can decrease the risk of developing strain injuries when working from home. I assume that many people do not have the opportunity to install a home office with good ergonomic furnitures.

In this project I investigate our home work space and its possible issues, to subsequently design a solution for the future that provides and protects the human against the develop of body injuries when during static remote work.

METHODS

The entire process is based on the design thinking method and the double diamond design process. The project has been developed through a continuously conductive and inductive work flow, including sketches, mock-ups and tests.

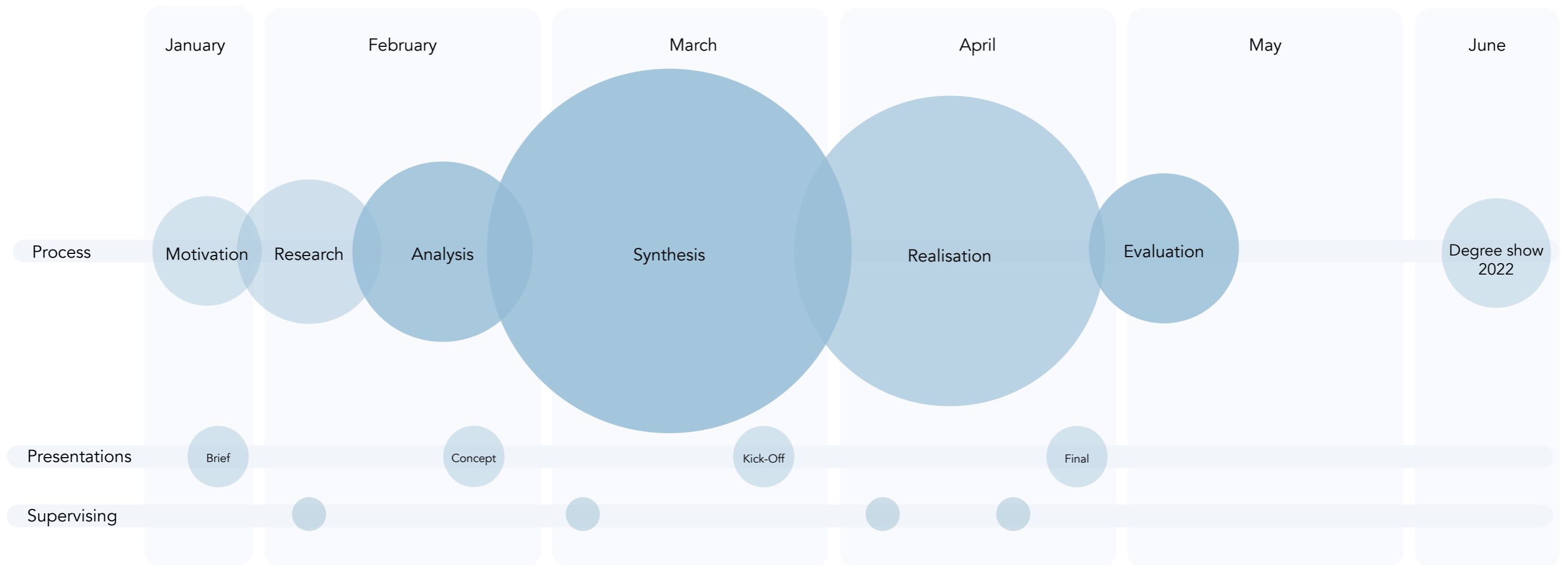
The research and analysis is build on a collection of quantitative and qualitative empiri. Articles and reports have been used to understand the situation of the future remote work and its possible issues. To include the user, a quantitative questionnaire and a collection of photo material was conducted to illuminate the situation and needs.

Qualitative empiri from interviews of expert persons have been included to illuminate the topic. A physiotherapist, was involved to confirm the data and apply ergonomic suggestions for the project. A cabinet maker, was involved in an early stage of the research to clarify important aspects of the design and manufacturing of a chair. Personas have been developed to limit and specify the needs of the final solution.

The ideation and synthesis parts have been created from methods such as mindmapping, brainstorm, sketches and tests.

The project is developed with the focus on the philosophy "Human-centered design". To design a product providing good ergonomics, the user have been involved for usability testing to illuminate pros and cons of the product throughout the process. Achieved feedback have been used for the refinement of the design and function.

TIMELINE



MOTIVATION



RESEARCH

INJURIES & REMOTE WORK

To collect data about strain injuries due to the remote work an initial research was initiated. Articles, reports and statistics confirmed the hunch of an issue with physical pain due to bad ergonomic sitting positions and less breaks during home work.

“Many have worked for months from the dining table and sofa on a laptop and this provides a very locked working position”.

Tina Lambrecht, Chairman of Danske Fysioterapeuter¹

Physiotherapists across the world reports about an increase of numbers of injuries caused of the remote work. Most injuries are located in back, neck, hips and arms. In June 2020 a study from “Dansk Magisterforening”², based on 1200 respondents, showed an increment of 57% work injuries due to the remote work.

¹ Danish union for physiotherapists.

² Danish union for employees.

THE FUTURE WORK SPACE

Based on articles and studies its expected to include the remote work day in the future, since it provides flexibility for the employees. In addition to that, the companies reduces the real estate costs not having full time workspaces for all employees. On a bigger perspective the remote work can reduce the environmental pollution by not having employees travelling back and forth to an office every day.

A study from Deloitte, based on 800 respondents across the world and industries, shows that 36,1% of employees in the future will work 50% remotely. Related to the percentage pre-covid this is an increment on 93%.



GOOD ERGONOMICS AND STATIC WORK

A research of good ergonomics were conducted to get more insight and knowledge about the topic and to understand why the remote work have caused an increment of strain injuries.

Demarcation; The research is done with the focus on an average human size and shape. The difference of the human anatomy has not been included.



An ergonomical goal for the static sitting position is to strive for a straighten back and neck. A repetitive back arch can result in permanent strain injuries. The angle of the hips needs to be at least 90 degrees or more to reach a good blood circulation and to make it easy to straighten the lumbar and back. In addition to this, a support of the lower back will force the human to straighten the back. The neck should be kept straight as well as the back. This can be obtained by placing the work equipment in an

appropriate height and distance. The elbow should not be more than 90 degrees to prevent a damaging tense of the muscles.

“The best posture is your next posture.”

In addition to the physical positions - movement and movability are an important aspect when talking about good ergonomics. Breaks and movability through the work day can prevent strain injuries as the body will not be tensed and locked in the same position for long periods of time.

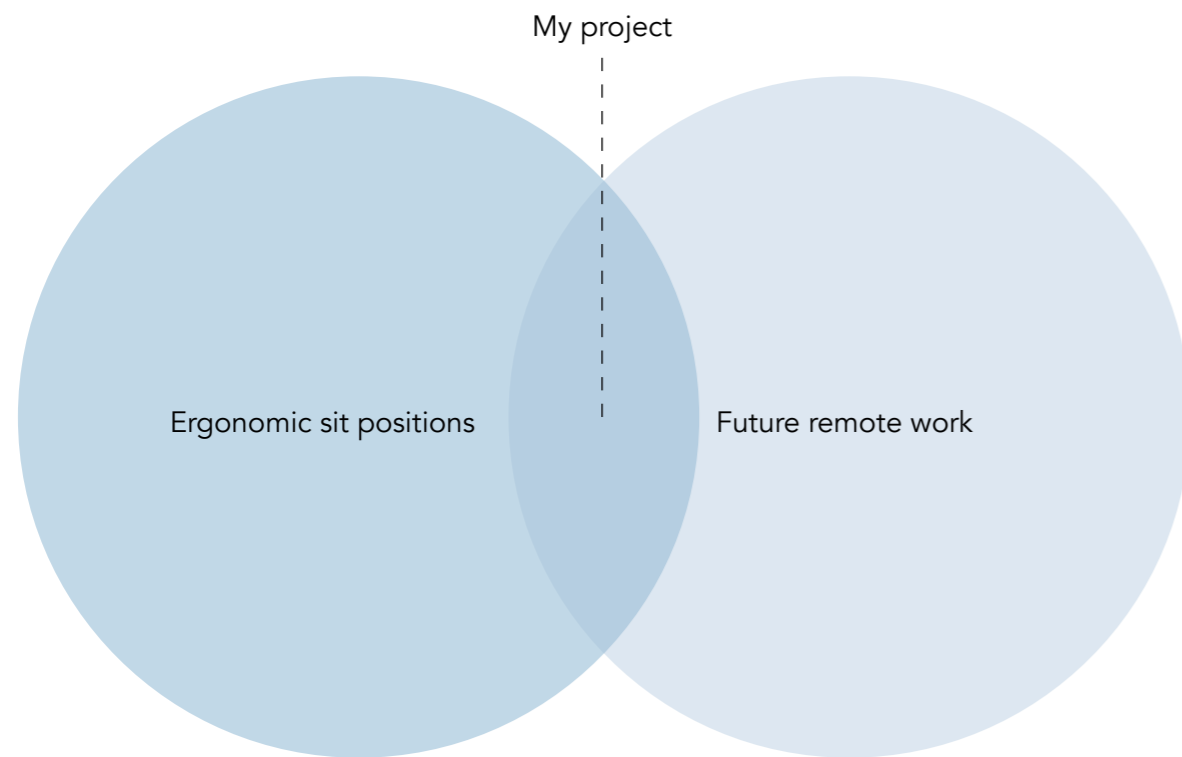
HOW DO WE LIVE?

The average floor area in EU is according to European Commission, 42,56 square meters per human. On a global point of view, the area has only increased the last 15 years. This is caused by the positive development of countries, such as a higher income and need for more privacy in our home.

In addition to this, over the last couple of years we have seen a raising popularity of scaling down the needs of a home by building tiny houses and live on a minimum amount of square meters. In 2017, the amount of tiny houses sold was increased with 67% compared to 2016.

For ethical reasons this should be the future of living. Less space also means less square meters to heat and less need of products which will have a positive impact on the pollution.

SUMMARY



REFLECTION

Based on the research the world needs a solution to solve and prevent bad ergonomic sitting positions when working from home. Otherwise, the increment of strain injuries will continue as we will continue the remote work in the future.

The solution must fit into the average home, which contains 42,6 squaremeters per person. The increment of humans living in less space will naturally have an impact on the amount of products needed in the home and the functionality of the products will be high prioritized.

INITIAL BRIEF

With the focus on good ergonomics how is it possible to design a multifunctional sitting furniture that decreases the risk of developing strain injuries when working from home?

TARGET GROUP

The main target group is humans doing static remote work without having the possibility to install an office in their home.

ANALYSIS



EMPIRI

QUESTIONNAIRE

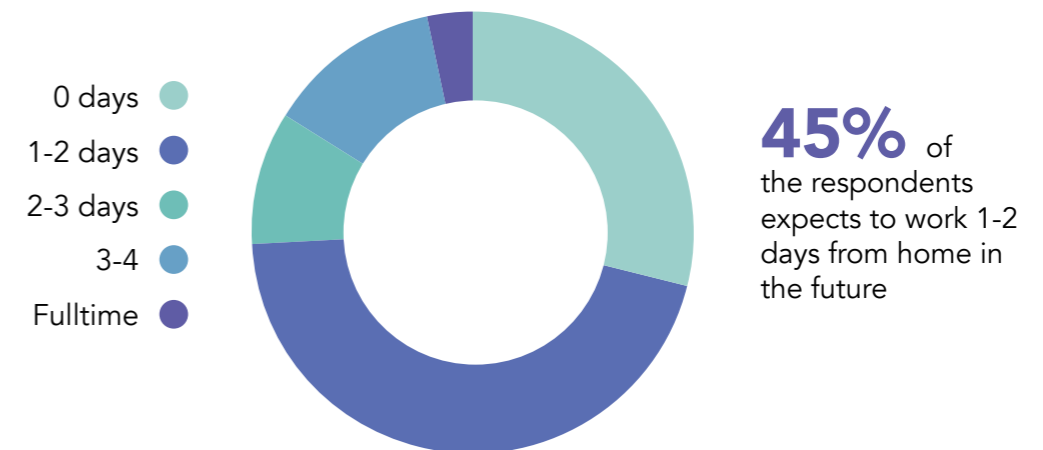
A questionnaire was conducted to research the actual issue and needs of the target group. The respondents were aged from 20-69, all genders and working in different industries.

The respondents answers substantiated the data from the research. 45% of the respondents expects to work remotely 1-2 days a week in the future.

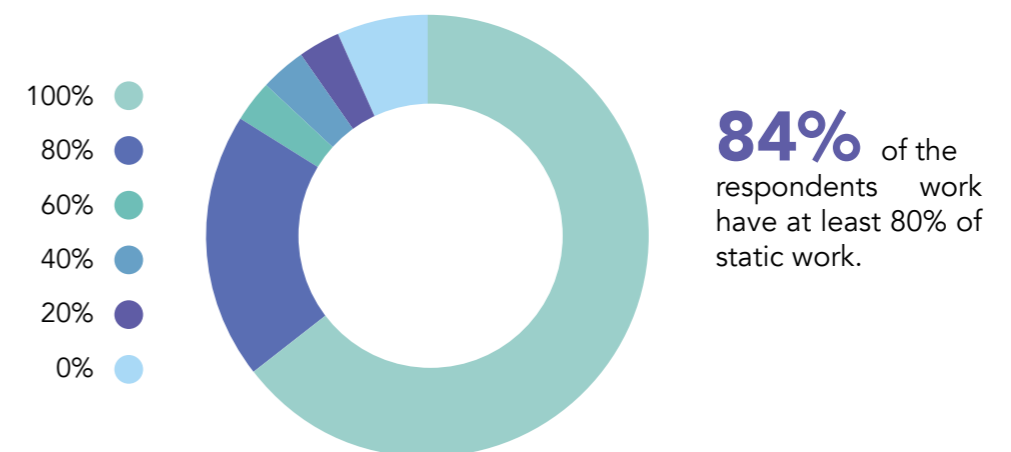
Asking the respondents about their experiences with body pain or injuries caused of the remote work, 51% commented about pain especially in the lower back, neck and shoulders. The primary location and sitting furniture have been the dining room table and a dining room chair.¹

¹ Link to entire questionnaire https://docs.google.com/forms/d/1HGD-juUzKhc53HKSYHOj9Vb2X_SLiRnfrRfLZuAQkVY/edit#responses

How many days do you expect to work from home in the future?

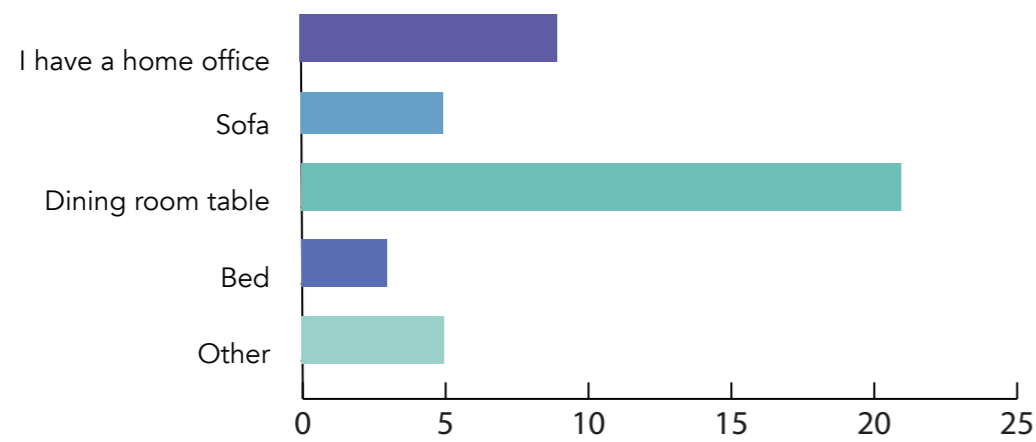


How much of your home work consisted of static work?

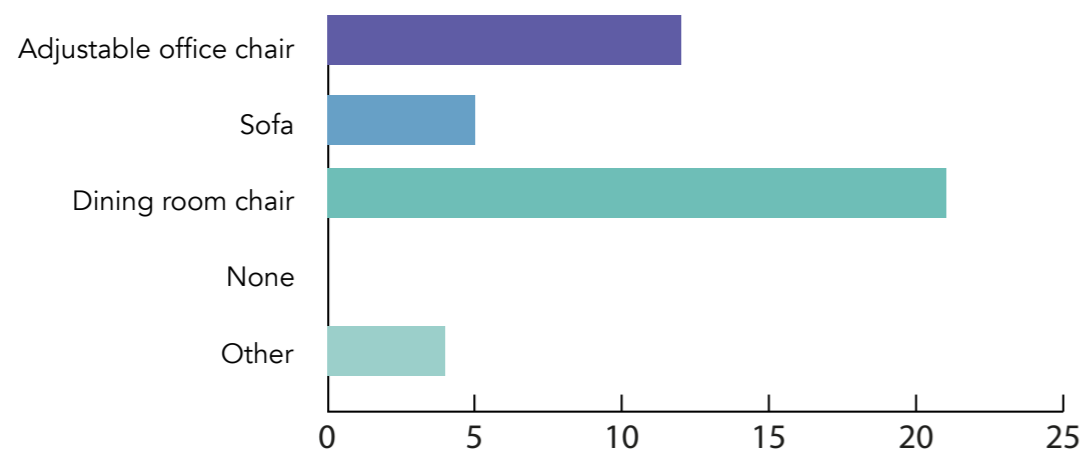


QUESTIONNAIRE

Which location in the home have you primarily worked from?



What is/have been your primary used sitting furniture?



Have you experienced physical pain / injuries due to homework?
If so, which ones?

"Increased pain in the lower back and cold feet".

"Pain in the lumbar, back and shoulders".

"Yes, enormous tension in the back/neck/shoulders".

51,6% of the respondents have experienced body pain cause of the home work.

Most important features in an office chair?

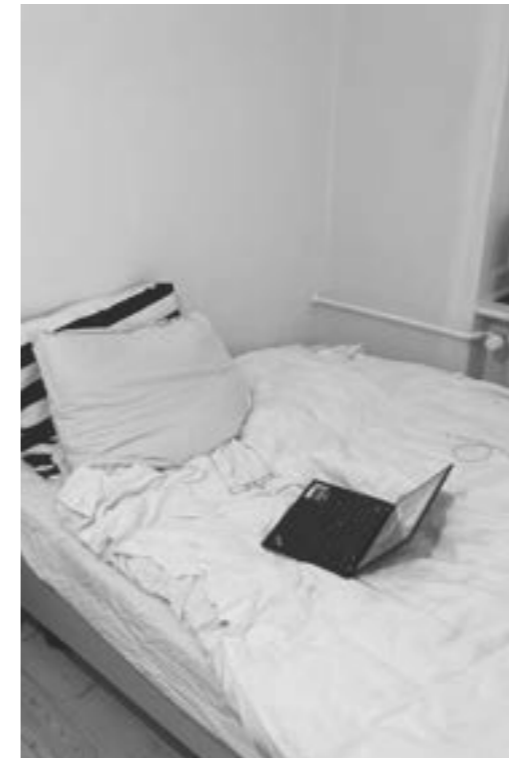
- Adjustable seat height
- Support of lower back
- Adjustable back rest
- Chair with wheels

”SHOW ME YOUR HOME WORK SPACE”

To get more insight of the target groups behavior and choice of remote work space, 20 new respondents were asked to show a picture of their home work space including the sit furniture. To the right is shown a selection of the collection of the respondents personal work stations.

The data collection showed that only 5% of the respondents uses an ergonomic sitting furniture; an adjustable chair. To improve the need of a better sitting position, some respondents has been adding cushions or paddings at the furniture to achieve a better support of the lower back or a softer seat. Also a hybrid and movable work space was represented.¹

¹ Referring to [Appendix A](#) for a collection of all photos.



MARKET ANALYSIS

DINING ROOM CHAIRS

An analysis of dining room chairs from the 19th century contributed a great impression of the prioritized features based on the shapes. A select of the different chairs is shown at the bottom page. Referring to [Appendix B](#) for a collection of all used photos.

The typical shape of a dining room chair has a back leaned seat, support of the upper back while some chairs provides armrests.

The standard measurements for the dining chair are a seat height of 450 mm and a 10 degree backward angle between the seat and backrest. The optimal incline for the seat is 3 degrees backwards.

Although, the chairs come in a variety of different looks, materials, budgets, constructions etc., the shape and purpose is designed to achieve a relaxing and comfortable sit position. From the analysis, this is a back leaned, unformal body posture.



OFFICE CHAIRS

An analysis based on office chairs from the 19th century was conducted to clarify the similarities, differences and main features. A select of the different chairs is shown at the bottom page. Referring to [Appendix C](#) for a collection of all used photos.

An unexpected aspect was the low amount of chairs providing support for the lower back or lumbar, which is an important feature to prevent good ergonomics. Only the professional chairs includes this feature. The similarities for all represented chairs was the adjustable height, the swivel function and the wheels. The wheels requires a lot of space, which could be an essential aspect for the user when prioritizing space for it in the home.

Based on the material and shape of the high-end office chairs the majority could be compared with a dining room chair. The function of providing support of the lower back and a back leaned seat, fits more to the dining chair needs than the office chair.



MAIN DIFFERENCES

The analysis clarified one main difference; they provide two different functionalities.



The need for a dining room chair is to sit comfortable at the dining room table while eating, conversing or similar.

- Provides support of upper back
- Back leaned or flat seat
- Invites to a relaxed sit position
- High focus on aesthetics

Risk of strain injuries when used for a longer period of time e.g for static work.



The need of an office chair is to ensure an ergonomic sit position while doing static work by providing adjustable features.

- Provides support of the lumbar
- Adjustable to fit all bodies
- Focus on ergonomics

Can be used as a dining room chair but requires lots of space around the dining table

REQUIREMENTS AND NEEDS

FUNCTION ANALYSIS

Comfortable dining room chair	MF
Ergonomic work chair	N
Intuitive transformation	N
Adjustable seat	N
Adjustable back support	D
Adjustable seat height	D
Adjustable armrests	D
Enable movement	D

ENVIRONMENT

The environment for the sitting furniture is home work space at the dining room table.

SUMMARY

DEFINED BRIEF

“How is it possible to design a dining room chair that intuitively can be transformed to a work chair and provide ergonomic support of the body while during static work?”

SPECIFIED TARGET GROUP

The specified target group is defined as humans living in small homes not having the opportunity to install a home office for remote work. The target group are aged from 20-35 years old, all genders and from the western of the world.



PERSONAS



Peter, 24

Student
Working from home 2-3 days a week.
Monthly income 800 euros

Living on 16 km² in a college. The home is arranged with a work desk, a cabinet and a bed. When Peter has visitors, the primary sit furniture is his one chair at the desk or the bed which in that case is used as a sofa.

Interests
Social life, board games, sustainability & sport.



Anna, 33

Employee, HR manager
Working from home 1-2 days a week.
Monthly income 5500 euros

Living in a 58 m² flat in the city with her husband and their one year old child. Anna uses the dining room table or the sofa for her remote work. Due to the size of the home it is not suitable for installing a permanent home office.

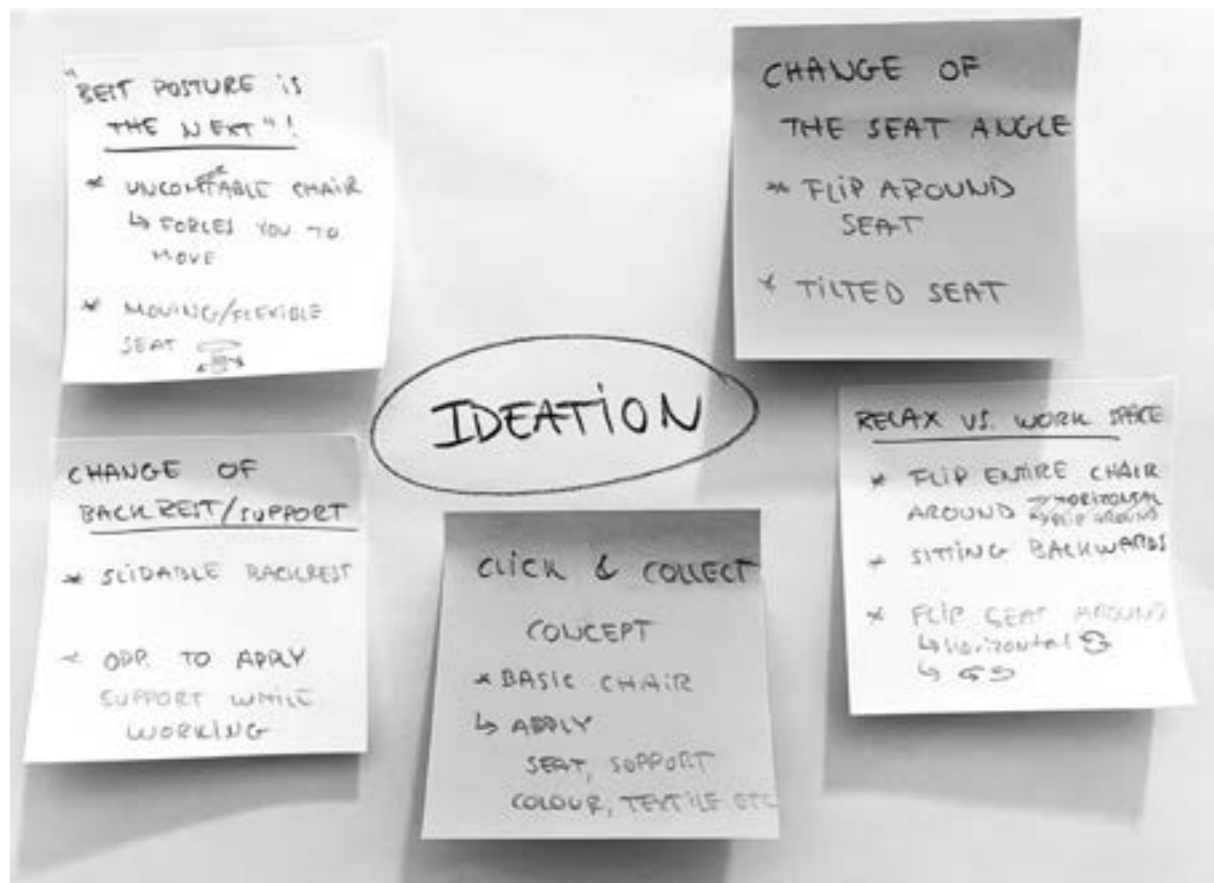
Interests
Yoga, healthy food & interior.

SYNTHESIS



IDEATION

The developing of ideas and concepts where conducted with a brainstorm and sketching sessions.



CONCEPT 1

BODY MOVEMENT

Based on the quote "the best posture is the next posture", this concept provides a flexible seat that achieves movement of the body while during static work. Movement makes is intuitive for the user to keep a straight posture. The body will automately be forced to keep the balance when using the chair.

The continuously movement indicates a risk of squeezing parts of the body. This issue should be reconsidered since a possible accident is a non-acceptable aspect for the product.



Rotating seat enables movement



Tilt the seat back and forth



CONCEPT 2

CHANGE PARTS

Concept no. 2 is inspired of the idea of sliding, rotating or applying parts of the chair to achieve a transformation from a relaxing dining room chair to an ergonomic work chair.

Flipping the seat around and sliding the back support will be a simple action for the user and will transform and obtain the different needs of the chair.

The solution should be further developed to eliminate the risk of squeezing parts of the body when adjusting the seat and back rest.



Flip/rotate the seat and backrest around

FURTHER DEVELOPMENT CONCEPT 2

An physical test of concept 2 was conducted by creating a full scale mock-up to explore the functionality and different sit angles.

The main issue is the feature of only being able to change the seat angle in two different degrees. The angle of the work chair providing a good support and angle for the back and the hips while the relaxing position was too back leaned and not comfortable.

Considerations; How to easily change and adjust the angle of the seat in more levels? How to make it safe in use?



Static work position

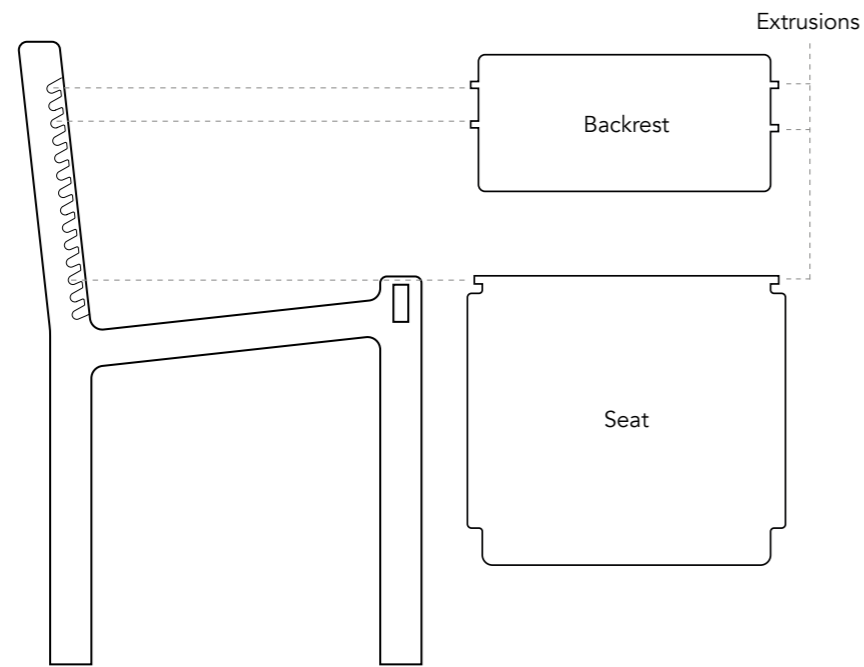


Relaxing position

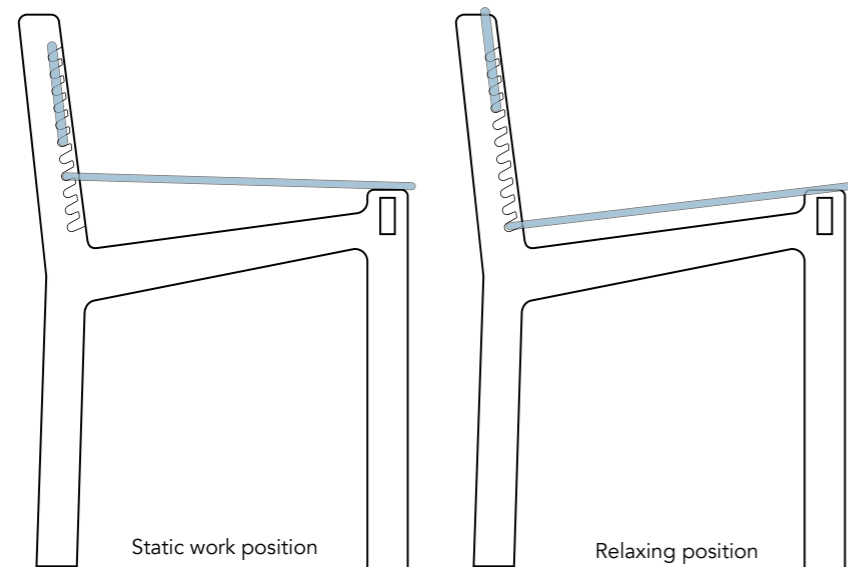


NOTHCES

A simple shaped chair with notched in the back leg. These acts as temporary "fixing-points" for the seat and back rest.

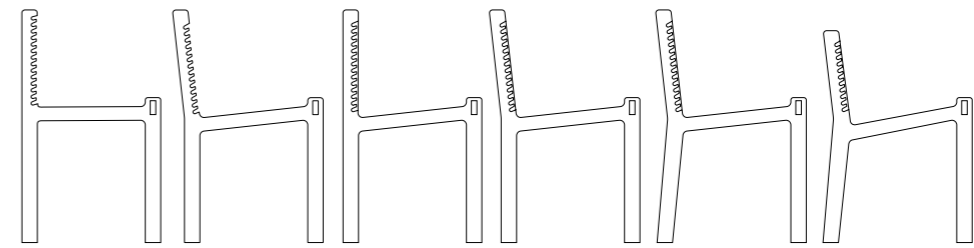


By using different notches, the movable seat and backrest can be adjusted in the height and angle.



VARIATIONS

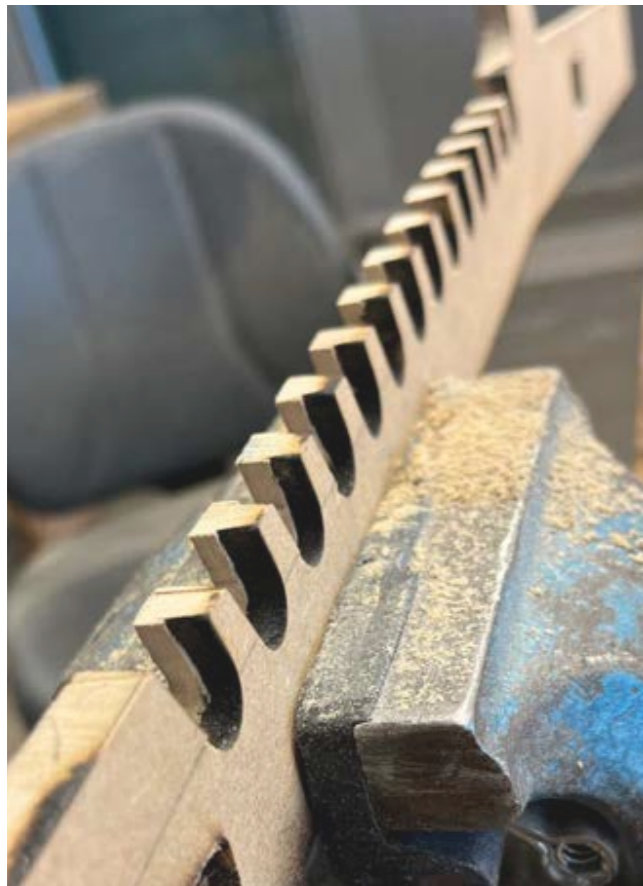
Different variations of the back leg design was developed to explore the aesthetics and the optimal sit angles.



Quick 3D modelling to show the overall visual concept

3D MODELLING SCALE 1:1

A full scale mock-up was produced to explore and test the concept and mechanism.



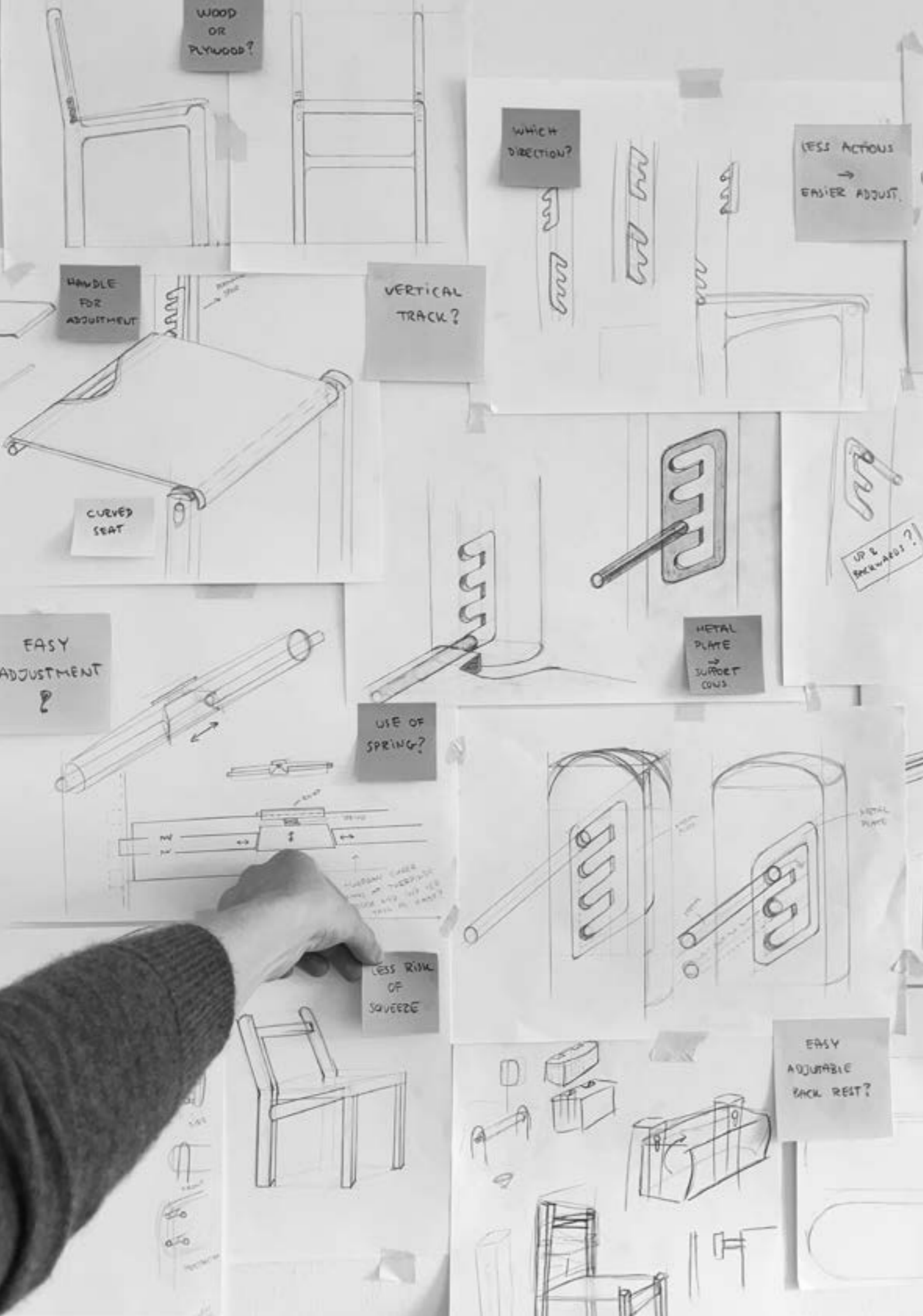
USER TESTING

User testing were conducted to investigate how the target group acted with the chair and if they were able to understand and adjust the features intuitively. To obtain diversity in the tests, the users were selected from different variables such as gender, height and body size. The result of the user testing was defined in pros and cons:

- + Size of the backrest
- + Sit height
- + Need of four different sit positions (angles)
- + Intuitively to understand

- Risk of squeezing body parts
- The backrest is difficult to adjust
- Edges needs a better finish
- Missing feedback after adjustment
- Missing lock mechanism





REFINEMENTS BASED ON RESULTS

A new ideation session was conducted based on the new knowledges and considerations from the user tests. The specific focus point in this stage was to design a safe adjustment of the seat.

The mechanism was developed from an unsafe free notch system to a locked system, containing of a vertical track with diagonal notches milled in each of the back legs. The seat will be fixed permanent to the back legs which prevents is to fall out of the position.



LIMITATION

The result of the user testing showed a minimum need for an adjustable height of the backrest. The construction of the chair as well as the placement of the backrest also posed a risk of squeezing the hand when adjusting the position.

Based on the above ideation session the further development was limited to a fixed backrest. To prevent an arch of the back, the focus has been to design a shape of the backrest that includes a support of the lower back when using the chair in a work situation.

DESIGN OF THE SHAPE 1:5

Different shapes of the seat and backrest were developed. A downscale measurement of the construction of the chair reduces the risk of squeezing body parts when adjusting the seat.

A combination of functionality and aesthetics has been in focus in the design of the shapes. To ensure an aesthetic uniformed chair, the seat and backrest are developed in pairs.

On the following pages three design concepts are being presented. The concepts are based on the overall shapes and mechanism of the product. CMF is for further development.



CONCEPT A

Concept A is a simple cubic design. Curved edges are applied for both aesthetic and functional reasons. The curved edges will provide a comfortable sitting position for the user and create a finished look to the shape. The 3D model is designed to be manufactured in ash wood.



A vertical track with diagonal notches in the back legs creates the mechanism for adjustment of the seat.

CONCEPT B

The design of Concept B is based on an oval shape of the backrest and seat. Two horizontal lines are created at the adjacent edges of the parts to create a uniform design language. The backrest is assembled to the construction with metal pegs like the adjustment mechanism underneath the seat. The 3D model is designed to be manufactured in ash wood.



The backrest is placed in a low height to ensure support of the lower back when used in work situations.

CONCEPT C

The organic shape of the seat and backrest are designed to protect the human body. The lower arc on the backrest is shaped to support the lumbar in a work situation. A cushion is applied on top of the seat to ensure a soft and comfortable sitting position. The 3D model is designed to be manufactured in plywood



Raised seat to ensure a straighten back.

CONSIDERATIONS

From the three developed concepts, Concept C showed the best potential for further development. The organic shape of the backrest and the seat, which is shaped after the human body ensured the needed functions for the chair.

Due to the fact that the measurements of the construction was compromised in a former stage, the seat will be used as grip for adjusting the seat angle by changing the notches. This solution will cause a main issue in another act of use; moving the chair. When moving the chair by pulling the seat, the seat will then be unfixed and in risk of falling down. Therefore, a new lock system is needed to fix the seat to the legs and provide a safe use.

In addition to this, the seat must also be fixed to the front legs to eliminate the risk of squeezing the body. This issue will be solved later in the process.

In the further development I choose to continue with Concept C.

NEW LOCK SYSTEM

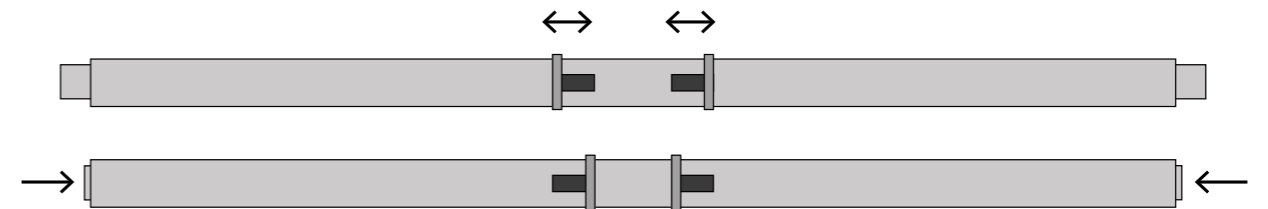
The new mechanism is a vertical track consisting of four deeper notches inside, placed in each back legs of the chair. When not using diagonal notches for the action the system will be with less steps (and interactions) by only releasing and moving the seat up and down.

A metal component fixed underneath the seat constitutes the lock mechanism. Pulling the two handles together a spring forces the metal component to compress and the seat releases from the fixed position in the legs. The seat can be adjusted in the height by moving the seat up or down using the handles.

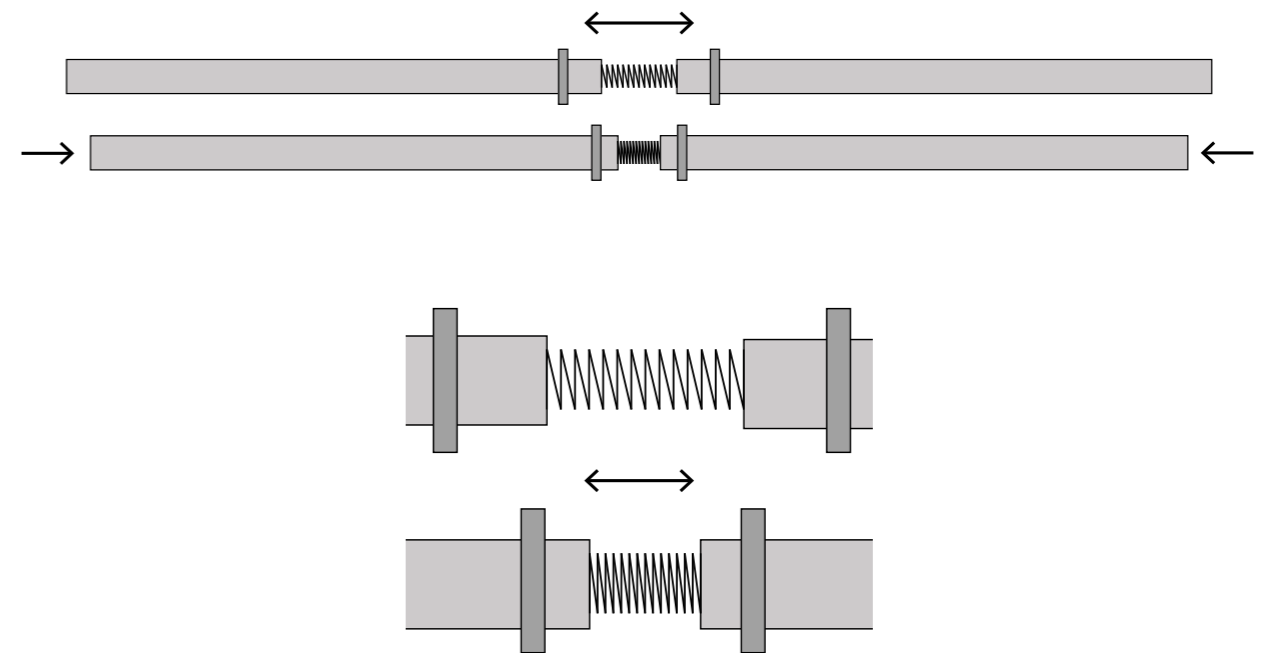
This mechanism creates a feedback for the user by making a sound when the spring bounces back and the metal stick is forced into a new notch.



An outside metal pipe keeps the spring and metal sticks as one unite. The milling tracks and the handle on the metal sticks keeps all parts together and creates the correct distance from notches and track.

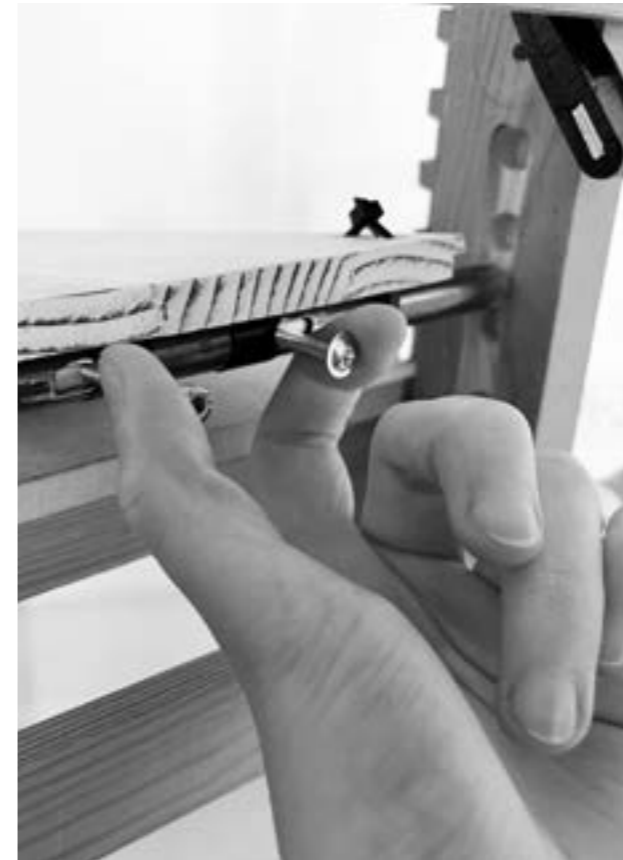


A spring placed between the two metal sticks forces the sticks inside the cylinder when squeezing the two handles.



TEST OF MECHANISM

A mock-up of the new mechanism was developed to understand it further and clarify the pros and cons.



- + Feedback is obtained
- + Safe lock system
- + Easy to use
- + Intuitive to understand

- Maybe difficult to use in sitting position
- Backrest can be in the way for the hand for adjustment
- Seat must be fixed to front leg
- Metal cylinder should run inside the vertical track

PERMANENT FIX OF THE SEAT

To minimize the risk of squeezing parts of the body between the seat and the front legs, a mechanism was developed to fix the seat to the legs.

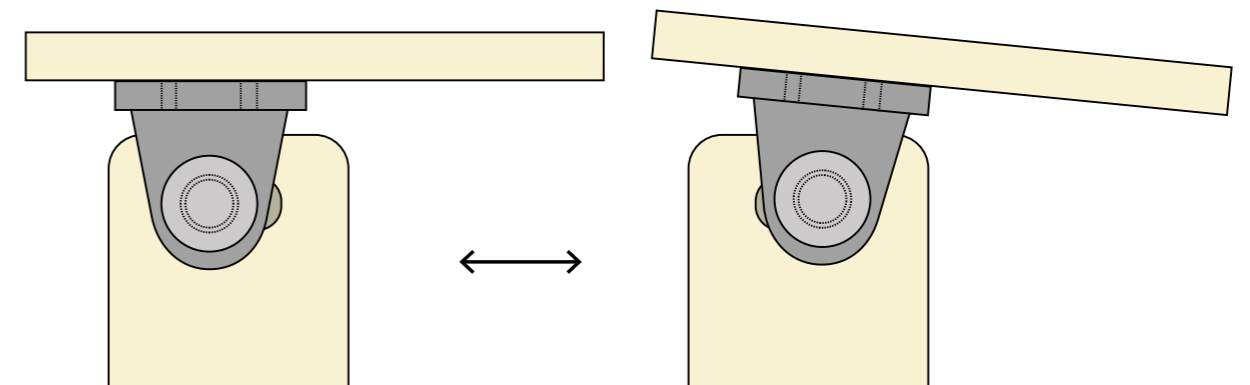
When adjusting the sitting angle the seat must be able to move back and forth as the turning point of the seat changes. This means, that the mechanism requires a movability in both the x and y-axis.

The solution consists of a vertical track milled inside each of the front legs, brackets fixed underneath the seat and special designed screws to assemble the parts. By only having treads in the first part of the screw the last part can run back and forth in the milled track when adjusting the angle of the seat.

Using this mechanism will minimize the risk of squeeziness significantly since the seat is fixed to the construction of the chair. Although, a smaller risk is still represented between the seat and the front legs. Due to the timeline of the project, I decided to use this mechanism in the further development.



A visual of how the bracket and the screw will be positioned when it is assembled to the front leg.



When adjusting the seat angle, the bracket and screw will run back and forth in the vertical track milled inside each front leg.

REALISATION

FINAL RESULT

The final result is a transformable dining chair with an adjustable seat to provide a relaxed and ergonomic sitting position depending on the situation of use.

The legs are angled to strengthen the construction of the chair and to make it possible to have an aesthetical dimensioned seat. The shape of the back rest provides a support of the upper back while using the chair in a back leaned position. The lower part of the back rest will support the lower back, when the seat is raised to a front leaned position.



DETAILS



The chair shown in a back view. The metal pipe ensures a stable seat and keeps the inside parts together.



The inside mechanism consists of two metal sticks and one spring. A handle is assembled to each stick. The spring is placed between the sticks which makes it possible to squeeze the sticks together to release the seat from the contemporary fixed position in the back legs.



The seat and the metal pipe are assembled with metal plates.

ACTIONS

ANIMATION



The animation shows how the seat can be adjusted in different angles.



SQUEEZE

Squeezing the handles together by using one hand will release the seat from the fixed position in the back legs.



ADJUST

The handles are moved up or down to adjust the seat and sitting angle.



RELEASE

Release the handles to fix the seat in the wanted position.

SCENARIOS



A dining room situation. The seat is positioned leaned back to provide a comfortable and relaxed sitting position for the user.



The static work situation. The raised seat ensures a great ergonomic angle of the hips when during static work. The lower part of the backrest forces the user to straighten the back to avoid an arch of the back.



MATERIALS

An initial selection of the materials. To achieve a strong construction of the chair solid ash wood is chosen. The decision is based on the material properties, since ash wood is a strong but still resilient material, which is a benefit when used for furniture. A lot of force is placed inside the vertical tracks in the legs, which will cause in wear of the wood material. To ensure a long lifetime an aluminium plate/offset is placed on the inside surface in each track. The metal offset will protect the wood against wear.

Steel is used for the adjusting mechanism, to be able to weld the components together. The spring is produced in steel. The material must be able to do an elastic deformation when forcing the spring to compression.

An upholstery fabric and a foam are applied on the wooden skeleton of the seat to obtain a soft and comfortable sitting surface. A more specific choose of foam, color and material of the fabric is for further development.

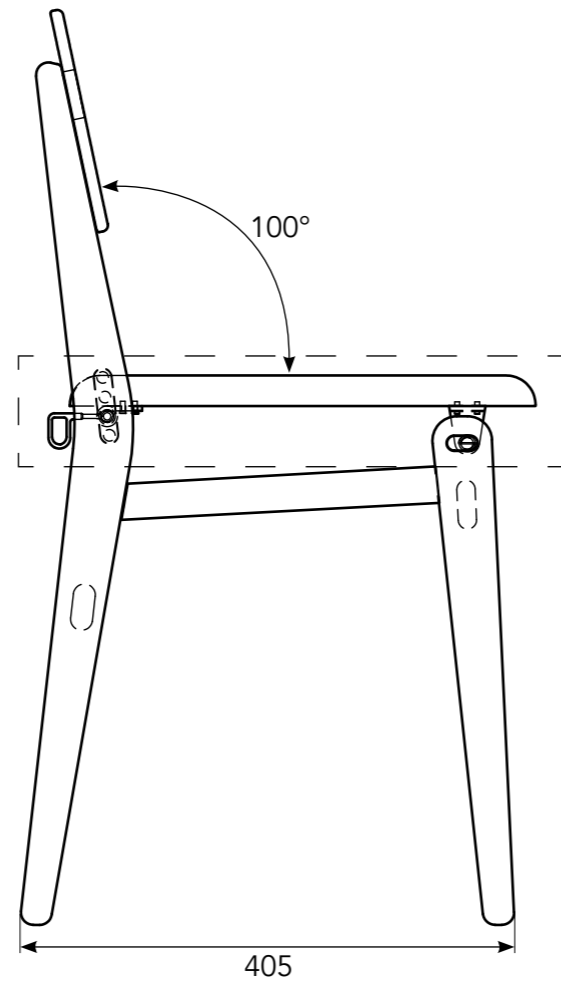
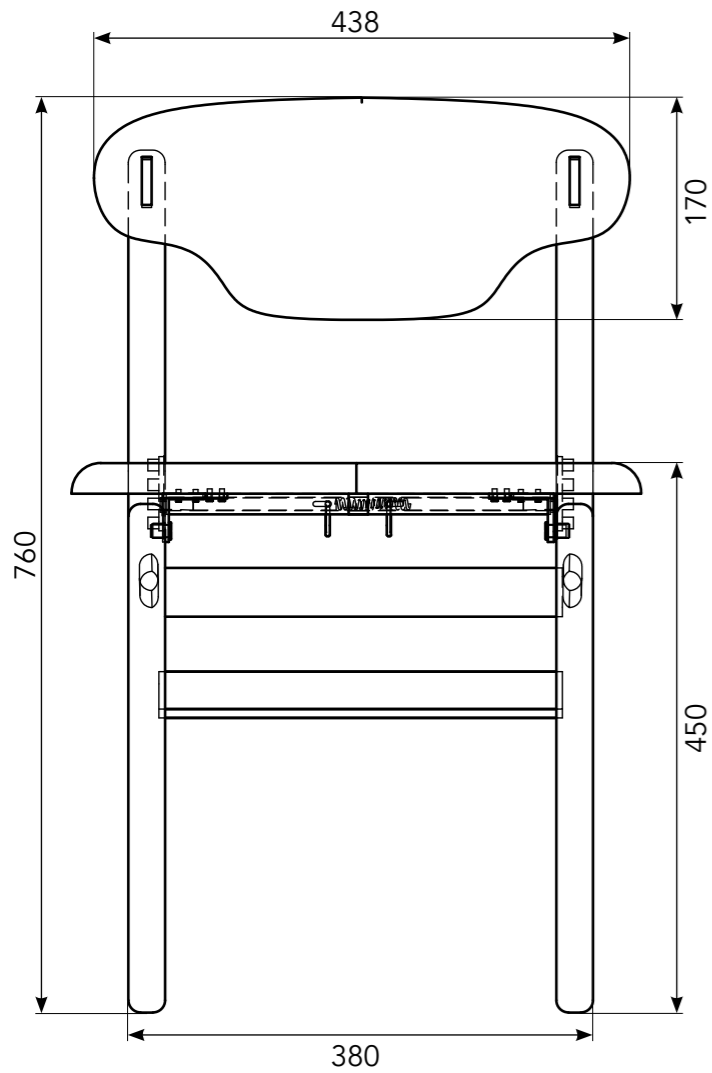
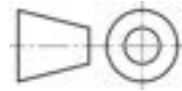
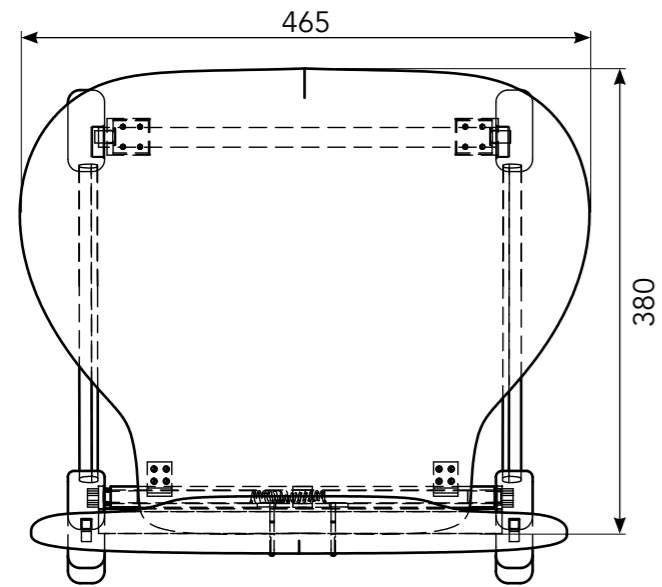
Add overview photo

MANUFACTURING

The number of parts used to manufacture the chair are 22 excluding the screws to assemble the seat to the adjusting mechanism.

The wooden parts are glued together while the metal parts are welded together. Screws are used to fix the parts together. The legs are CNC milled.

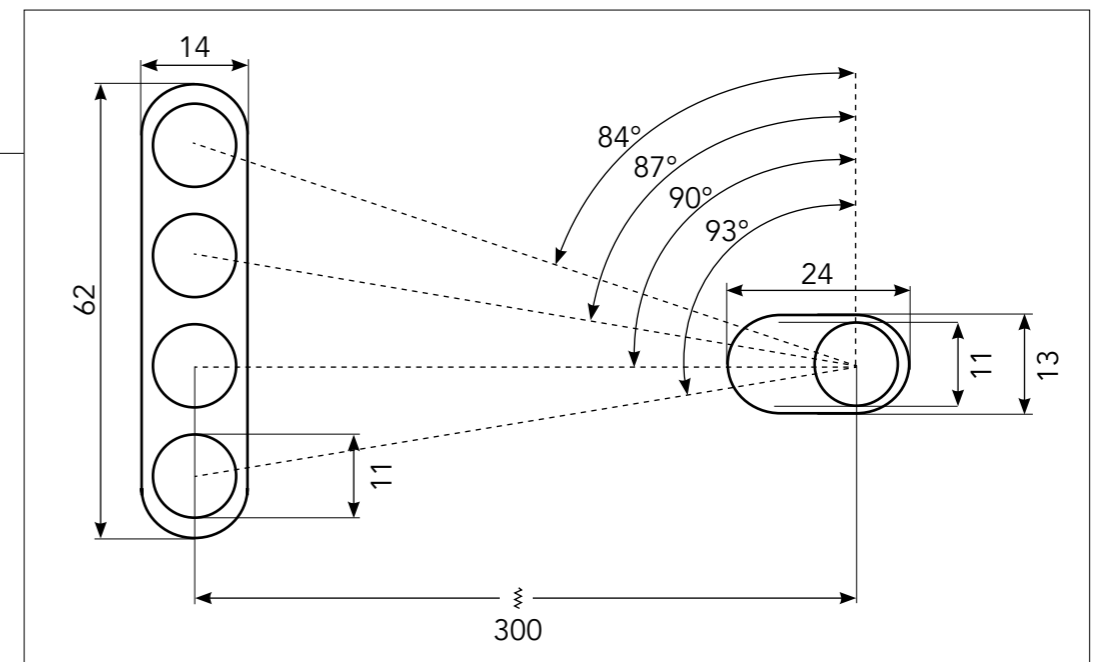
From an economical perspective, the different components should be refined to fit standard measurements. This would lower the price of the manufacturing process. The use of ash wood can be locally produced in Scandinavia which is an economical and sustainable benefit.



TECHNICAL DRAWING

The size of the chair is based on the standard measurements for a dining room chair. The angle of the seat is 100 degrees backwards to achieve a comfortable position for the human back.

The sitting height is 460 mm in a zero-degree position and can be fixed in four different angles. The adjustment is three degrees per fixing point, which has been tested to ensure the needed angles.



FURTHER DEVELOPMENT

A physical prototype should be developed to test the final construction and the adjustment feature. A user test should be held to explore if the measurements and angles fits the human body and provides good ergonomical sitting positions.

A general refinement of the CMF should be prioritized in the further development to upgrade the aesthetic aspects such as the design of the shape, color of the fabric, a curved backrest, details, finish, etc.

REFLECTION

Reflections over this project (and former design projects) has resulted in a better understanding of me as a designer. The choose of a complex brief, losing my motivation and at the end, downscaling the ambitions due to the deadline has again been my way of working. When starting this project, it was my ambition to keep up the motivation and follow my time schedule to make it possible to have enough time to focus on the aesthetics and complete the project with a satisfying (and physical) prototype. As a fact, I often stock in the ideation stages - maybe because this stage is what drives my passion and motivation.

In general, I feel that this project has parts that is not connected as it should. The choose of material should be connected to the target group (economical, aesthetical etc.), the different components should be connected to easy manufacturing, the ergonomical part should be better tested etc. This has been down prioritized or forgotten, due to my high focus on the adjusting mechanism.

Related to that, I am happy that I included a physiotherapist and a cabinetmaker in the beginning of the process such as an engineer for the development of the mechanism. I have learned how important it is to include experts and how it should have been done more continuously through the process. This could have given me more time to focus on the CMF and the focus on creating a coherent project.

I am sure, the brief could have been solved in an easier way. Due to the time schedule and mentally motivation I am happy about this project.

It has been a learning full process and I believe it will be useful for further reflection about me as a designer - My strengths and my weaknesses.

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Litterature

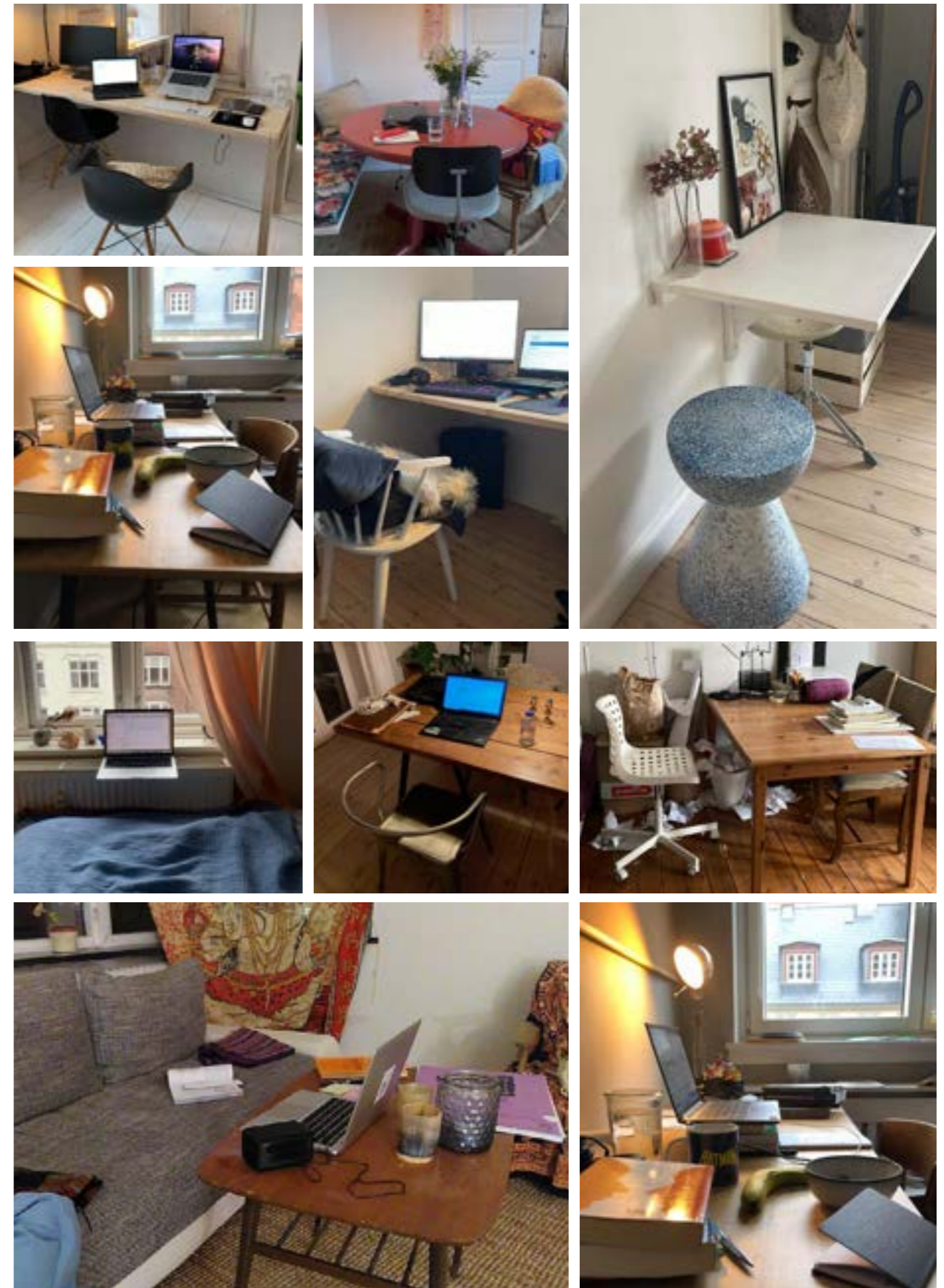
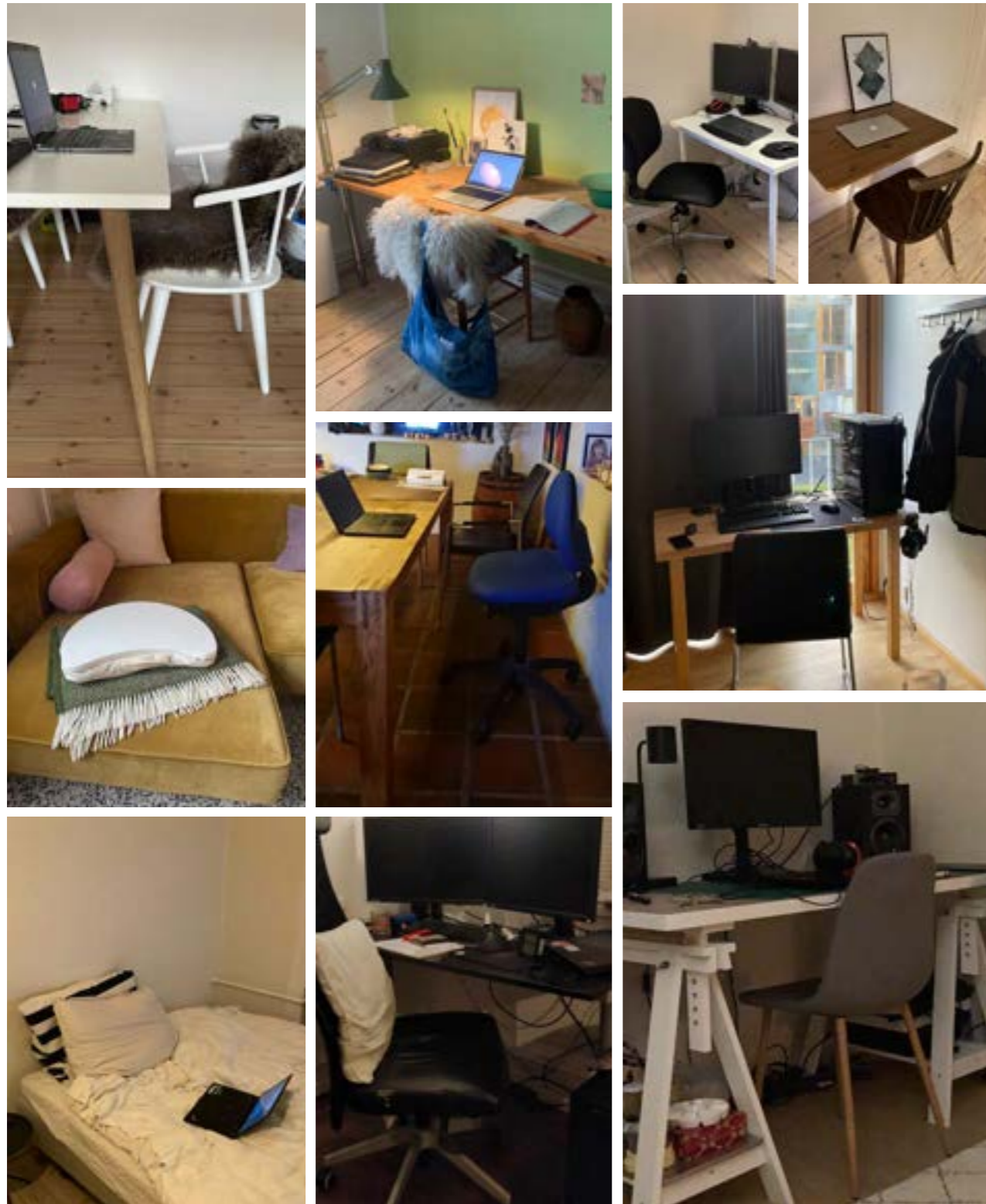
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APPENDIX A

A collection of all collected photos from the research



APPENDIX B

Market analysis of dining room chairs

Romantic



Classic



Unique



Mainstream



Low budget



APPENDIX C

Market analysis of office chairs

Low budget



- Low quality
- Affordable materials
- Minimum of features/support
- Designed for the mob

High end



- Leather & chrome material
- Exclusive look
- High quality and price
- Minimum of features/support

Professional



- Focus on adjustabilities
- Maximum of features
- Extra support
- Light/breathable material

Ergonomical



- Focus on legs and hip angle
- Enables movement
- Focus on a straight posture



LUND
UNIVERSITY

Degree Project for Bachelor of Fine Arts in Design

Main field of study Industrial Design

By Mette Bruun Bager

Spring 2022