IDC School of Design
अभिकल्प विद्यालय

IIT Bombay

DEP 703 - Project 3

DESIGNING A COMPACT WHEELCHAIR FOR MND-ALS PATIENTS

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Guide: Prof. Purba Joshi

APPROVAL

This is to certify that Industrial Design Project - III (P3) entitled **“Designing compact wheelchair for ALS/MND patients”** by **Pranay Dilip Gurumukhi** is approved in partial fulfillment of the Master’s Degree of Industrial Design at IDC, Indian Institute of Technology, Bombay.

Project Guide: 

Chairperson: 

Internal Examiner: 

External Examiner: 

DECLARATION

I declare that this written report represents my ideas in my own words. Where others' ideas or phrases have been included, I have adequately cited and referenced the sources.

I also declare that I have adhered to all academic honesty and integrity principles and have not falsified, misinterpreted, or fabricated any idea, data, facts, or source in my submission.

I understand that any violation of the above will be caused disciplinary action by the Institute and can also evoke penal action from the source, from which proper permission has not been taken or improperly cited.

Pranay Dilip Gurumukhi
206130013

ACKNOWLEDGEMENT

The success of this project is a cumulative outcome of a lot of guidance and assistance from many people.

I would like to thank our guide **Prof. Purba Joshi** for her constant guidance, feedback, and suggestions on generating new ideas for tackling the problems at hand. In addition, I also thank assistants in IDC for their support, and guidance and for helping me to drive my work in the proper direction to achieve the goals.

Also, sincere appreciation for the valuable resources and assistance provided by the other assistants and staff.

I would like to extend my acknowledgment to our ID coordinator, **Mr. Avinash Shende** for their encouragement and support for the accomplishment of this project.

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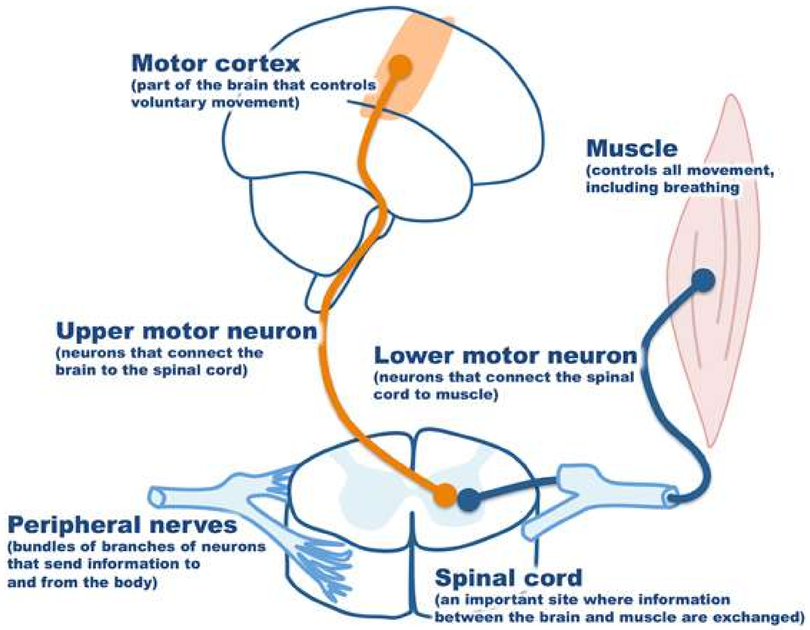
INTRODUCTION



MND stands for Motor Neuron Disease, which is a group of **progressive neurological disorders that affect the nerve cells (neurons)** responsible for controlling muscle movement.

The most common forms of MND are

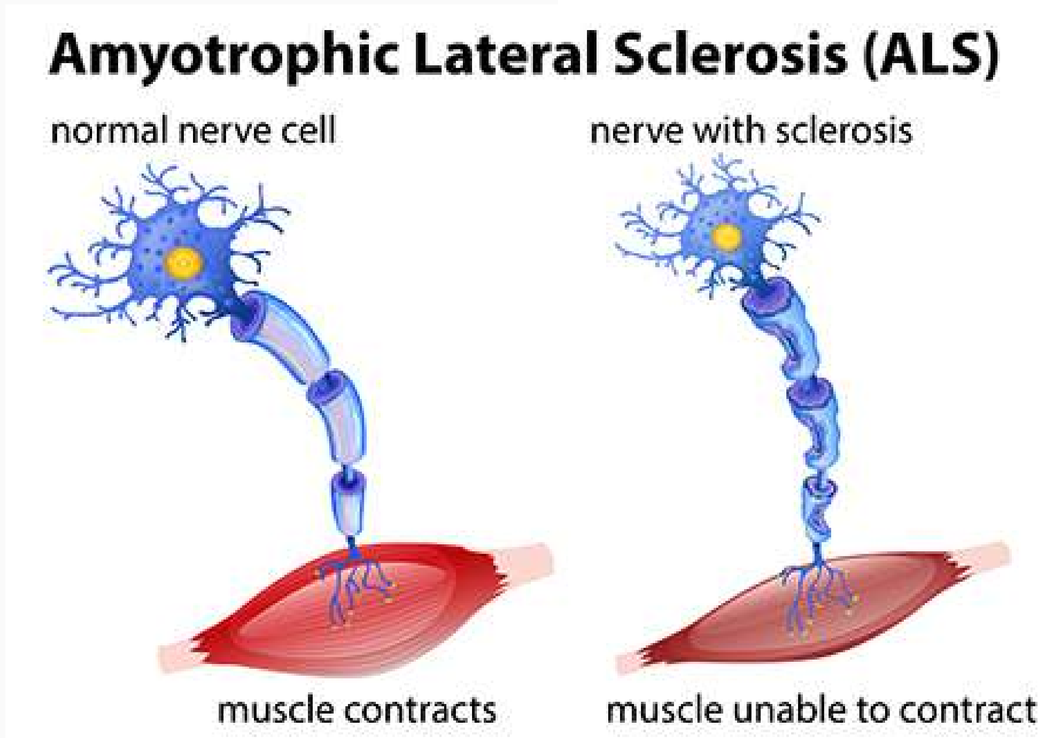
- **Amyotrophic lateral sclerosis (ALS) and**
- **Progressive bulbar palsy (PBP)**

The **affected nerves stop sending messages to the muscles** gradually leading to weakness and thinning (atrophy/ wasting) of those muscles. This is known as **neurodegeneration**.

ALS

ALS is the most common type, characterized by **muscle weakness and stiffness, overactive reflexes**, and in some cases, rapidly changing emotions. Initially, the limbs cease to work correctly. The speech, swallowing, and breathing muscles are usually also later affected.

ALS is the term commonly applied to MND in many parts of the world. **Average life expectancy is on an average of 2 - 5 years from the onset of symptoms.**



RESEARCH

ALS and MND are relatively rare conditions in India, with a limited number of patients and a **limited amount of research** on the subject.

The prevalence of ALS and MND in India is estimated to be between **2 and 4 cases per 100,000 people**, although these estimates may be underestimated due to a lack of data.

There is **limited public awareness** of ALS and MND in India, leading to a lack of understanding and support for patients and their families.

There have been a few studies conducted in India on the genetics of ALS and MND, but **further research is needed to better understand the disease in the Indian population.**

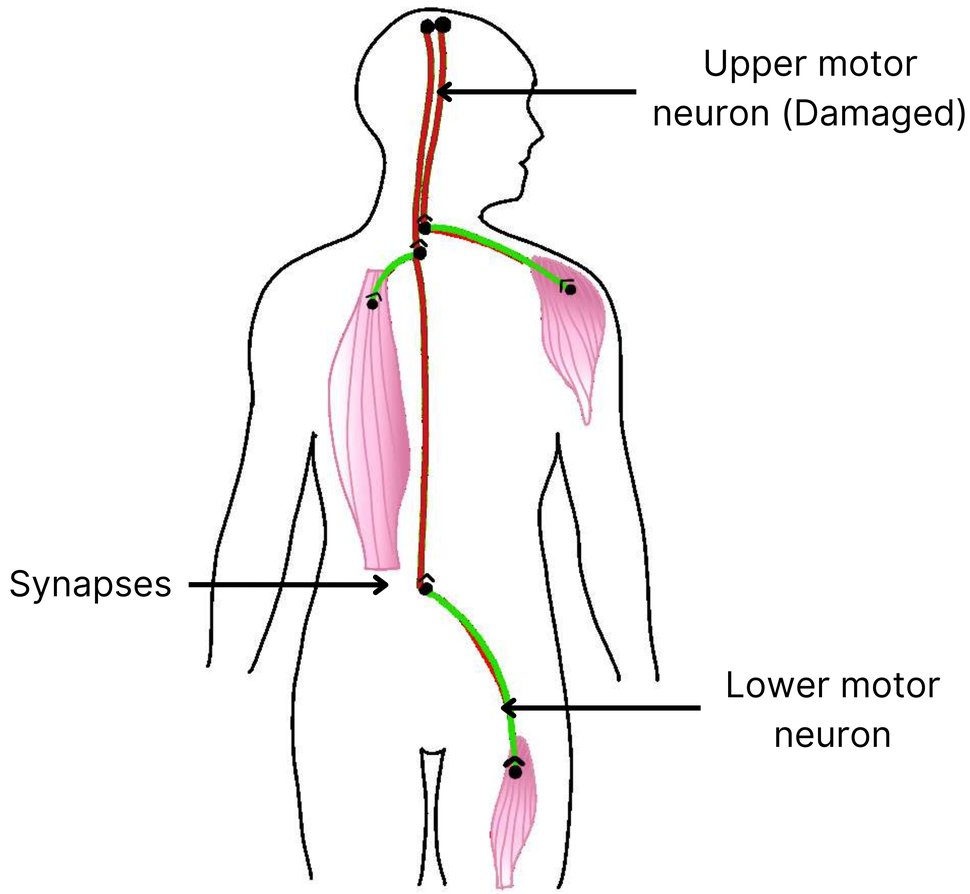
MND IN INDIAN CONTEXT

- Even with all the advancements in the field of medicine, the cause of MND is uncertain.
- Medical science has **not been able to identify a definite cause** for this disease but some of the risk factors have been identified.
- These risk factors may contribute to causing the disease but the presence of these risk factors does not always lead to the disease.
- MND has also been presumed to have a **genetic origin** where the disease may be transmitted from **one generation to the other**. When there is a **gene involvement** it is called **familial MND.**
- However, MND may be present **without any family history** (**sporadic**). But 90% of the time MND is sporadic and only 10% of the time a definite genetic cause is identified.
- The incidence of ALS in the USA is 2 per 100000, in Canada it is 2.4 per 100000, and in the UK it is 2.16 per 100000 however the **incidence rate in India has not been identified.**

FACTORS AFFECTING GROWTH OF MND

Factors that can affect the progression of the disease include:

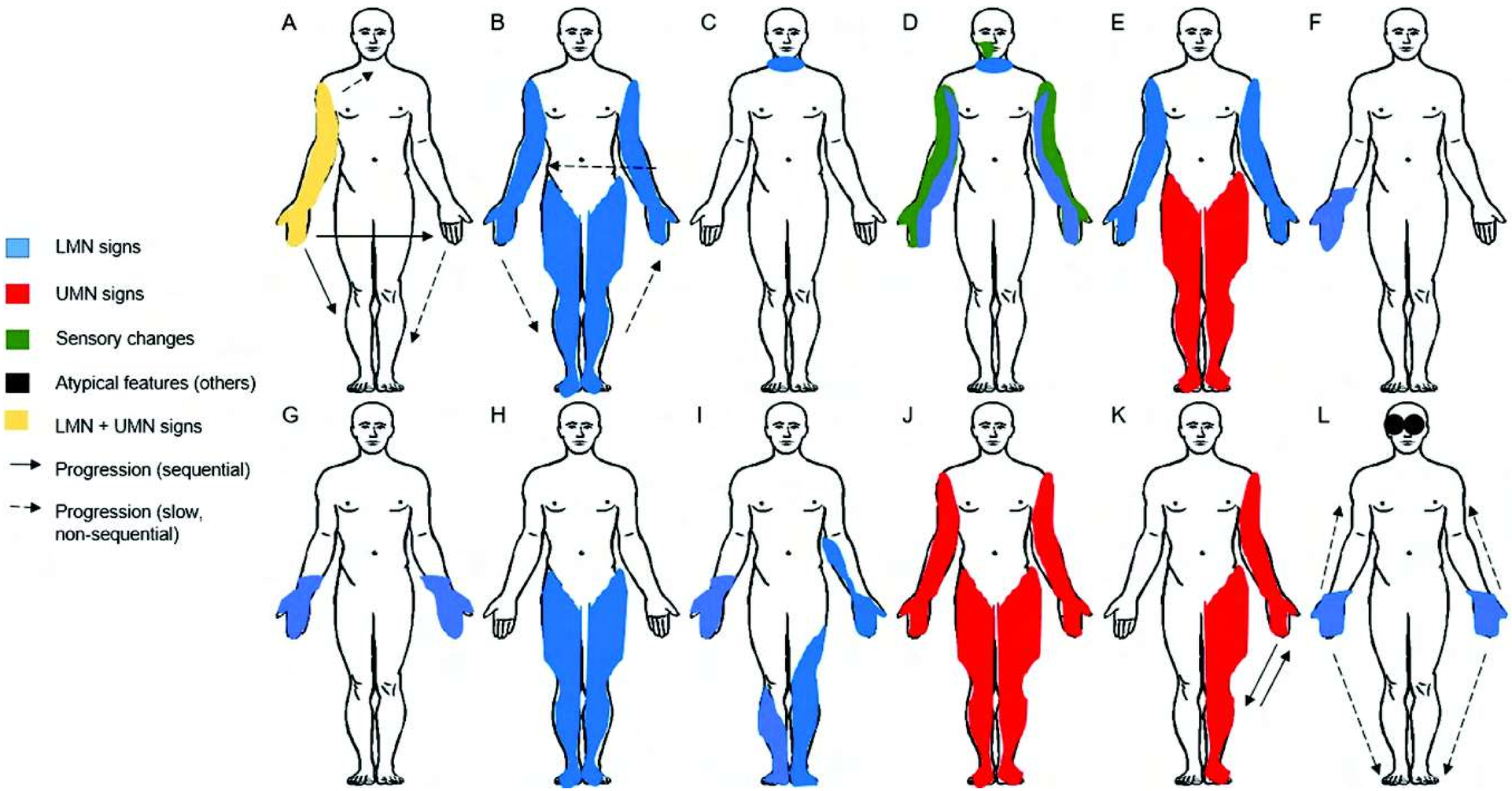
- **Age**: Most people with ALS are diagnosed between the age of 55 and 75, although the disease can occur at any age.
- **Gender**: Men are more likely to develop ALS than women.
- **Mental condition/health**: Adaptability, acceptance, social interactions.
- **Treatment**: Assistance received in terms of physiotherapy, diet, and therapy.



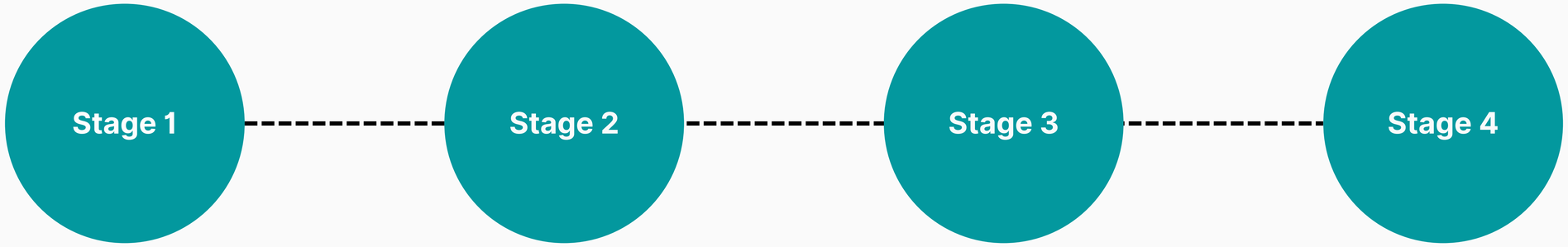
TYPES OF MND

These are various types of MND and how it progresses.

As we can see it mostly affects **upper and lower limbs** of a person.



STAGES OF MND



Early stage

- Weakness in leg or ankle
- cramps
- muscle twiching

Middle stage

- Severe symptoms
- affects the brain functioning

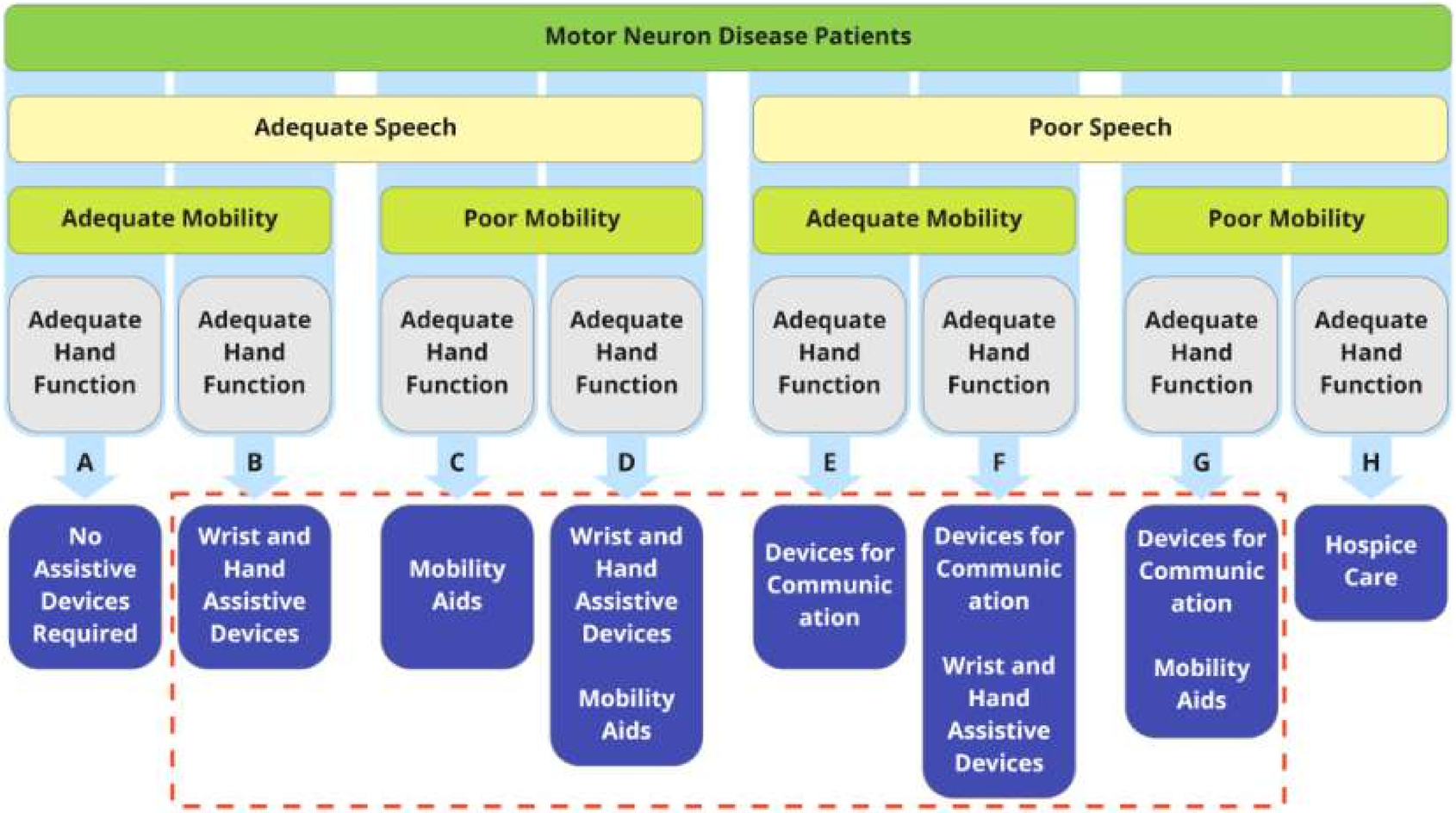
Advanced stage

- Thinning of muscles
- Slurred speech
- Difficulty in swallowing
- Weak grip

End stage

- Body paralysis
- Respiratory problems

AREA OF INTERVENTION



The recommended use of assistive devices for ALS/MND patients based on disease stage

ASSISTIVE AIDS FOR PATIENTS

There are several products currently available in the market that can help people with Amyotrophic lateral sclerosis (ALS) to **maintain their independence and improve their quality of life**. These products include:

- Mobility aids, Wheelchairs
- Communication devices
- Adaptive equipment
- Breathing aids
- Orthotic devices

Crutches

Wheelchair

Enlarged gasp cuff

Sock helper

Rollators

Bed cane

POTENTIAL TREATMENTS

There is currently no cure for ALS (amyotrophic lateral sclerosis) or MND (motor neuron disease). However, there are several treatments available that can help manage symptoms and improve the quality of life for patients.

Some potential treatments for ALS and MND patients include:

- **Medications** that can help manage symptoms such as muscle cramps, stiffness, and excessive saliva production. These include muscle relaxants, anti-spasticity drugs, and medications to manage respiratory function.
- **Breathing support options** may include noninvasive ventilation or mechanical ventilation.
- Speech therapy and **communication aids**, such as electronic communication devices or eye-gaze systems.
- ALS and MND can also cause difficulty swallowing, which can lead to malnutrition and weight loss. **Nutritional support**, such as a feeding tube, may be necessary to ensure adequate nutrition.
- **Physical therapy** can help maintain muscle strength and flexibility, prevent muscle atrophy, and improve mobility.
- **Occupational therapy** can help patients adapt to changes in daily living activities, such as dressing and grooming, and provide strategies to maintain independence.
- There are ongoing **clinical trials** investigating potential treatments for ALS and MND. Patients may be able to participate in these trials and receive experimental treatments.

COMPREHENSIVE CARE FOR PATIENT NEEDS

Patients with MND and ALS require comprehensive care that addresses their unique needs throughout the course of their disease.

The key needs and aspects of care that should be considered:

- Patients with MND and ALS may **experience a range of symptoms** such as muscle weakness, spasticity, difficulty swallowing, and breathing problems. Comprehensive care should involve managing these symptoms with medications, rehabilitation therapies, and other interventions as appropriate.
- Patients may experience difficulty with swallowing and eating. **Nutritional support**, such as a feeding tube, may be necessary to ensure adequate nutrition.
- Care should involve **regular monitoring of respiratory function** and the provision of **respiratory support**, such as noninvasive ventilation or mechanical ventilation as needed.
- MND and ALS can have a significant impact on a patient's emotional well-being and quality of life. Care should involve providing **psychosocial support and counseling** to help patients and their families cope with the emotional and psychological challenges of the disease.
- Caregivers play a critical role in the care of MND and ALS patients. Care should involve providing **education and support for caregivers** to help them manage the daily challenges of caregiving, prevent caregiver burnout, and maintain their own physical and emotional health.
- As the disease progresses, patients with MND and ALS may require **end-of-life care**. Comprehensive care should involve providing palliative care and support for patients and their families throughout the end-of-life process.

PROBLEMS OF PATIENTS

- Limited treatment options
- The feeling of frustration and helplessness among families
- The cost of treatment puts a financial burden on families
- Difficulty in dressing, eating, and other daily activities
- Makes communication difficult for Bulbar palsy patients
- Difficulty in mobility while going to washrooms
- Had a risk of respiratory infections
- Physical challenges
- Emotional impact, feelings of anxiety, and loss of self-esteem
- Need to ask for a caretaker if they lose their initial position

DESIGNING A BETTER PRODUCT

ALS/MND is a progressive neurological disease that affects muscle function, leading to mobility, communication, and coordination difficulties. The disease often results in the **patient's reliance on others to carry out activities of daily living**, making them a **significant target group for products that can help them maintain their independence.**

Designing products for ALS/MND patients requires **considering their physical and cognitive limitations** and **finding solutions** that address their needs to improve their quality of life.

FIELD VISIT

NeuroGen Brain and Spine Institute is not just an organization, but a collective, committed concept, of paving the way to a brighter future, and a life of independence, for individuals with incurable neurological disorders, through the combination of revolutionary regenerative medicine, **holistic comprehensive neurorehabilitation** and medical intervention.

NeuroGen Brain and Spine Institute was established with a **vision to aid patients suffering from various incurable neurological disorders** like Autism, Cerebral Palsy, Muscular Dystrophy, Intellectual Disability, Spinal Cord Injury, Brain Stroke, Head Injury etc. Their multidisciplinary approach attempts not only to treat these conditions, but also to **restore health and vitality.**

DR. HEMANGI SANE

Consultant Physician,
Deputy Director at Neurogen

Dr. Hemangi Sane has been named one of the **"Leading Physicians of the World, 2013-2014"**, and is dedicated to **finding cures** for neurological disorders, through research.

It's been **11 years** since she was diagnosed with MND. There was progressive weakness and the symptoms worsened. She also suffers from **Bulbar palsy**. She underwent Stem Cell Therapy (SCT) and her condition became stable.

She is the **founding president** of **Asha Ek Hope foundation**, the **only NGO for MND patients in India**. They have published more than **25 medical research papers and 10 books.**

Discussion with Dr. Hemangi Sane during a field visit to Neurogen hospital, and **addressing the issues she faces with her electric wheelchair** in her regular activities.

INSIGHTS GAINED FROM THE INTERVIEW

Motorized vehicle easy to maneuver

Manual vehicle has lot of problems

No organized pattern and floorplan for the caretaker

No alert button in need of assistance

Sometimes controls are hard to interact with

No one pushes for longer duration

Not comfortable on harsh roads in absence of suspensions

Absence of handlebar grip for a caretaker

Height and hand rest must be adjustable

Two levers to switch from manual to auto mode

Weight of wheelchair matters

Battery should be accessible for caretaker

Economical product needed

Compact enough to fit in sedan trunk

Proper cushioning for handrest

No radium strips on the wheelchair

Improper footrest, she had to cut and adjust for herself

Accessible storage space

She had to extend the seat to ingress properly

Alexa- bring my wheelchair!

OBSERVATIONS

- She can **control** the wheelchair when its in **electric mode**
- For other tasks, she has to **call for a caretaker** to help
- She **can't** manage to **use the features** of the wheelchair by herself
- For charging the battery, the charging port is beneath the controller but she's unable to connect the cable
- The Caretaker has to push the backrest in absence of proper grip handles, which makes it **difficult for her to maneuver**
- Its a hassle for the caretaker to take out the battery and reinsert it, the **battery** itself **weighs around 7 kg**
- She has to call her caretaker as there's **no alert button** on the device
- There is a need for **adjustments** in hand rest, seat, and seat height according to various body types of patients
- The motor output power should not exceed **99 kWhr**
- She doesn't need other hand rest as she keeps her hand close to her body resting on her lap
- She **can't access her storage space** where she keeps her purse and other belongings
- Wheels can **deflate**, but the maintenance cost is low for tires with tubes

Product:

Pride I Go Plus

Specifications:

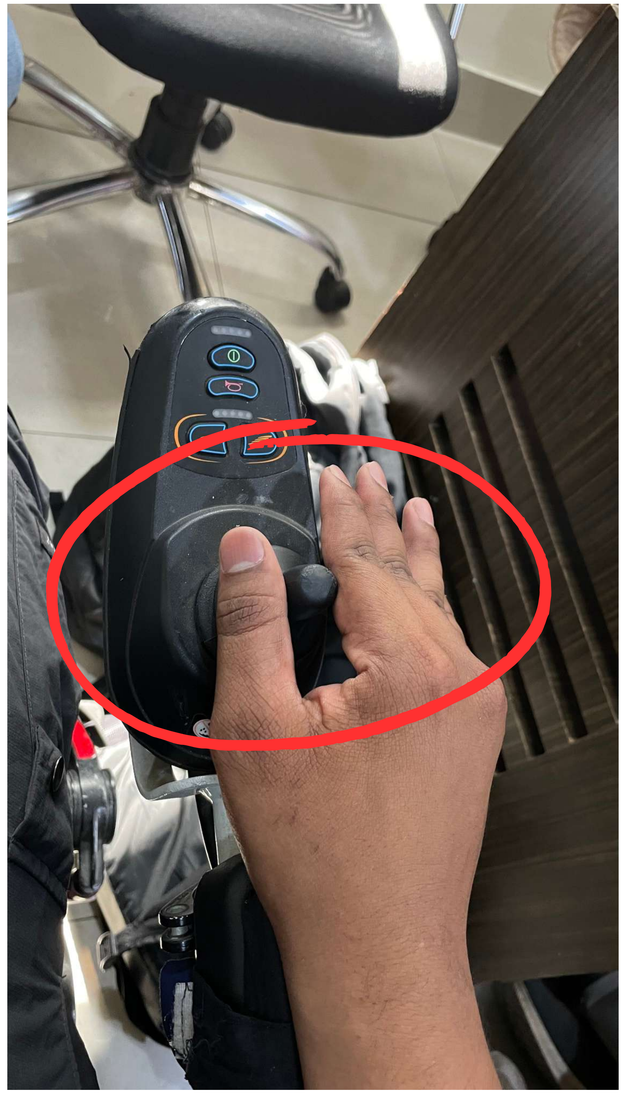
Brand: Pride
Max range- 10 km to 19 km
Max speed- under 6 km
Battery- 18.2 Ah lithium-ion
Battery weight- 3.4 kg
Weight capacity- 108.7 kg
Ground clearance- 4.4 cm
Total weight- 24 kg
Overall length- 101.6 cm
Overall width- 59.7 cm
Turning radius- 61.6 cm
Seating- Saddle back seat
Tires- Pneumatic rear tires and solid front castors

There is **no sufficient cushioning** on the armrests or backrests, and there is **no proper ergonomics** for sitting.

lack of a sufficient grip hold allowing the caretaker to easily maneuver the wheelchair

On the control handle, there is **no adequate palm rest** for the user

The user is **unable to access** the controller's control **buttons**.



The user can grasp the joystick **between her thumb and index finger**

They had to **manually cut** the **surplus footrest** because it **interfered with folding** and took up **too much space**.

She has **difficulty** in correctly **adjusting her legs** on the footrest due to the excess length of the seat.

Because the battery is located at the **bottom** and is **inaccessible**, the caretaker was forced to go down on her knees and loosen the lever and slider towards herself, which was **quite a hassle**.

The battery **weighs roughly 7kg**, making it **challenging** for a female caretaker in these conditions, and they had to slide it horizontally.

DR. ARNAB GHOSH

Medical Specialist,
Nanobios lab

Insights from the interview

There should be voice-controlled devices to minimize physical strain

Lightweight tools for patients

Ergonomic controlled devices, foot operated devices

Wearables that can track physical activity and remind one to perform exercises

Use of home automation and smart devices

Eye-tracking for communication and movements of vehicle

Safety features around patients's environment

Accessible and specialized mobility devices

DR. NILESH BHANDARI

Neurologist,
Bhandari Speciality

He addressed some specific challenges and limitations associated with the disease.

Insights from the interview

The device should promote safe and independent mobility

Safety: minimize the risk of falls or injuries

Easy to maneuver with intuitive controls that don't require fine motor control

Adjustable seating system, footrests, armrests to minimize pressure

Made of high-quality materials to ensure reliability

Attachment for tablet or communication device

Accessible to patients as well as caregivers

Removable parts to clean

Compatible with other medical equipments

Accessory attachments for personal items


MEENA !!


I'M NOT FEELING SAFE, THIS CHAIR SHOULD HAVE SEATBELT ATLEAST

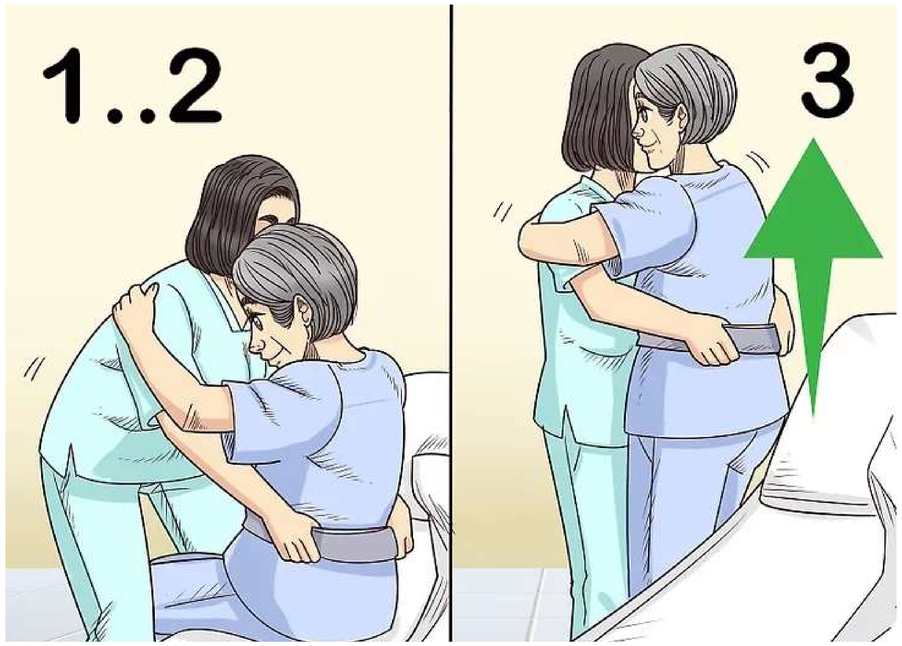

CARETAKER HAS TO LEAN FORWARD IN ORDER TO CONTROL THE JOYSTICK

CAN WE HAVE A WHEELCHAIR WHICH IS COMPACT , SO THAT IT WILL BE EASY TO LOAD IN CAR BOOTSPACE OR CAR TOP.

POOR MEENA! SHE IS STRUGGLING TO FOLD THE CHAIR TO PUT IT INSIDE THE CAR

MEENA ALWAYS HAS TO REMOVE LUGGAGE TO OPTIMISE THE SPACE IN BOOT SPACES OF CAR SO THAT THE CHAIR CAN FIT IN

SCENARIO



Using a gait belt to hold the patient while lifting

PRODUCTS - MANUAL

Invacare

Ergo Lite

KM 5000

Aurora 4

VIP Tilt

CA 3

Adaptive Start M5

AT20

PRODUCTS - ELECTRIC

GM Lite

E-Thorone Folding

Conqueror RS2

Nuk Eco

Forest 3

GM Lite

Timix SU

Conqueror RS2

Quantum Q6 edge

Jazzy Elite

PRODUCTS - ELECTRIC

Angel

P Access

Hero 4

Nuk Eco

Tracer

Luggie

P4 Country

Gochair

Bounder plus

Electric scooters

PRODUCTS - PEDIATRIC

Gemini 2

b-convertible

KP 12T

KM 7501

KM 7520

PRODUCT - LIFTZY

A Breakthrough innovation that **enables effortless movement like lifting**, transporting & repositioning of people immobilized due to physical challenges.

PRODUCT - ARISE

A '**standing wheelchair**' called 'Arise', was developed at the **TTK Center for Rehabilitation Research and Device Development (R2D2)** at the **Indian Institute of Technology, Madras.**

A hand-operated, **linkage-based mechanism** was developed to achieve the standing functionality.

Arise was designed such that the **user can actuate it from the sitting position to the standing position** and **vice versa independently** and in a controlled manner. This can be done using the power of the user's arms.

With optimal one-time fitting, the **effort required is no more than that required to propel the wheelchair**.

The wheelchair has been designed and built in such a way that the effort required for the user to stand using it is equal to or less than that of moving the wheelchair, as they have used a linkage with a **spring balancing system**.

WHEELCHAIR ERGONOMICS

The most important measurements are **seat width, back height, seat depth, and seat-to-floor height.** By providing a wheelchair with the proper dimensions in these four areas, we can avoid some of the most common and dangerous positioning concerns. Measuring all fields will help ensure optimal comfort and safety.

Resident's seat width

- Measure the resident’s hip width across the widest point of hips or thighs
- Add 1″
- Add thickness of side cushions (if a cushion is used)

Resident's back height

- Measure the resident’s buttocks to the underside of the extended arm
- Add half the thickness of the seat cushion (if used)
- Subtract 4″ for residents with good trunk muscles
- Subtract 3″ for residents with poor trunk muscles

Resident's seat depth

- Measure resident’s rear of buttocks to the back of the knee
- Subtract 2½”
- Add the thickness of the back cushion (if a cushion is used)

Seat-to-floor height

- If a resident is under 5′5″ tall, use a Hemi-size wheelchair with a 17½” seat height
- If resident is between 5′5″ and 6′2″, use an Adult size wheelchair with a 19½” to 20½” seat height
- If a resident is over 6′2″ tall, use a Tall size wheelchair with a 21½” seat height

MEASUREMENTS

Seat Width

Calculate Resident's Seat Width Requirement:

1. Measure resident's hip width across widest point of hips or thighs = _____
2. Add 1" = _____
3. Add thickness of side cushions (if cushion is used) = _____

TOTAL ☐

Seat Depth

Calculate Resident's Seat Depth Requirement:

1. Measure resident's rear of buttocks to back of knee = _____
2. Subtract 2½" = _____
3. Add thickness of back cushion (if cushion is used) = _____

TOTAL ☐

Back Height

Calculate Resident's Back Height Requirement:

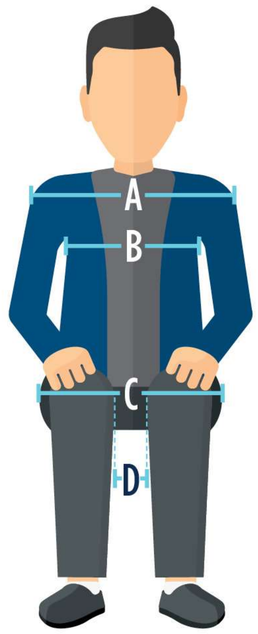
1. Measure resident's buttocks to underside of extended arm = _____
2. Add half the thickness of seat cushion (if used) = _____
3. Subtract 4" for residents with good trunk muscles = _____
4. Subtract 3" for residents with poor trunk muscles = _____

TOTAL ☐

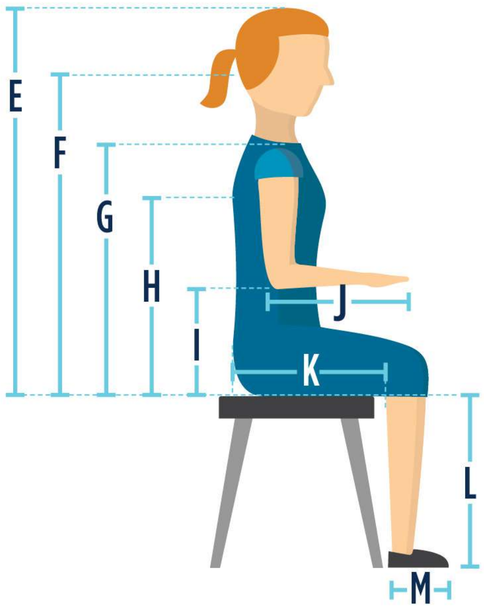
Seat-to-Floor Height

Wheelchair Style	Seat-to-Floor Height	Resident Height
Hemi	17½"	under 5'5"
Adult	19½" to 20½"	5'5" to 6'2"
Tall	21½"	over 6'2"

MEASUREMENTS



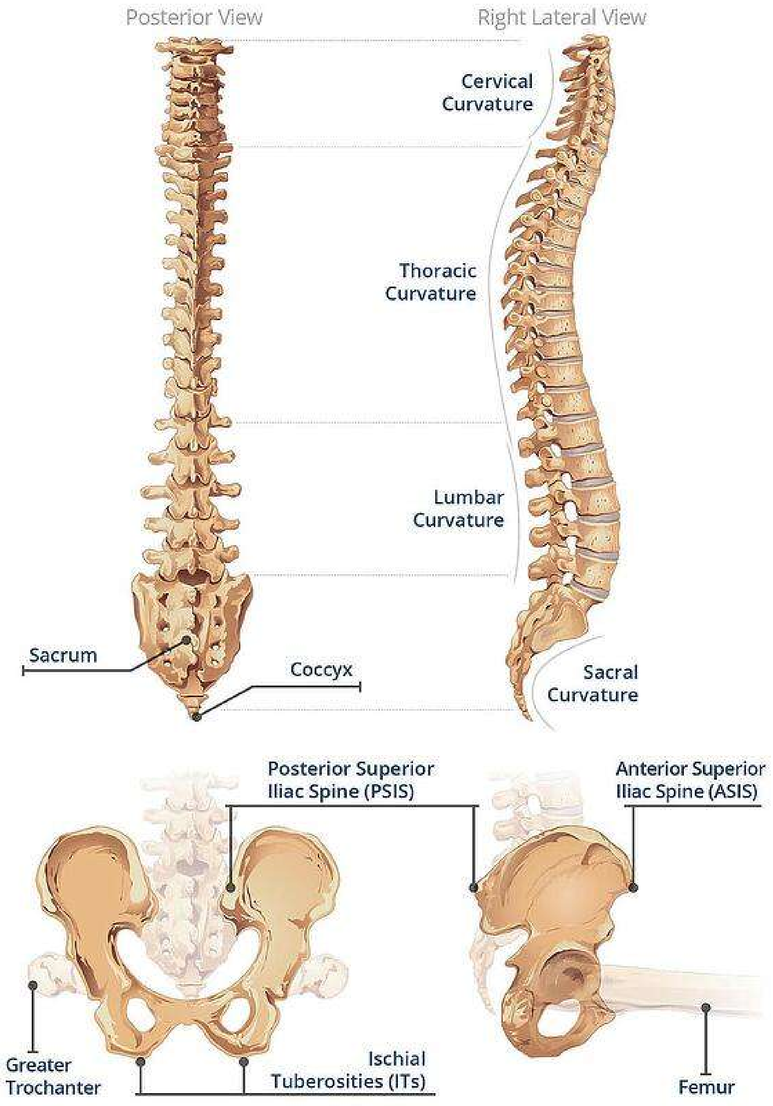
*	A - Shoulder width
*	B - Chest width
*	C - Hip width
	D - Between knees



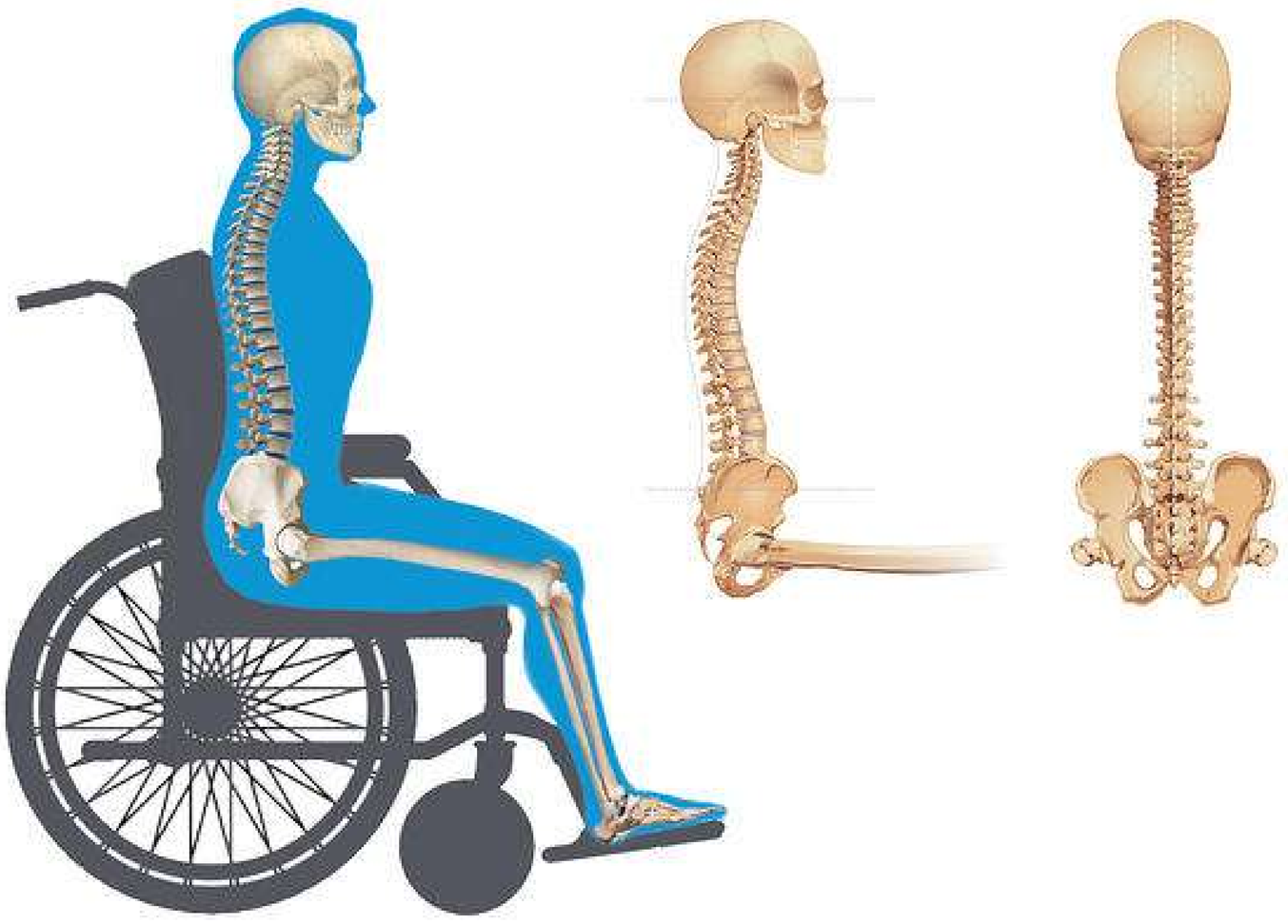
	E - Top of head
	F - Seat to occiput
*	G - Top of shoulder
*	H - Inferior angle of scapula
*	I - Seat to elbow
	J - Elbow to tip of fingers
*	K - Upper leg length
*	L - Lower leg length
	M - Foot length

- Shoulder Width (A)
- Chest Width (B)
- Hip Width (C)
- Between the Knees (D)
- Top of Head (E)
- Occiput (F)
- Seat to Top of Shoulder (G)
- Inferior Angle of Scapula (H)
- Seat to Elbow (I)
- Elbow to Tip of Fingers (J)
- Upper Leg Length (K)
- Lower Leg Length (L)
- Foot Length (M)

SEATING AND POSITIONING



Neutral Spinal Anatomy



Neutral Pelvic Posture

ABNORMAL POSTURES

Anterior Pelvic Tilt

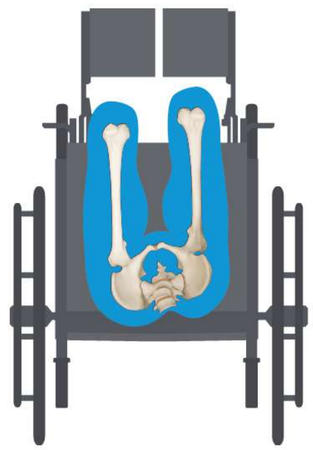
Tilt with lumbar lordosis with or without neck hyperextension

Posterior Pelvic Tilt

Tilt with thoracic kyphosis with or without forward neck flexion; also referred to as sacral sitting.

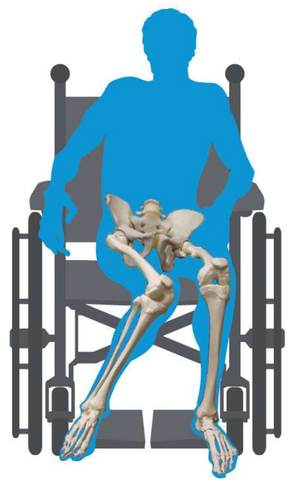
Pelvic Obliquity

Obliquity with scoliosis with or without lateral neck flexion.



Pelvic Rotation

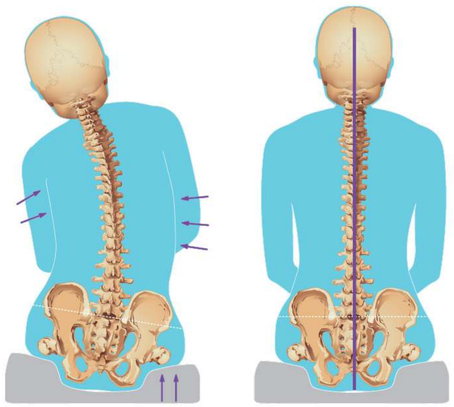
Rotation of the spine with or without lateral neck flexion.



Windswept Posture

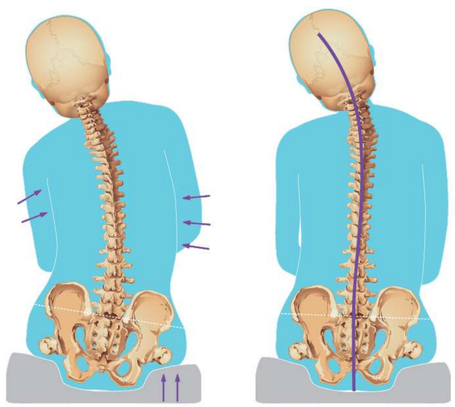
REDUCIBLE POSTURES

The goal when correcting a reducible posture is to achieve their most neutral posture that can be maintained over time with proper support in order to optimize function.



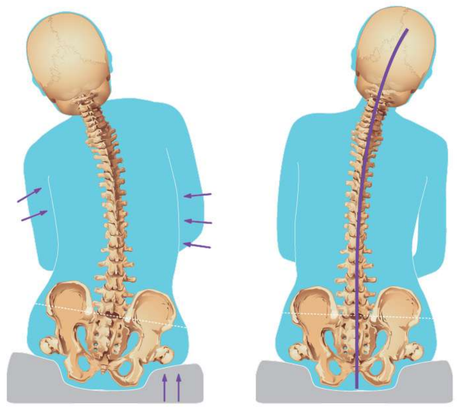
Reducible to Neutral

Posture can be moved with support to a neutral/midline position. If they cannot maintain midline over time, the goal is to find the most neutral position for the client and support them to that point.



Reducible NOT to Neutral

Even if a patient cannot achieve a truly neutral/midline posture, if the posture can be adjusted with support towards the midline, it is considered reducible.



Reducible PAST Neutral

With support, if a posture can be moved beyond a neutral/midline position, it is reducible with the goal to position them in midline.

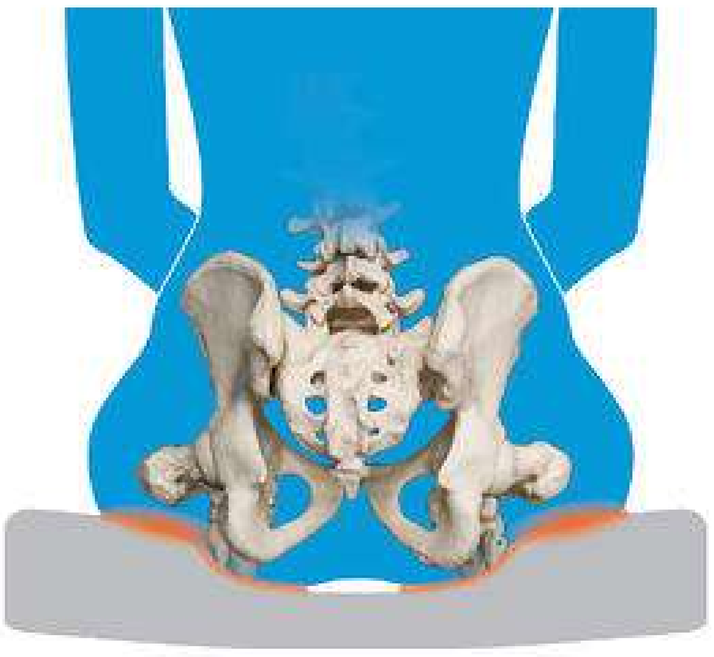
WHEELCHAIR CUSHION

If the pelvis is in a non-reducible posture, we have to accommodate that posture through cushion geometry and medium.
If the posture is reducible, we will look for contours and a medium that can correct the pelvic position.

Reducible PAST Neutral

Pressure cannot be eliminated in seating, so instead, we must focus on the redistribution of pressure.

Offloading/Partial Offloading

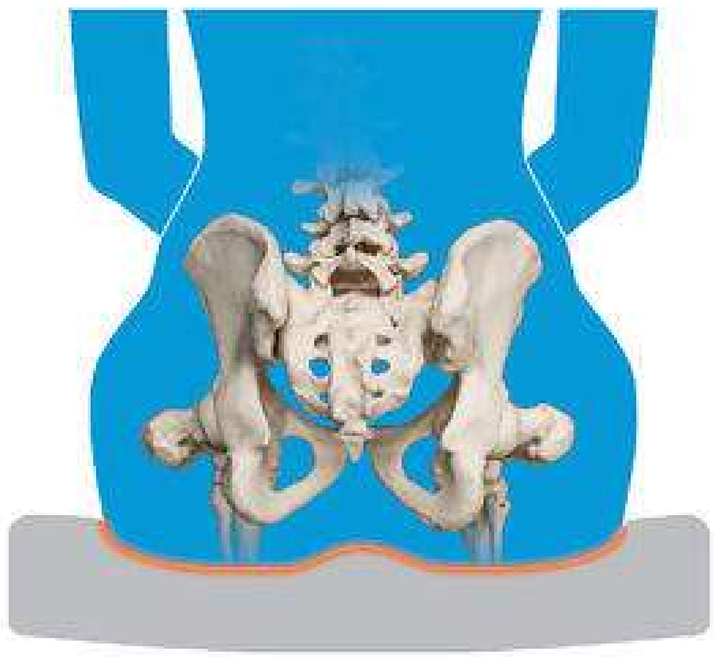


The principle of taking pressure off of a small surface area and loading it onto a greater surface area that can withstand more pressure and prevent unwanted skin breakdown.

Immersion

The principle in which a material allows the body to compress or “sink” into it to provide some pressure redistribution with increased surface area contact.

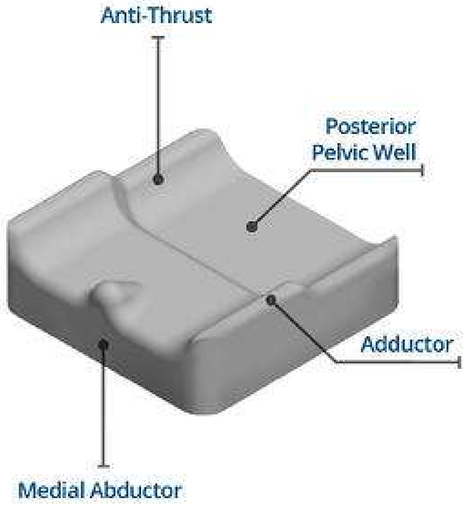
Immersion and Envelopment

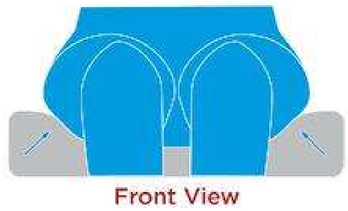


The principle in which a material allows the body to compress or “sink” into it and the material conforms to the body’s shape to provide further pressure redistribution and reduction of peak pressures.

CUSHION GEOMETRY

Each style of cushion geometry had different benefits and considerations associated with it.

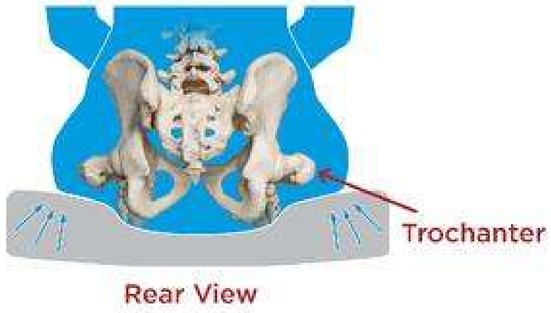




Linear

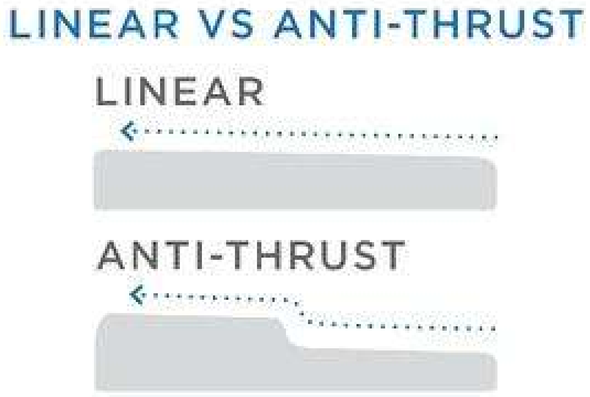
Contoured

Straight Adductors

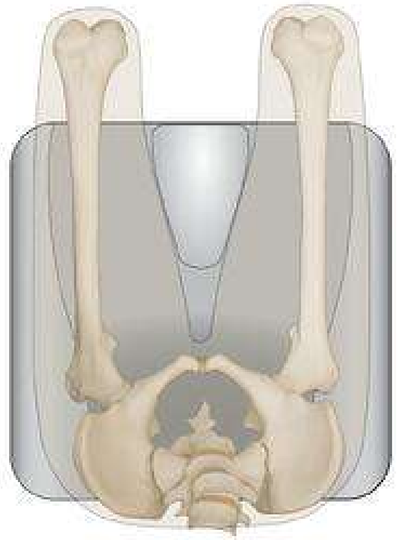


Tapered Adductors

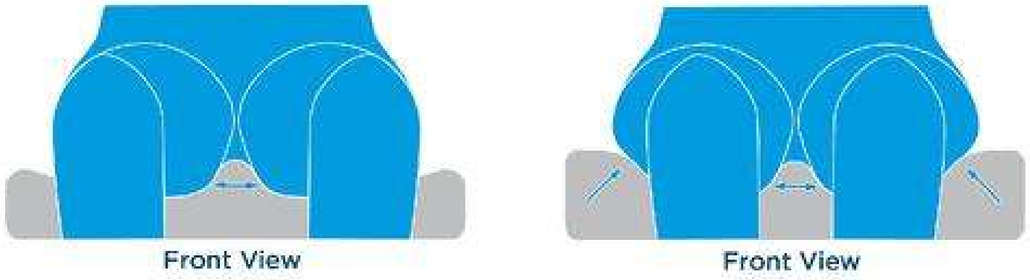
Posterior Pelvic Wall



Anti-Thrust



Wedge



Medial Abductors

FOAMS USED IN CUSHIONS

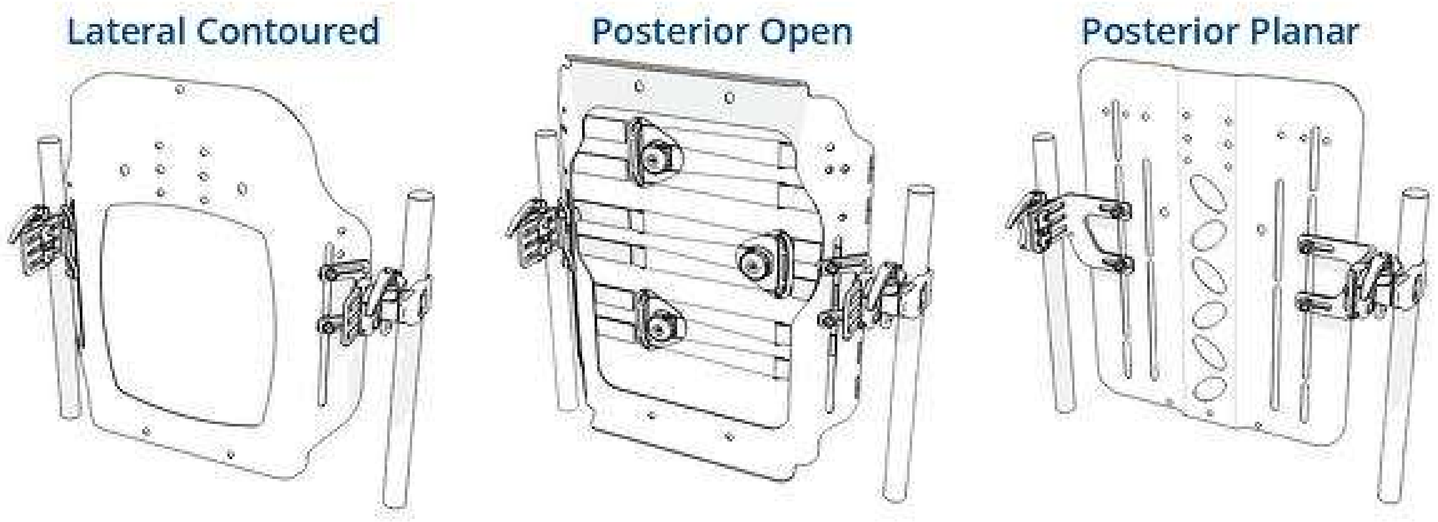
High Resiliency (HR) Foam

- Instantly "springs" back to its original shape post compression
- Durable foam, can withstand repeated compression and maintains resiliency over time
- Provides structure and stability
- Great for use as the base layer of a cushion

Visco Elastic Foam

- Memory foam, meaning it takes time to resume the original shape post compression
- Allows for the most immersion and envelopment, contouring to the unique shape of the user
- Great to use as top layer of a cushion

BACKSUPPORT



- Provides depth and angle adjustability through the hardware
- Provides trunk stability to promote functional sitting
- Works with the cushion to provide pelvic stability
- Provides increased pressure redistribution at the trunk and pelvis
- It can minimize the progression of abnormal postures
- Decreases pain by increasing stability and pressure redistribution

WHEELCHAIR SAFETY

- Do NOT force your chair down or up staircases, slopes, and inclines.
- LOCK the brakes before getting out or into the wheelchair. The power should be turned off for motorized wheelchairs before transferring.
- Lift up or adjust the foot rests and arm rests before transferring.
- Attach flashy items such as flashing taillights and flags to your wheelchair so that other pedestrians can see you quickly in the dark or at night.
- Service and replace the casters regularly. If you are experiencing a side-to-side motion while going at high speeds this is a sign it needs replacing.
- Adjust and program your motorized wheelchair settings to be comfortable with the speed.
- Do not go out in rainy weather. Wheelchairs can lose traction and the controls of a motorized wheelchair can get wet.
- Avoid having a large heavy bag or items on the back of the wheelchair. This can cause the wheelchair to tip backward during transferring.

FAIL PREVENTION

- Don’t over-stretch or overreach for an object - the user may tip over the wheelchair.
- Avoid leaning forward - the user may tip themselves out of the wheelchair.
- Lock the brakes before trying to move out of the wheelchair.
- Avoid sliding or positioning them too far forward on the seat.
- Move any footrests out of the way to avoid tripping on them during transfer.

DESIGN BRIEF

To design a wheelchair for ALS/MND patients that could be:

- A **lightweight, foldable, and compact** wheelchair with an **adjustable** and **ergonomic seating** system.
- The wheelchair could have **intuitive controls** and **anti-tipping features for safety and stability**, as well as **accessibility features** to make caregiving easier.
- Additionally, it could have **accessory attachments** for medical equipment or personal items to improve the patient's independence and quality of life.

FACTORS TO BE CONSIDERED

Needs

- Easy and intuitive controls that don't require fine motor control or excessive effort
- Adjustability to accommodate varying levels of mobility and comfort
- Lightweight materials to minimize physical strain on the user and caregiver
- Stability and safety features to prevent falls and injuries
- Accessory attachments for medical equipment or personal items

Caregiver Perspective

- Easy maneuverability to minimize caregiver strain and improve the patient's mobility
- Foldable design to promote portability and storage
- Accessibility features, such as removable armrests or easy-to-clean materials, make caregiving easier

Ergonomics

- Supportive and comfortable seating that minimizes pressure points and promotes proper posture
- Adjustable footrests, armrests, and headrests to promote comfort and prevent injury
- Anti-tipping features to ensure stability during transfers and daily use

FACTORS TO BE CONSIDERED

- **Improved mobility** and independence for ALS/MND patients
- **Reduced strain** on caregivers
- **Increased safety** and stability features, adjustable design to accommodate varying levels of mobility and comfort.
- **Cost** of the equipment
- The potential difficulty with **maintenance** or repair
- **Weight and size limitations**.

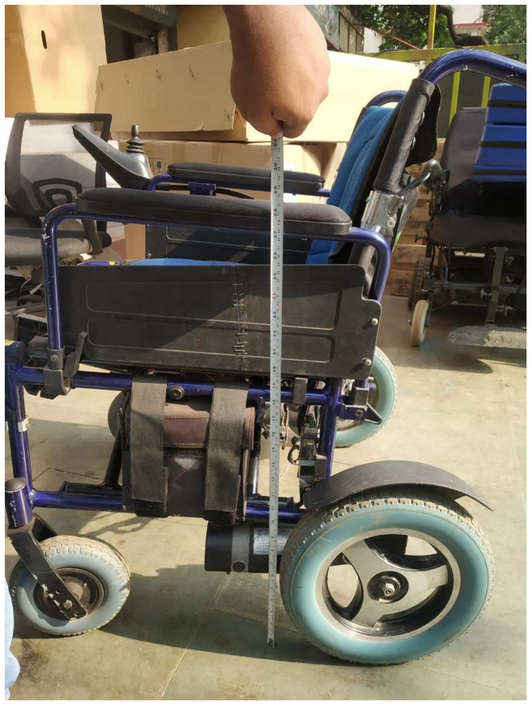
FIELD VISIT

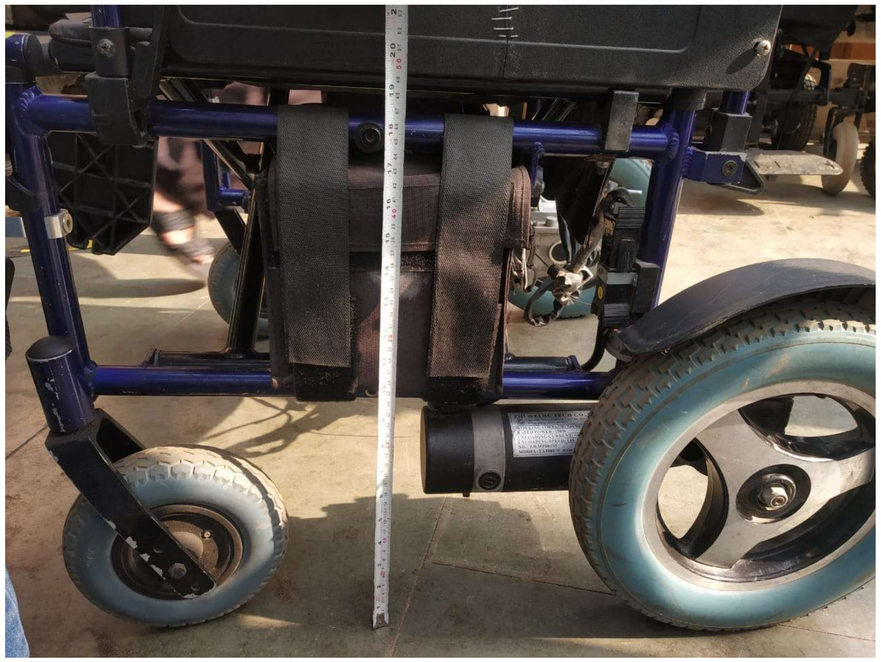
Nuk Healthcare is based in **Goregaon**. They have emerged as the **prominent Manufacturer and Importer of Electronic wheelchairs**, Power Wheelchairs, Mobility Scooters, Commode chairs, Paediatric wheelchairs, Paediatric walkers, Reclining wheelchairs, Patient Lifting Hoists, etc.

Recently they won an **award for the patent design** and development of the **LIFTZY Transfer wheelchair**. It has changed the way patients are transferred from one place to another.

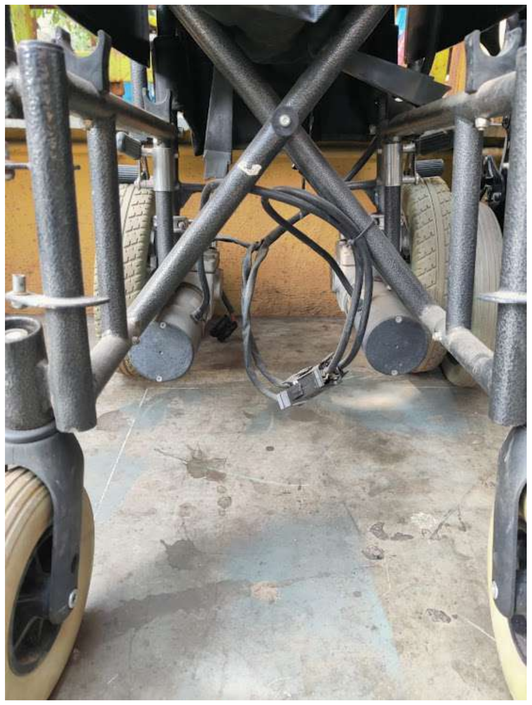
NuK Healthcare

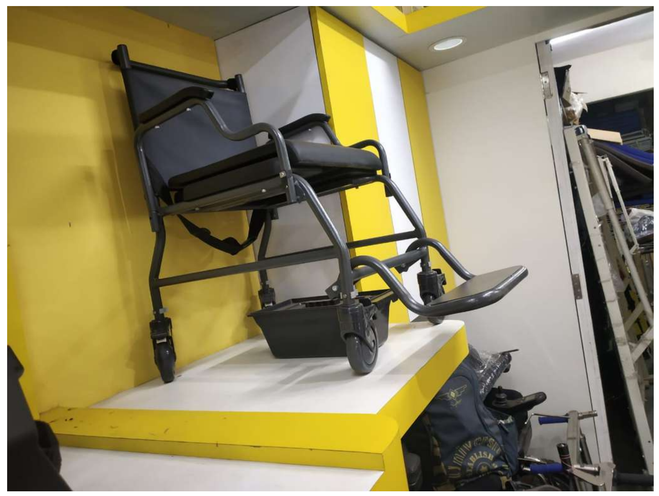
Goregaon, Mumbai

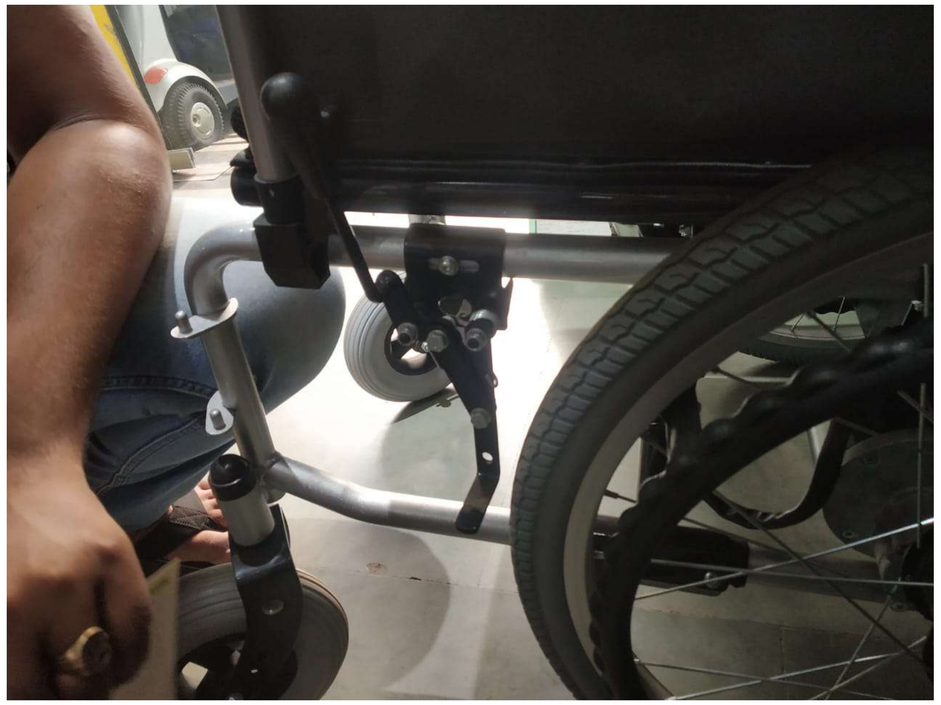


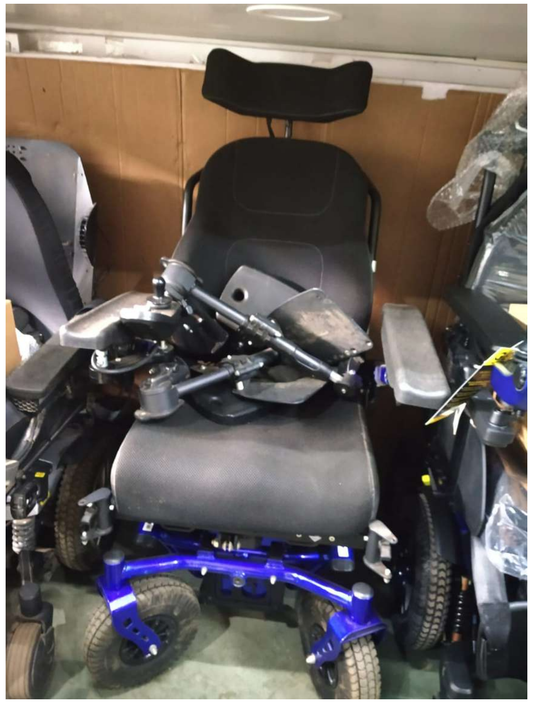



ZIP










ZIP 10
Inspired Mobility
Power Wheel Chair
For Indoor & Outdoor use
Venante


ZHI WEI NC TECH CO.,LTD
WORKING VOLTAGE: 24VDC
RATED POWER: 250W
UNLOADING CURRENT: <4.5A
UNLOADING SPEED: 140
NO.: ZWMP00155
MODEL: YA308E/F MADE IN CHINA

MORE INSIGHTS

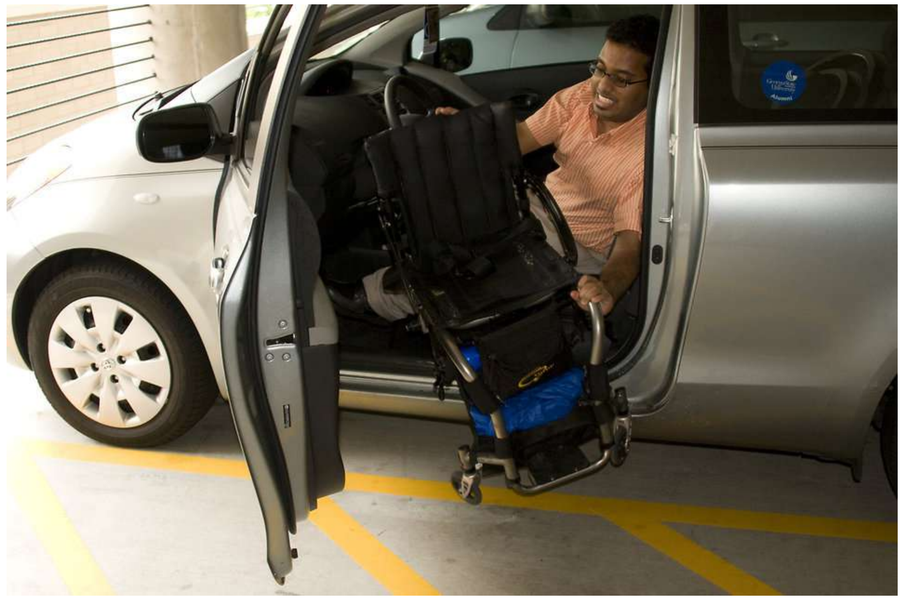
- The wheelchair has a scissor mechanism, is lightweight, and folds easily
- Because of the small size of the wheels, it was difficult to push forward on the slope
- As a result, the caretaker must rotate and push backward in order to climb from the larger wheel at the back

MORE INSIGHTS

- The wheelchair has a scissor mechanism and folds easily.
- However, it folds with respect to breadth but not length, making it difficult to place flat on the ground in small spaces.
- It was also difficult to maneuver, as it rotates in its castor wheels turning radius.
- So the nurse had to hold the handrest and push forward in order to move it straight.

MORE INSIGHTS

- Putting the wheelchair on the top carriage is a hassle for the caregiver
- The problem gets more prominent as wheelchair size increases
- The major problem of putting a wheelchair that cant be folded into compact one



- Even is difficult to adjust the wheelchair in car seats
- You need to have additional equipment for holding the wheelchair in place
- It needs constant attention as it doesn't affect the car interior parts

MORE INSIGHTS

- Boot space matters, some wheelchairs gets easily into sedan boot spaces, but it gives problem in hatchback boot space
- Or some users have to keep the hatch door open while driving

- Some had arranged a setup for attaching the wheelchair on rear side of the car
- The problem arises while parking the vehicle
- Even it tasks time to disassemble the whole kit from car body

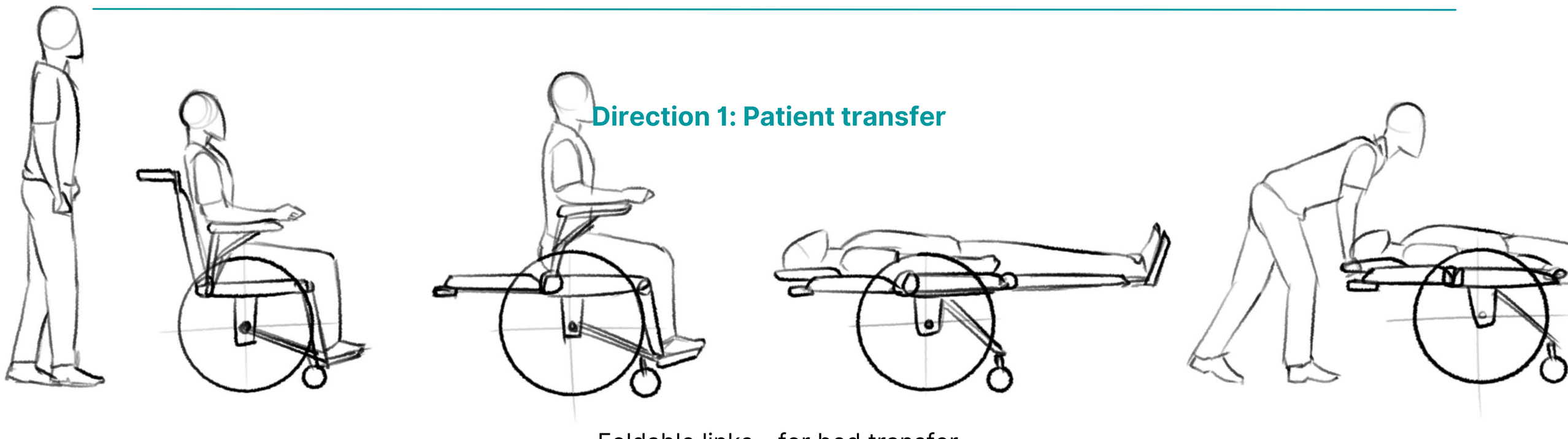
DESIGN DIRECTIONS

By **exploring various ideas and insights** from experiences related to patient transfer and engaging in **brainstorming sessions**, I aim to gather insights that will guide the development of **multiple design directions** for improving patient transfer methods focused on wheelchair.

Developing **three** design directions that address the needs and challenges associated with wheelchair and exploring further ideations in that context, I started with **understanding various types of wheelchairs based on wheel positions.**

WHEEL POSITION EXPLORATION

Direction 1: Patient transfer



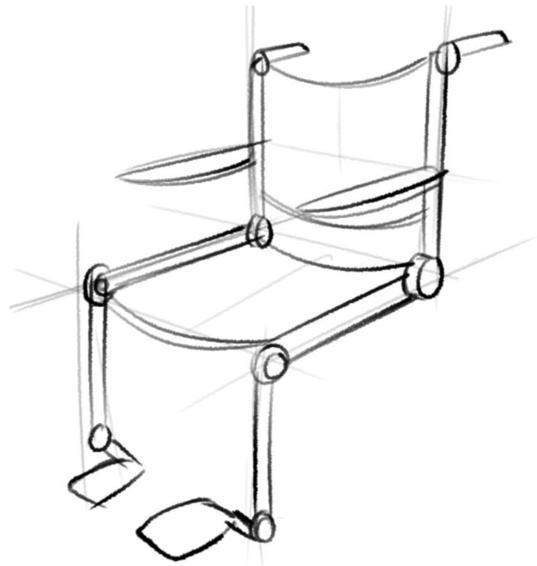
Foldable links - for bed transfer

Tilt-in-space features

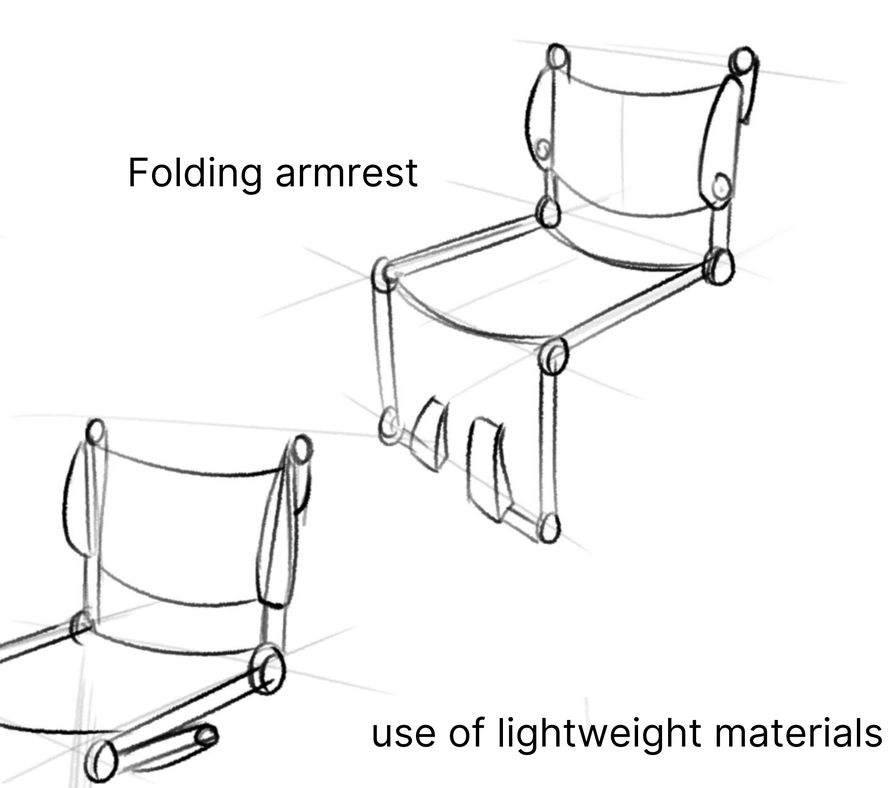
Sliding backrest for easy transfer from back

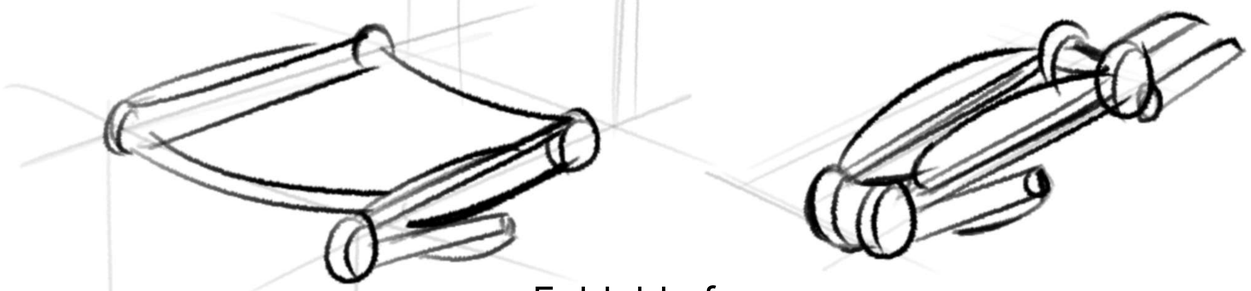
Direction 2: Compact wheelchair

Smaller wheel sizes

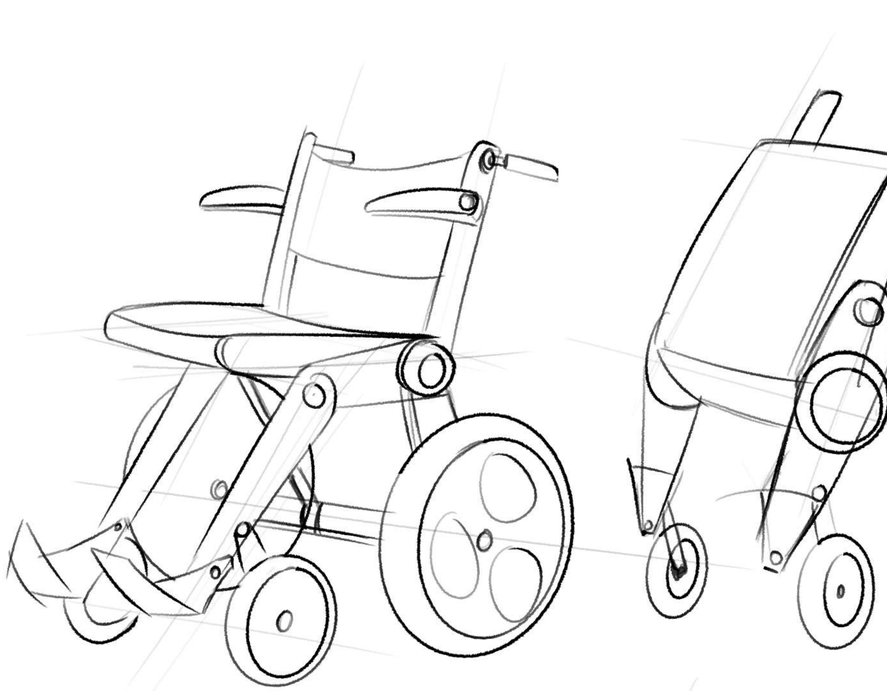


Compact footrest

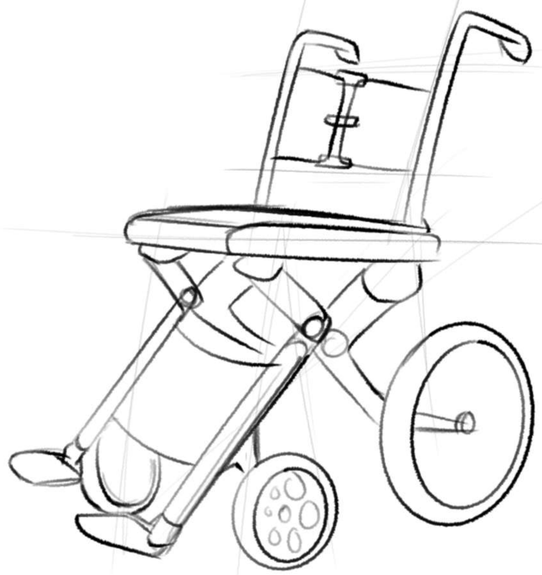




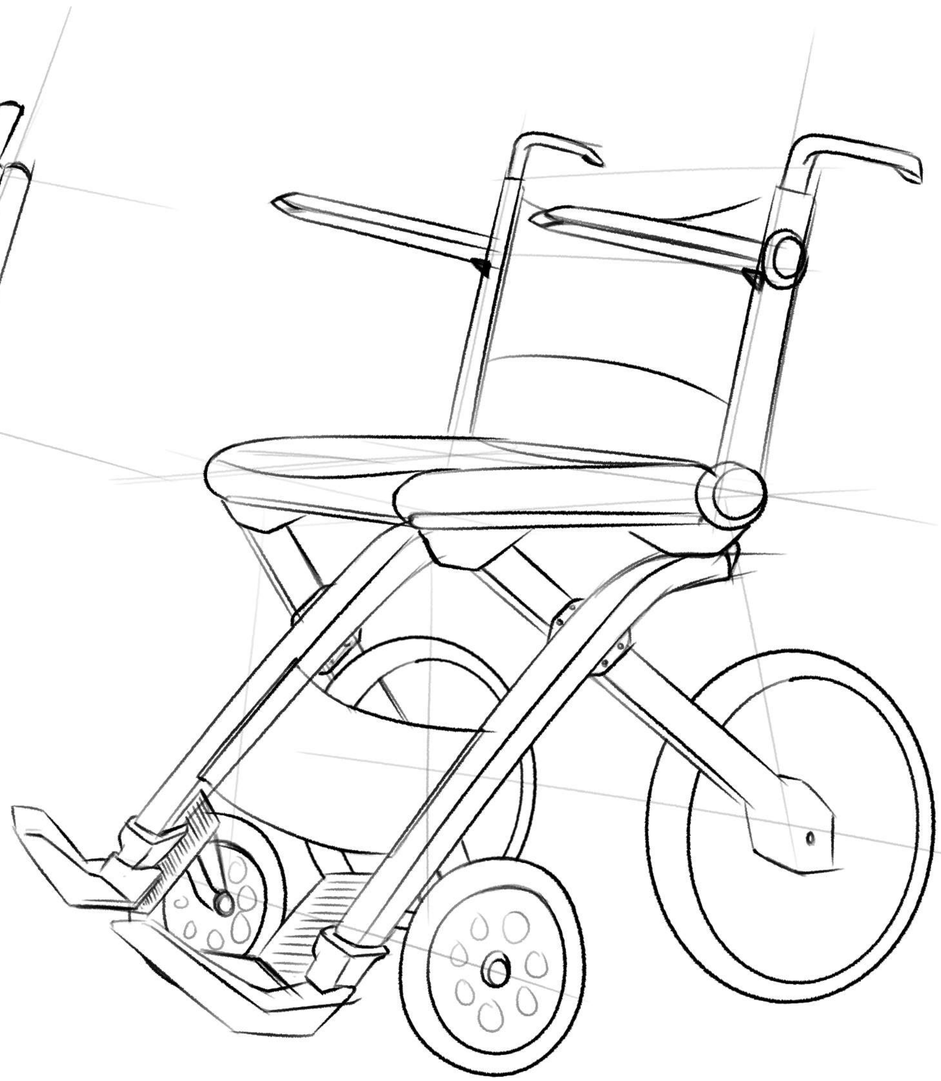
Foldable frames



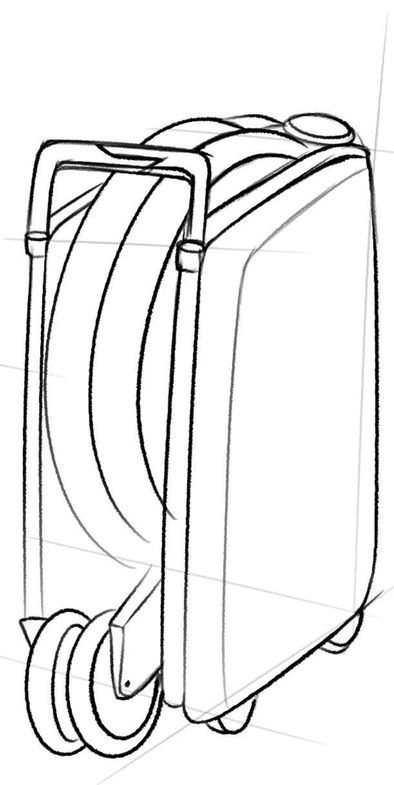
Easy folding mechanisms

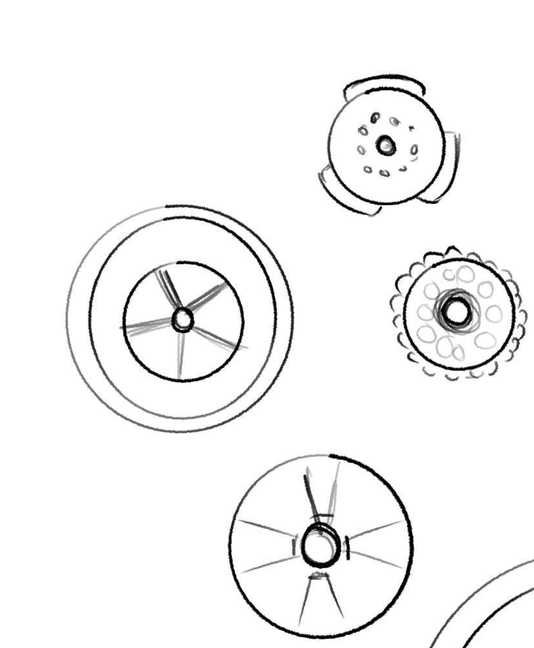


Removable parts

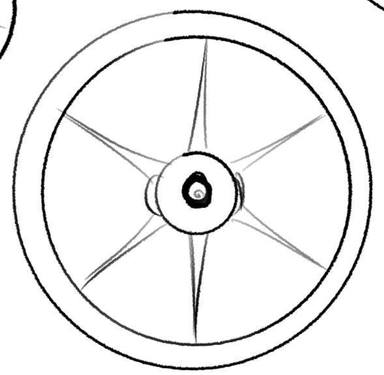


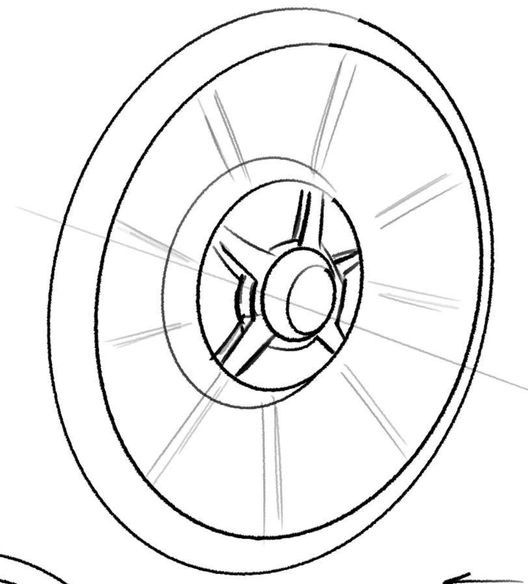
Easy to carry

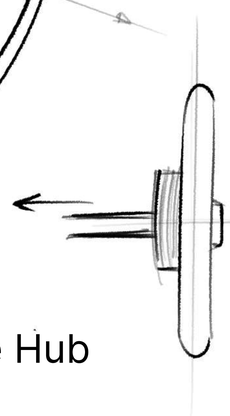




Smaller wheel sizes

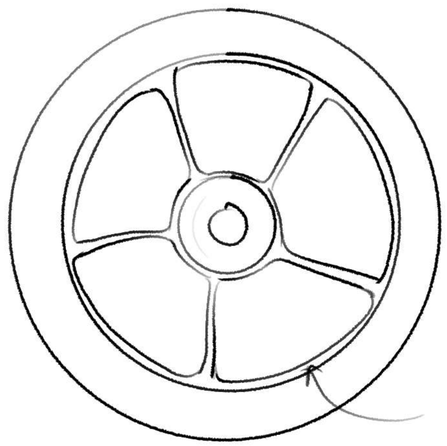




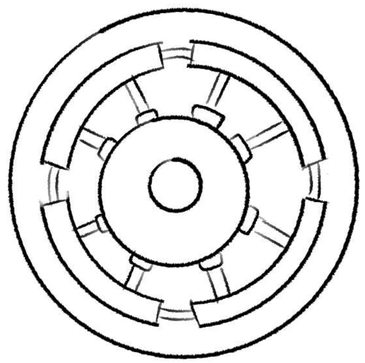


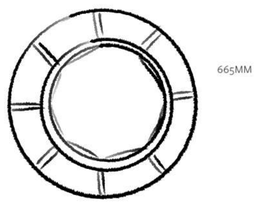
Detachable Hub

Revolve wheel mechanism



Air pockets

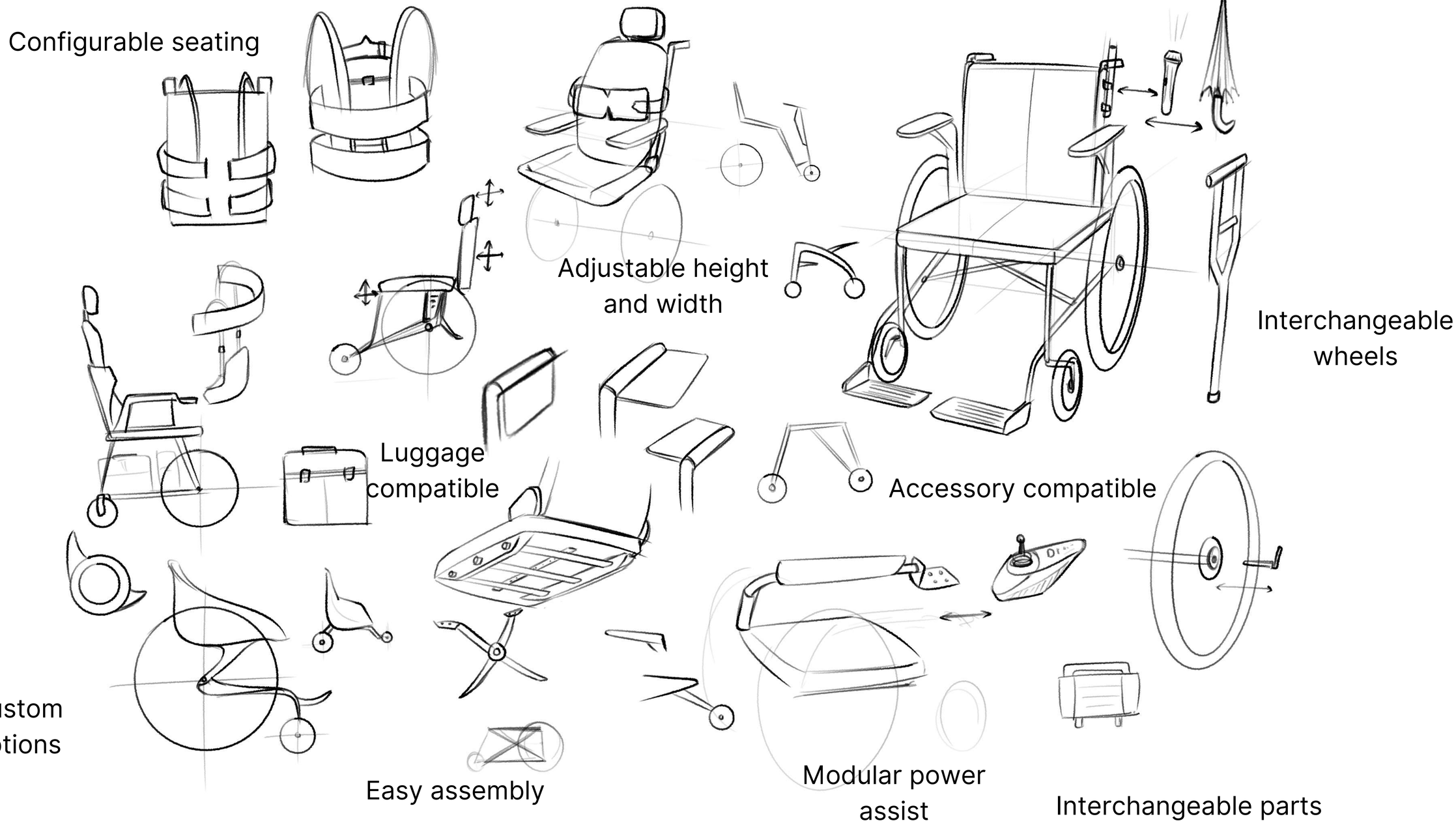




665MM

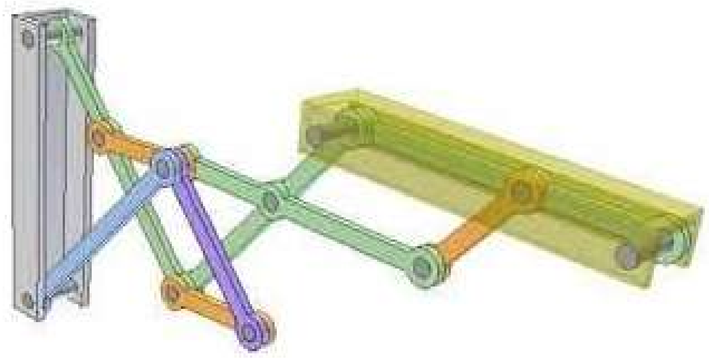
226MM

Direction 3: Modular wheelchair

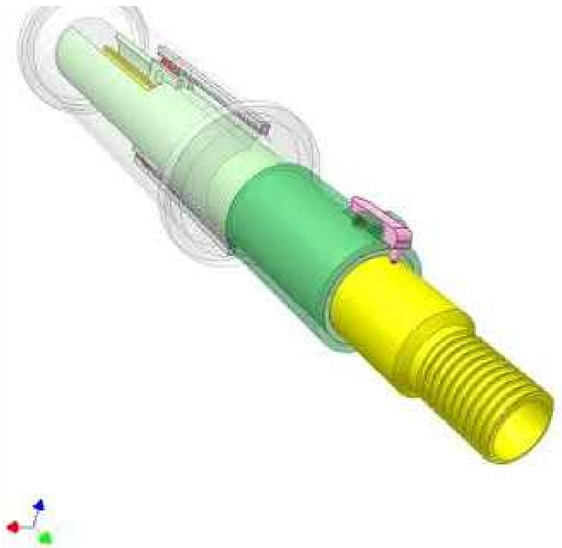


LINKAGES AND FOLDING MECHANISMS

- **Accordion design:** This design features a folding mechanism that allows the wheelchair to collapse down like an accordion, taking up minimal space when not in use.

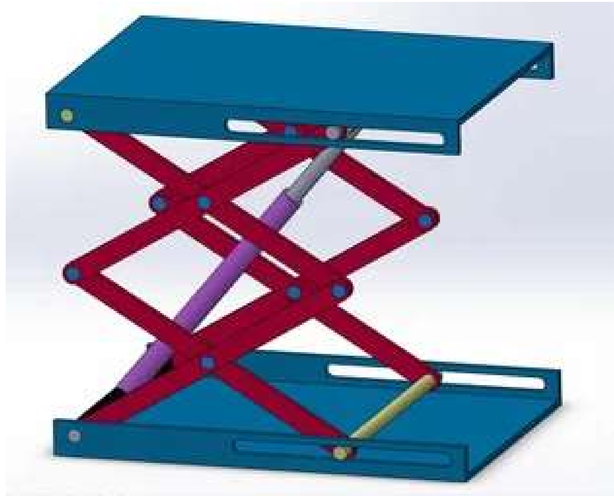


- **Telescoping design:** This design features a telescoping mechanism that allows the wheelchair to collapse down to a smaller size.

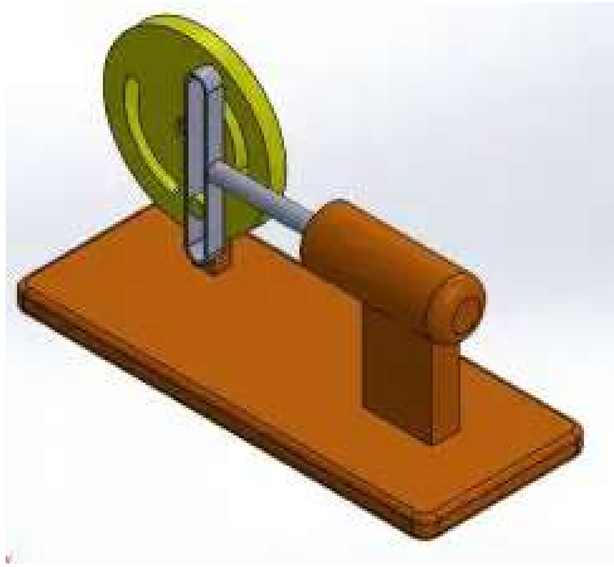


LINKAGES AND FOLDING MECHANISMS

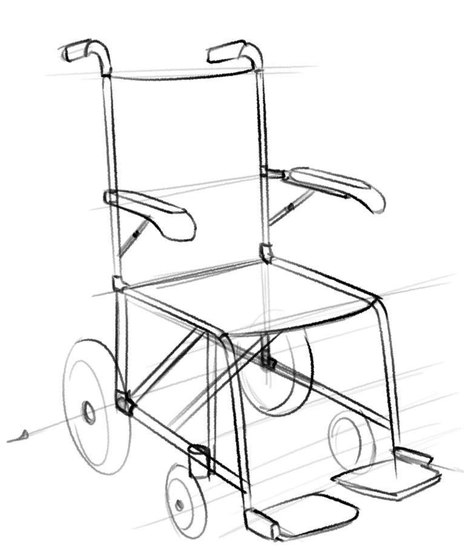
- **Scissor design:** This design features a scissor-like linkage system that allows the wheelchair to fold up into a compact size.

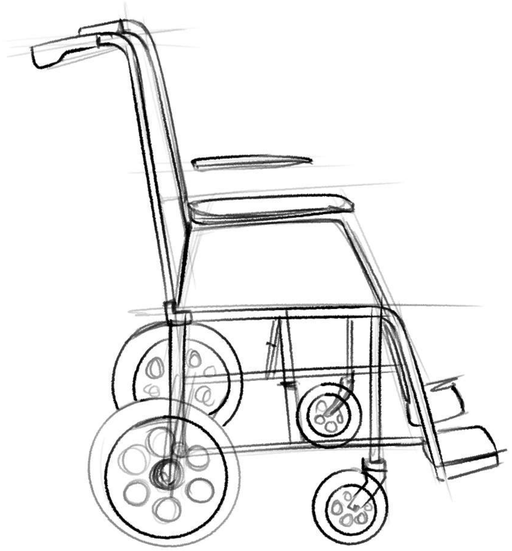


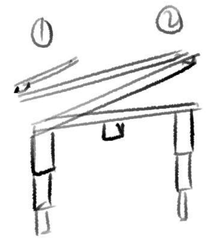
- **Rotary design:** This design features a rotary mechanism that allows the wheelchair to fold up into a compact size.

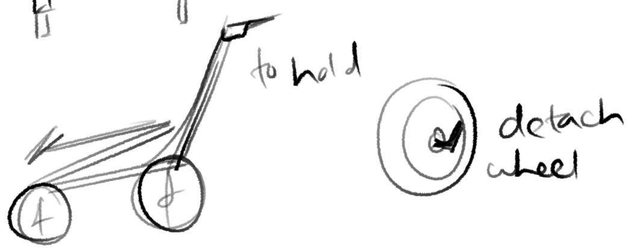


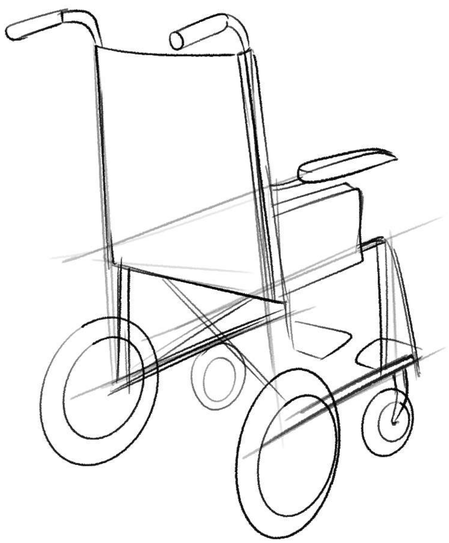
CONCEPT 1

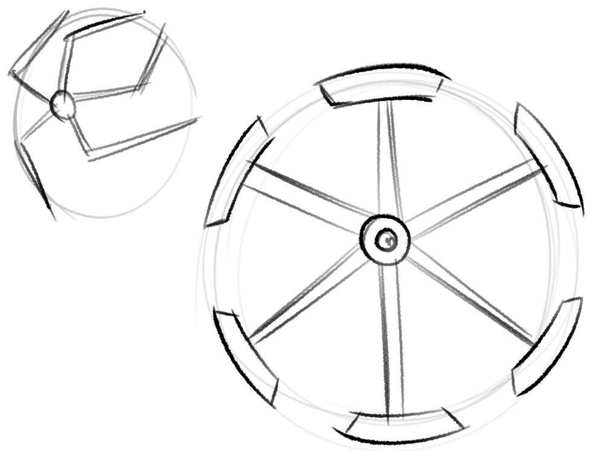




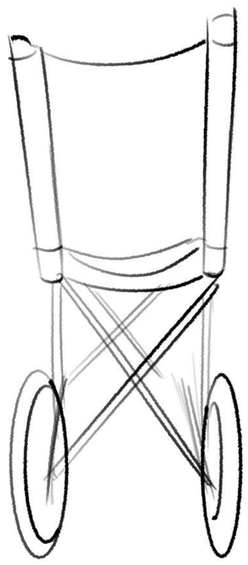




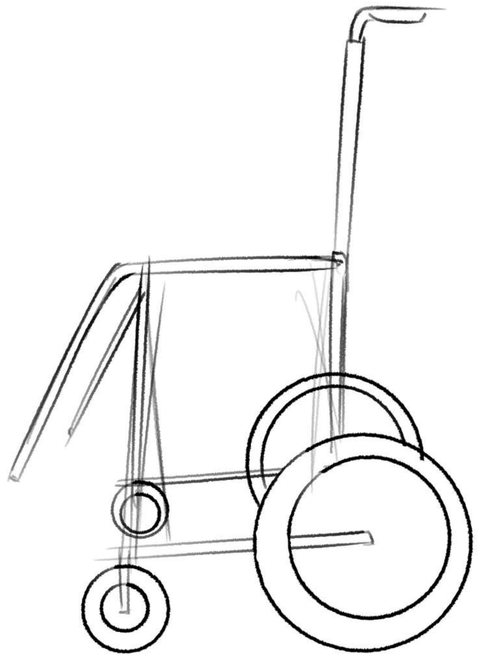


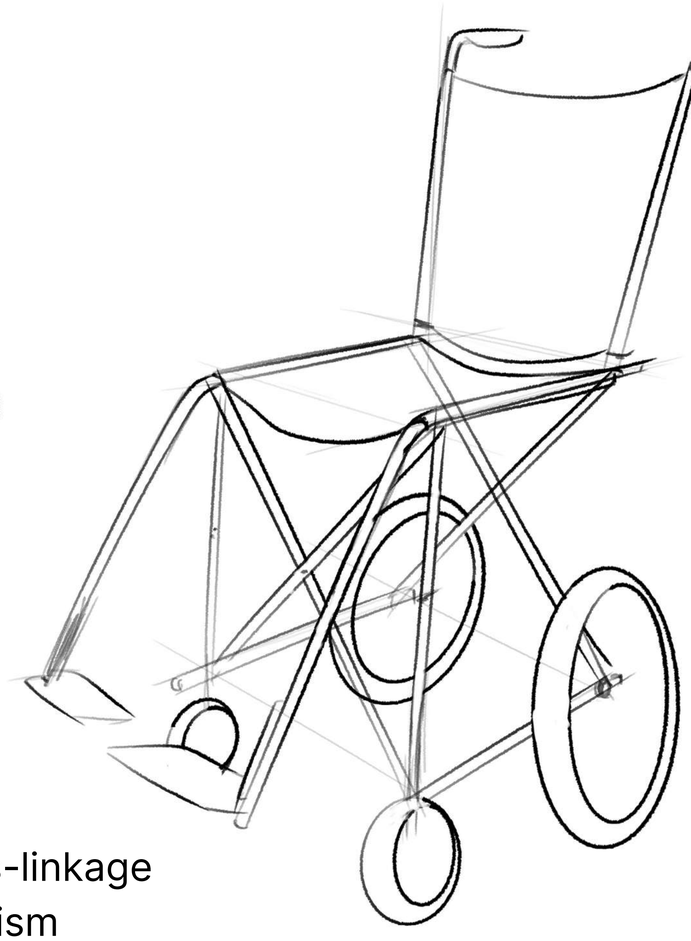


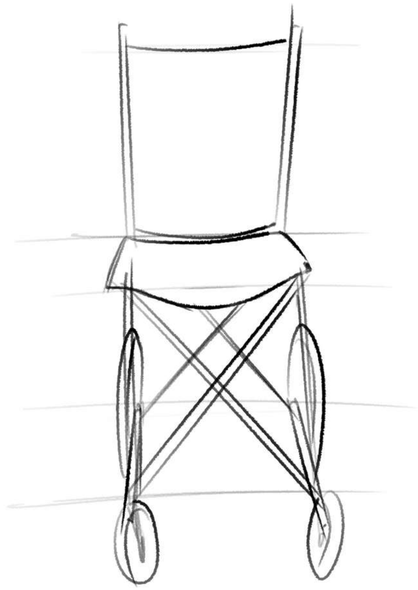
CONCEPT 1



Cloth/leather material

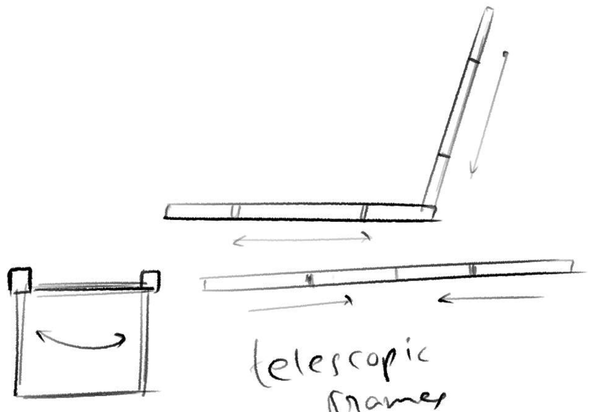


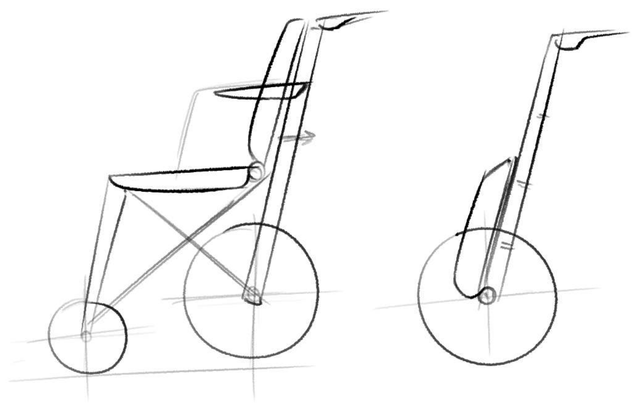




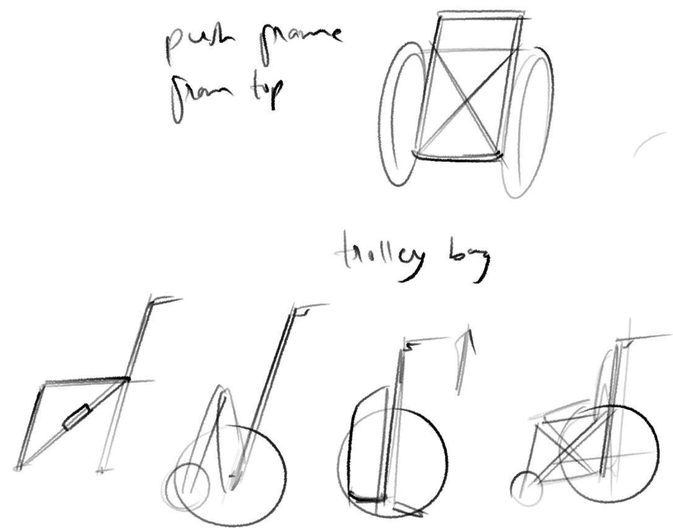
Scissor cross-linkage mechanism

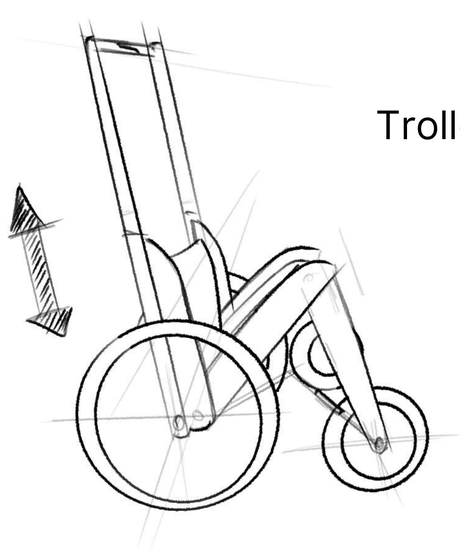
CONCEPT 2



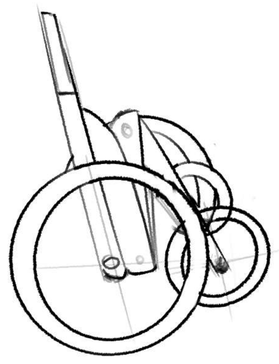


Telescopic frames



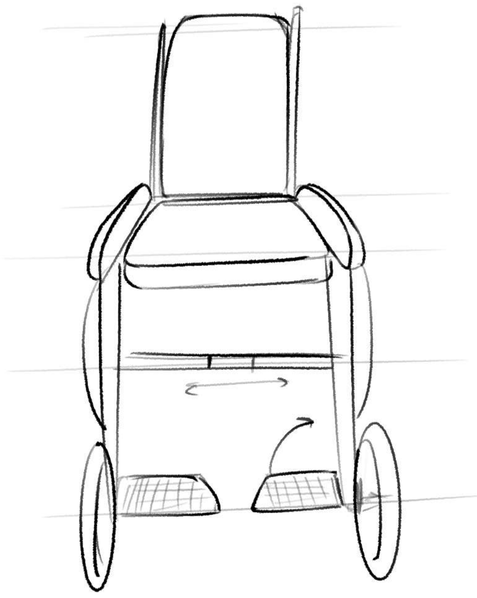


Trolley conversion

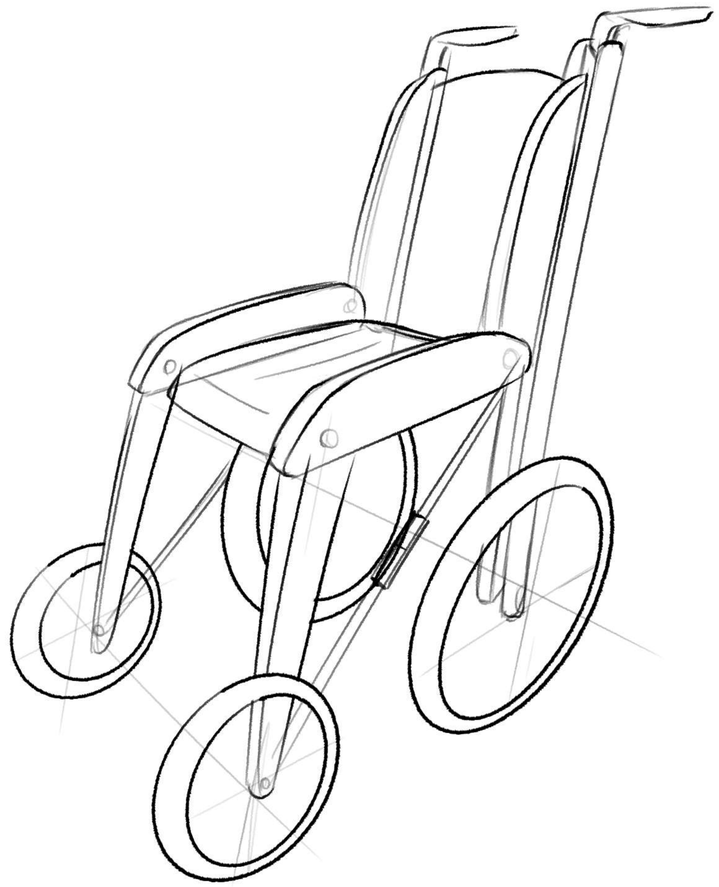


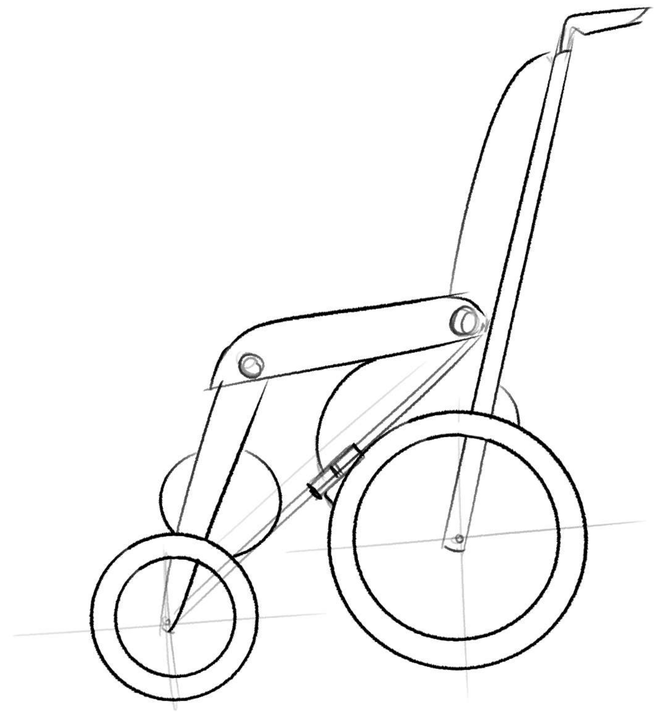
Easy transportation

CONCEPT 2



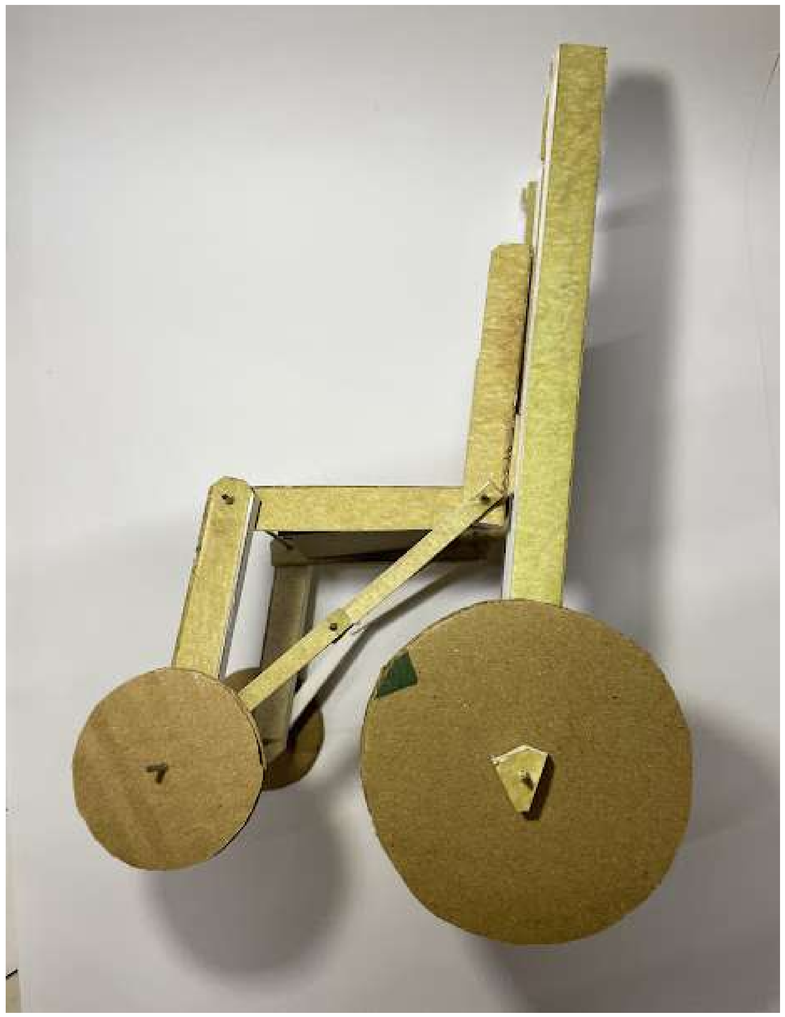
Footrest folding inwards



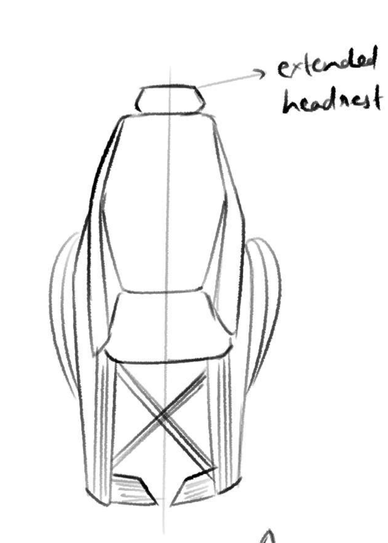


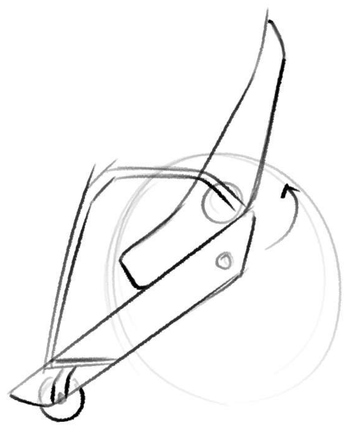
Supporting linkage

CONCEPT 2



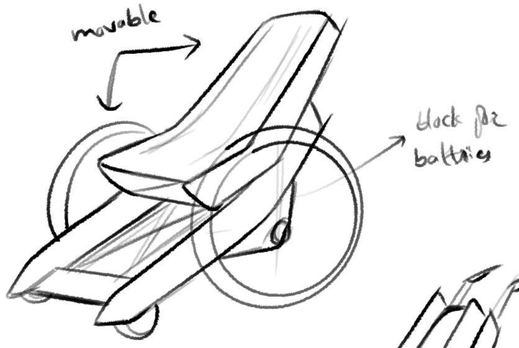
CONCEPT 3

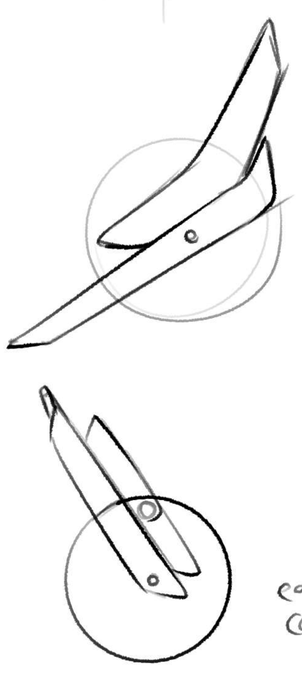




Sliding deck

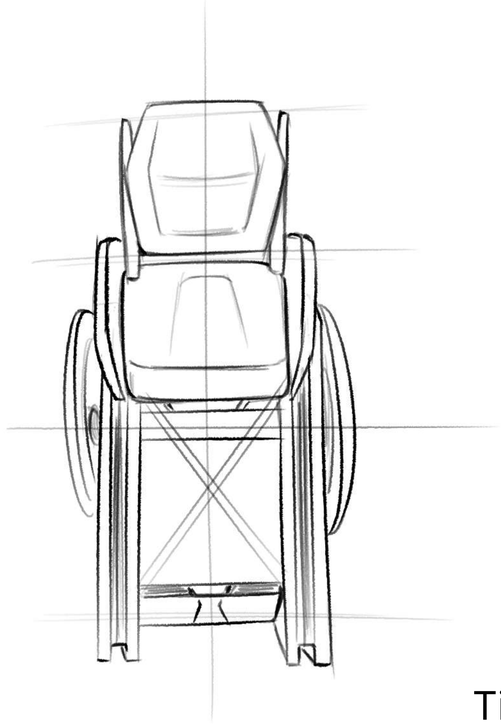
Triple fold

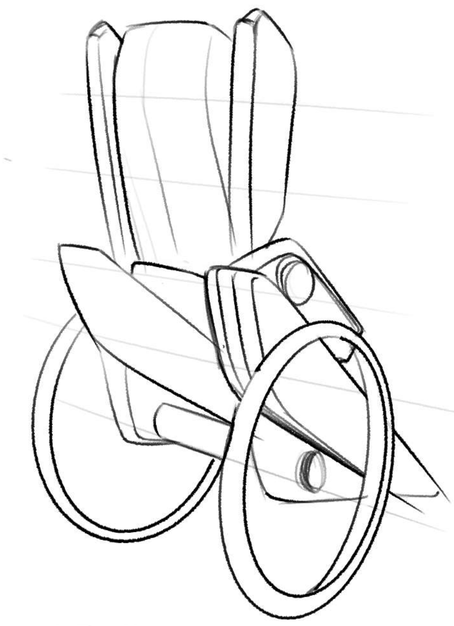




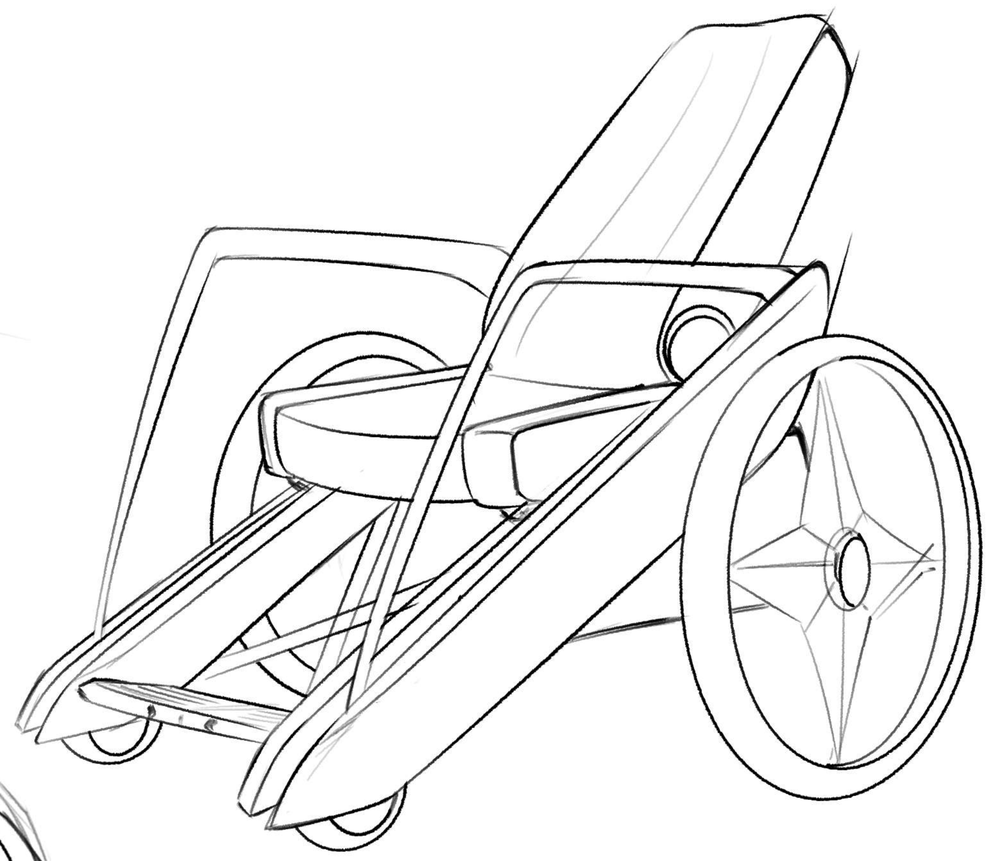
Adjustment according to user

CONCEPT 3

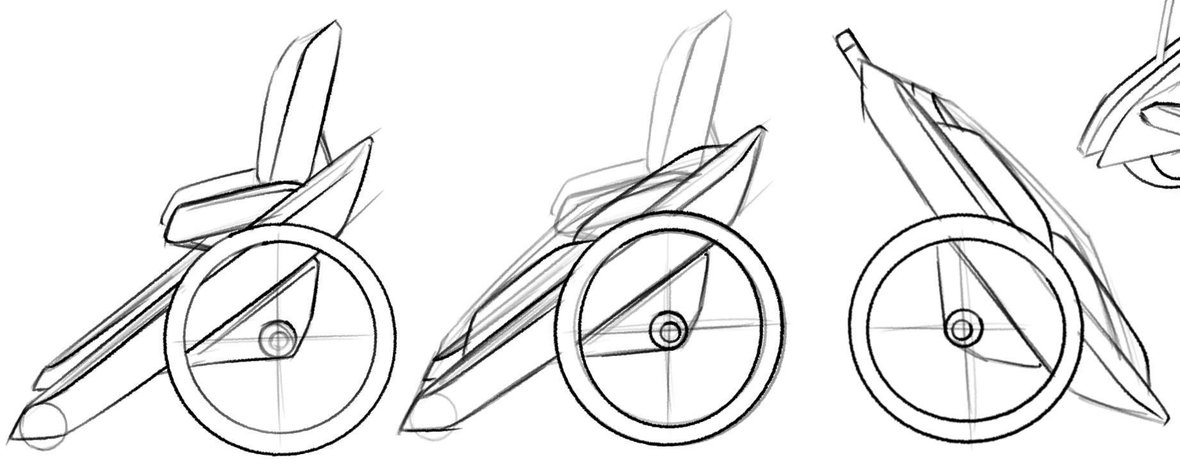




Tilt and Pull

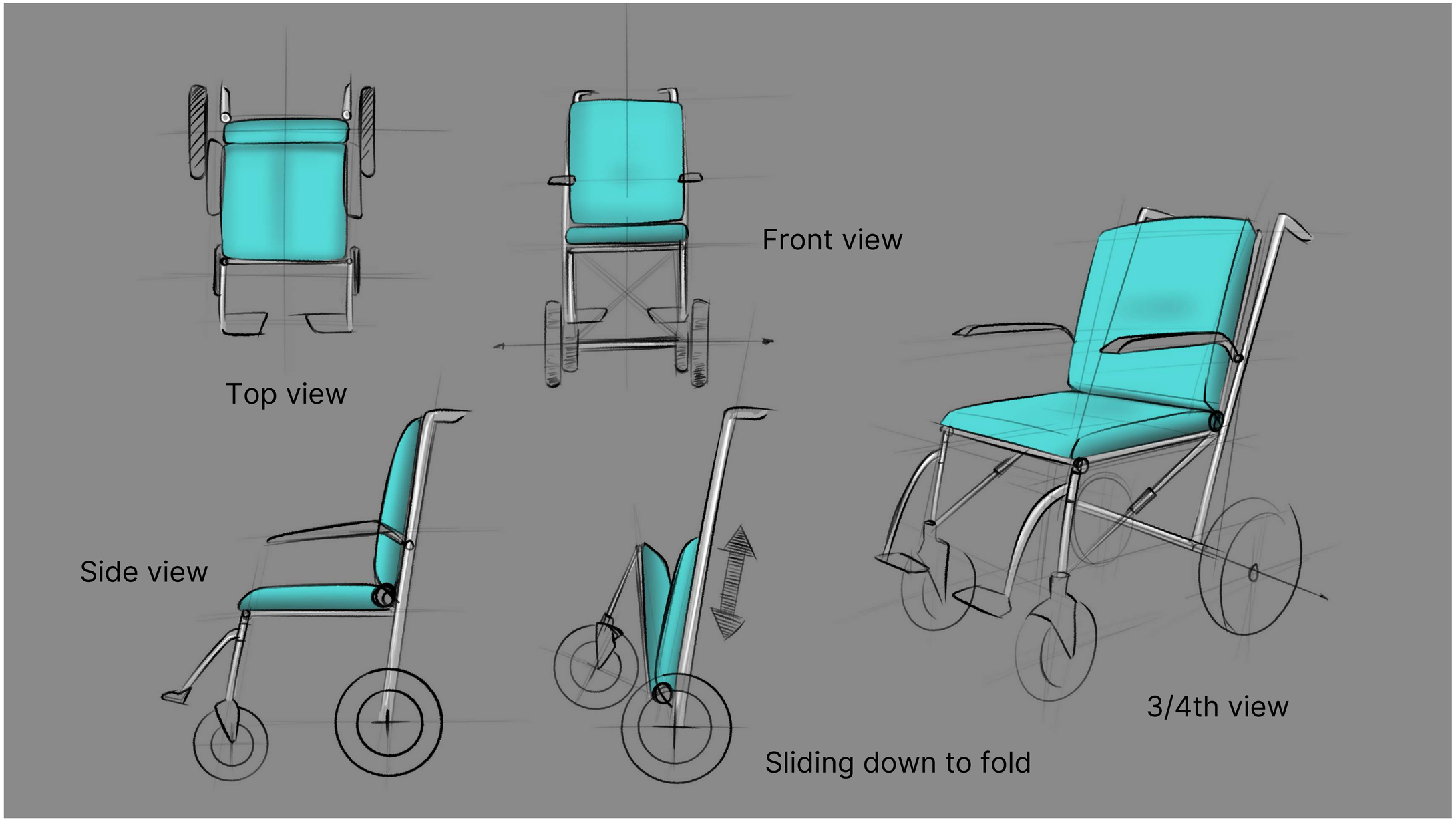


detachable wheels

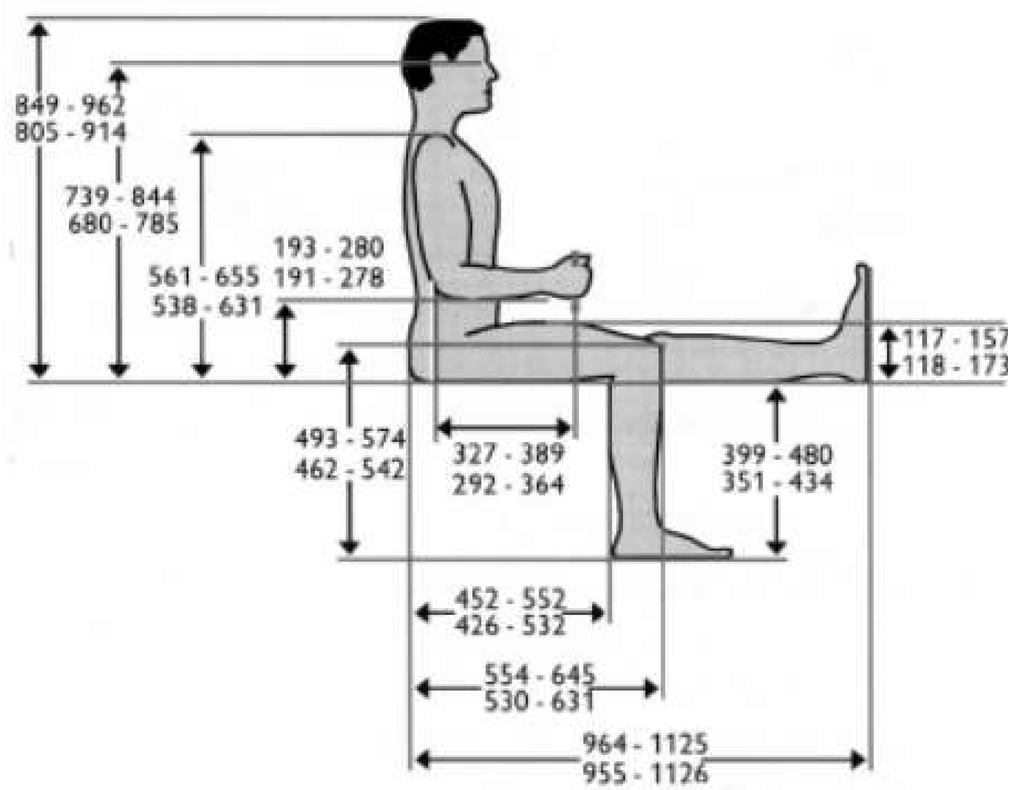


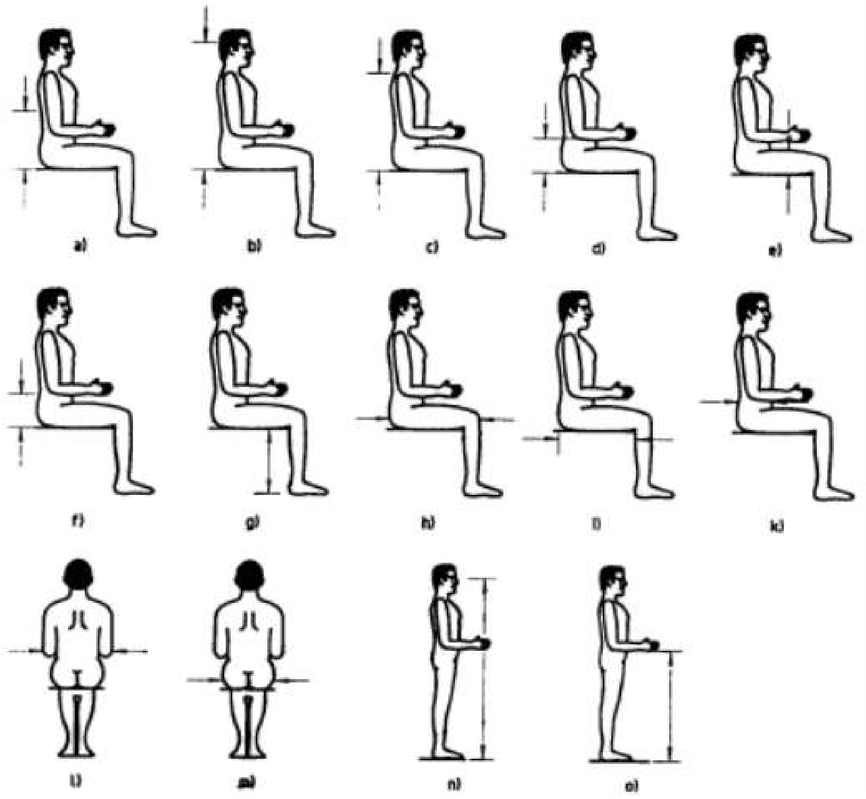
CONCEPT 2

FINAL CONCEPT



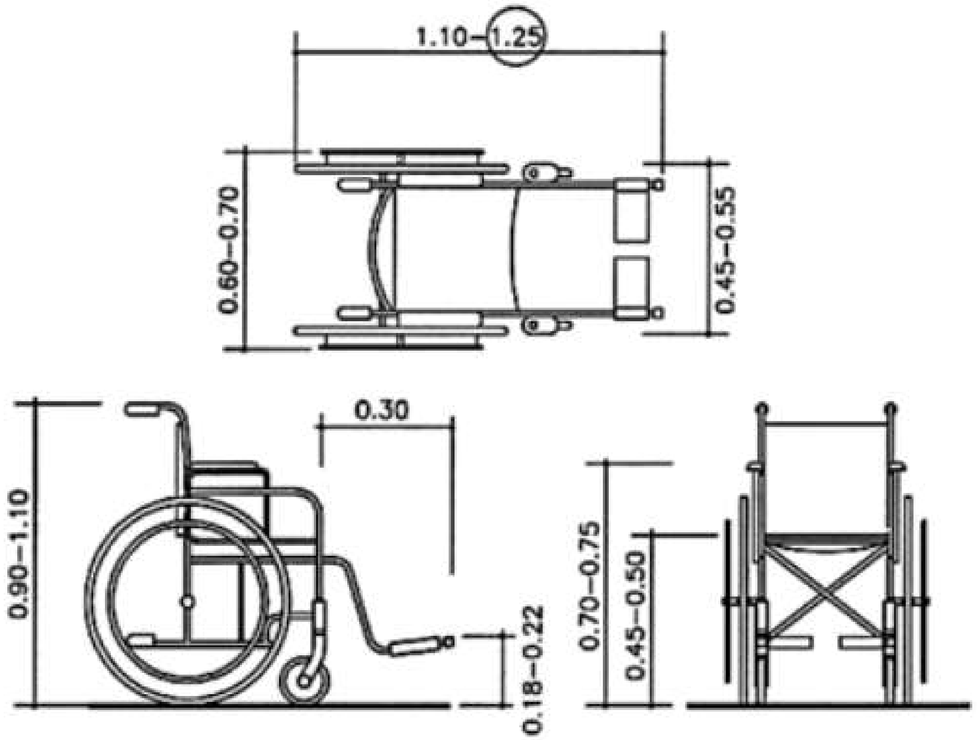
ANTHROPOMETRY



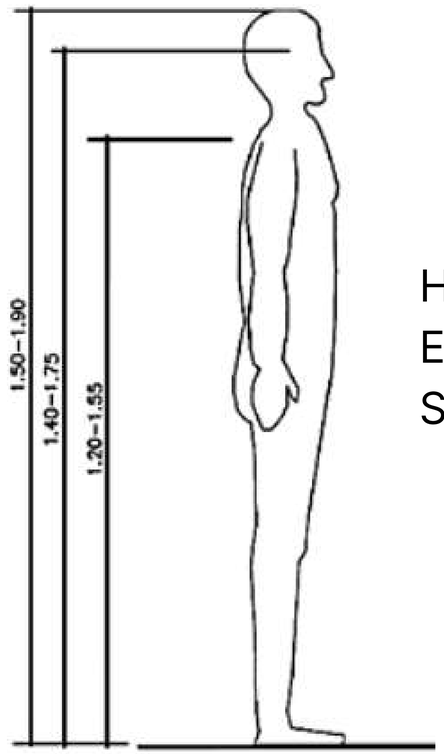


a) height of bottom corner of scapula
b) eye height, sitting
c) shoulder height, sitting
d) elbow height, sitting
e) thigh clearance height, sitting
f) buttock height above seat level
g) popliteal height, sitting
h) buttock knee length
i) buttock popliteal length
k) buttock abdomen depth, sitting
l) elbow-to- elbow breadth
m) hip breadth
n) eye height, standing
o) elbow height, standing

ANTHROPOMETRY



Dimensions shown in the figure are of a conventional manual wheelchair. The larger, encircled dimensions refer to electric wheelchairs.

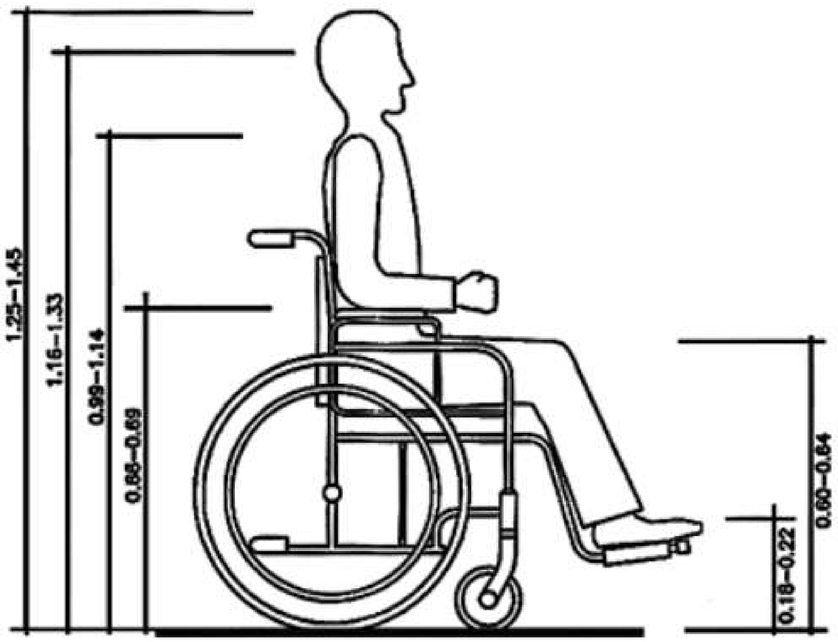


Height	1.50 m - 1.90 m
Eye	1.40 m - 1.75 m
Shoulder	1.20 m - 1.55 m

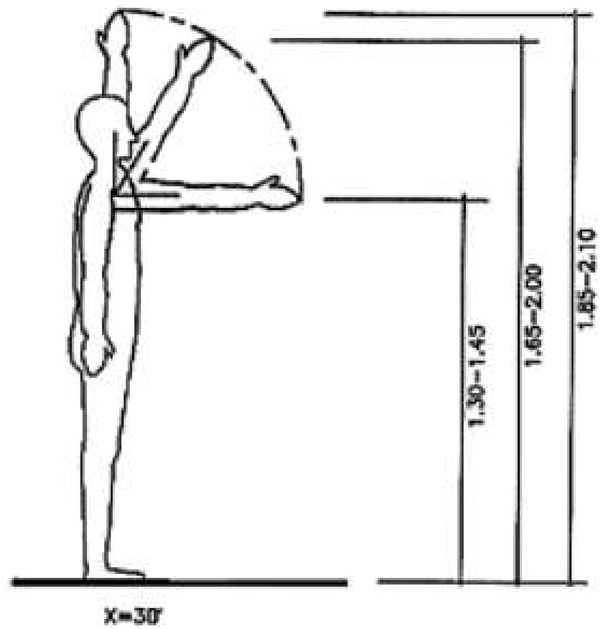
Dimensional data to a normal person

ANTHROPOMETRY

Max. reach up	1.85 m - 2.10 m
Oblique reach up	1.65 m - 2.00 m
Forward reach	1.30 m - 1.45 m



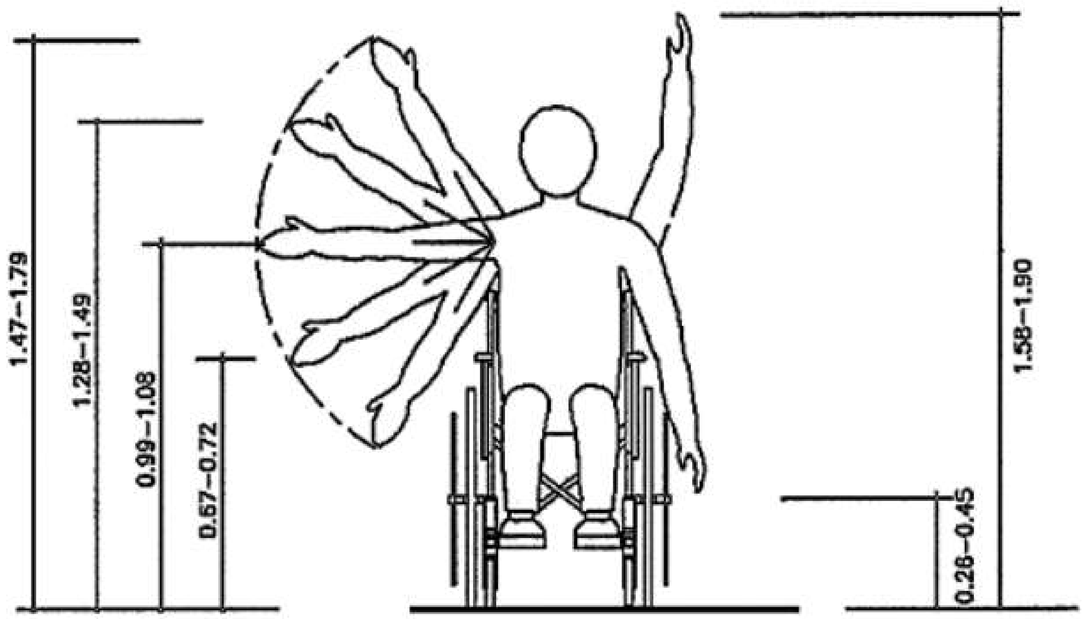
Dimensional data of a wheelchair user



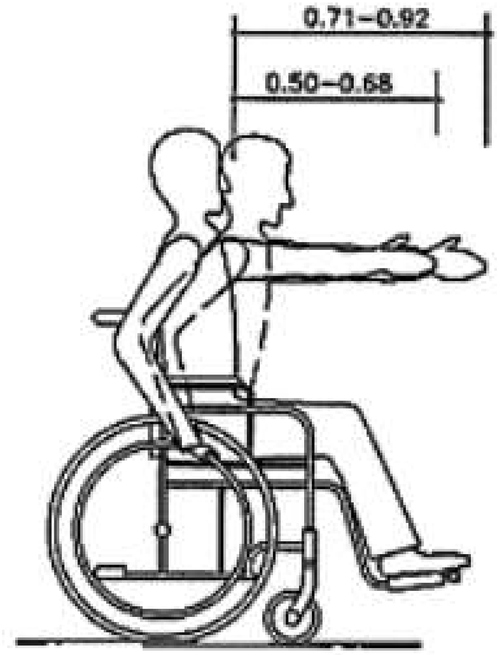
Reaching zones of a normal person

ANTHROPOMETRY

Eye	1.16 m - 1.33 m
Shoulder	0.99 m - 1.14 m

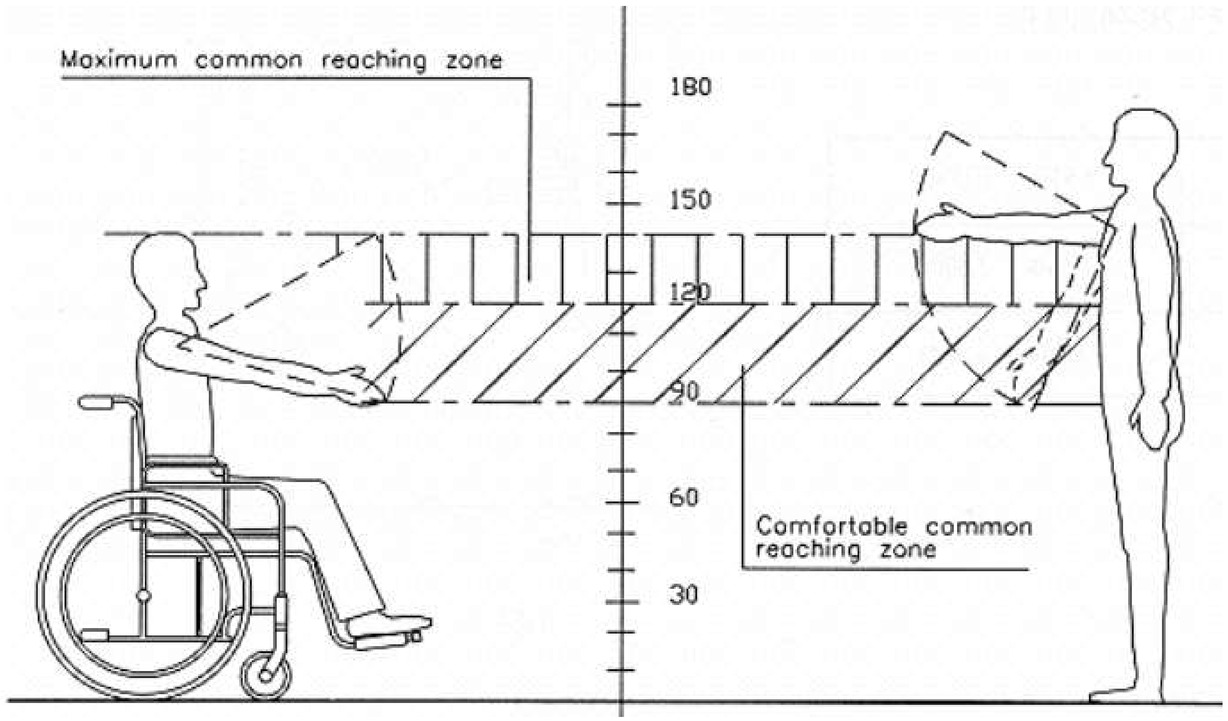


Vertical reaching zones of
a wheelchair user

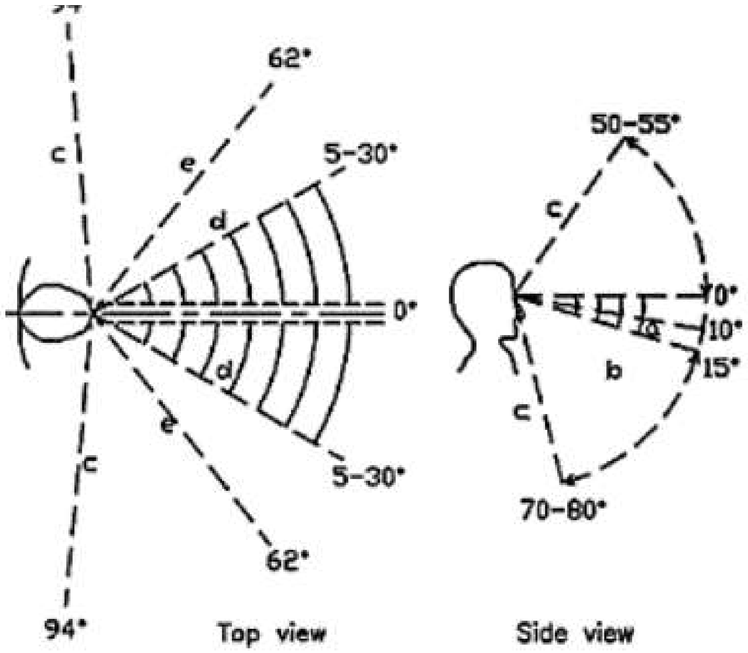


Horizontal forward reach of
a wheelchair person

ANTHROPOMETRY



Common reaching zone

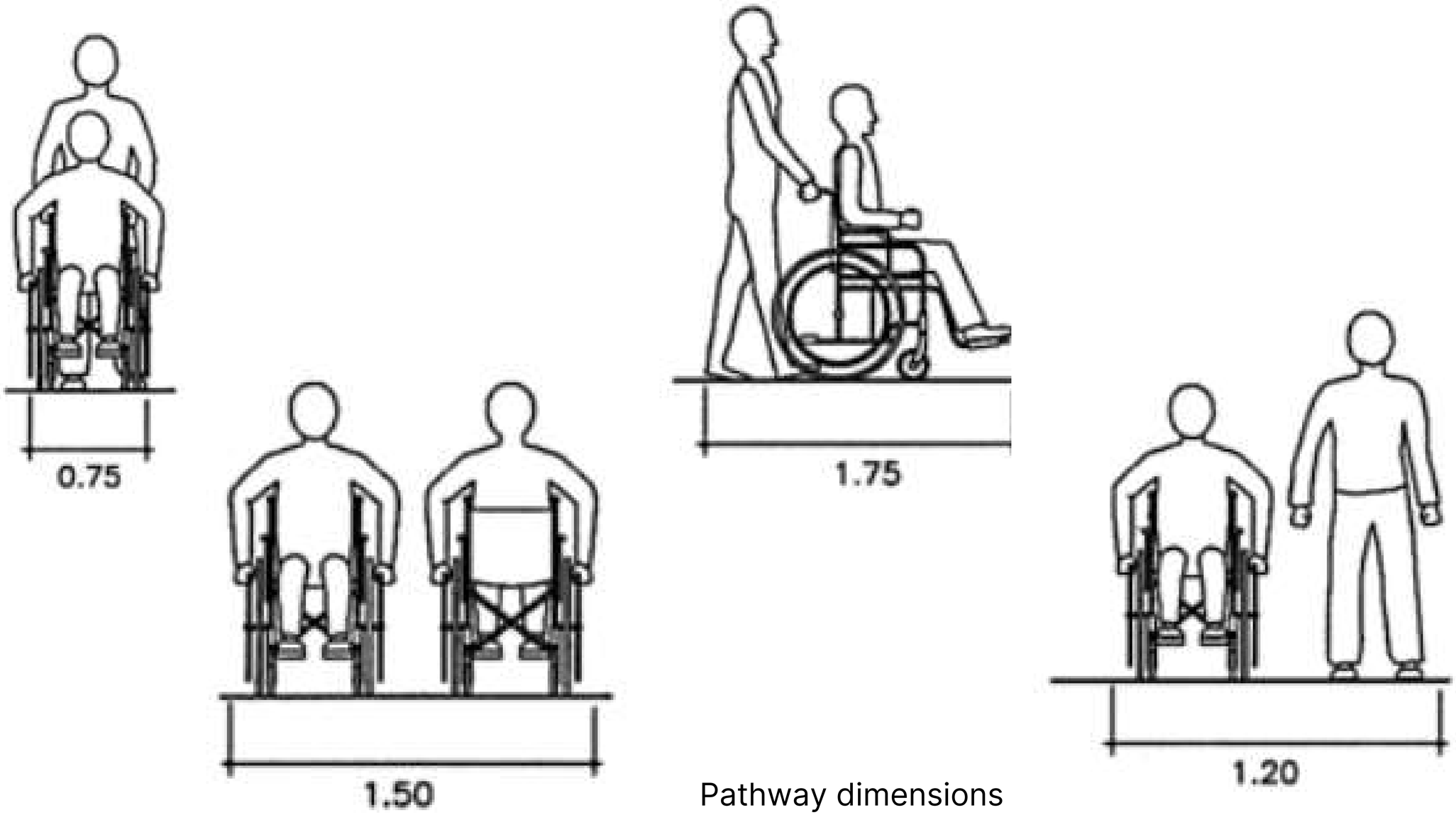


Field of vision

a Normal optical axis, standing person
b Normal optical axis, sitting person
c Limits of field of vision
d Normal angle of vision
e Max. angle of vision

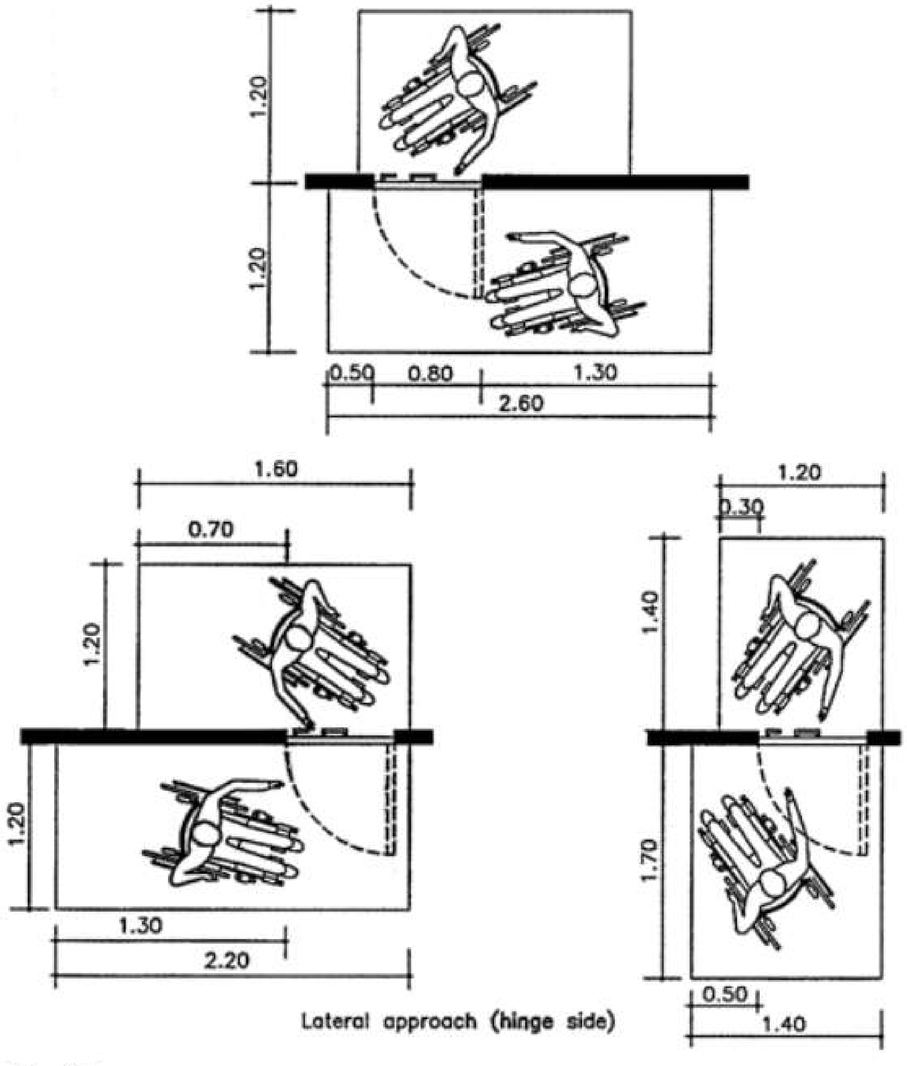
Field of vision

ANTHROPOMETRY

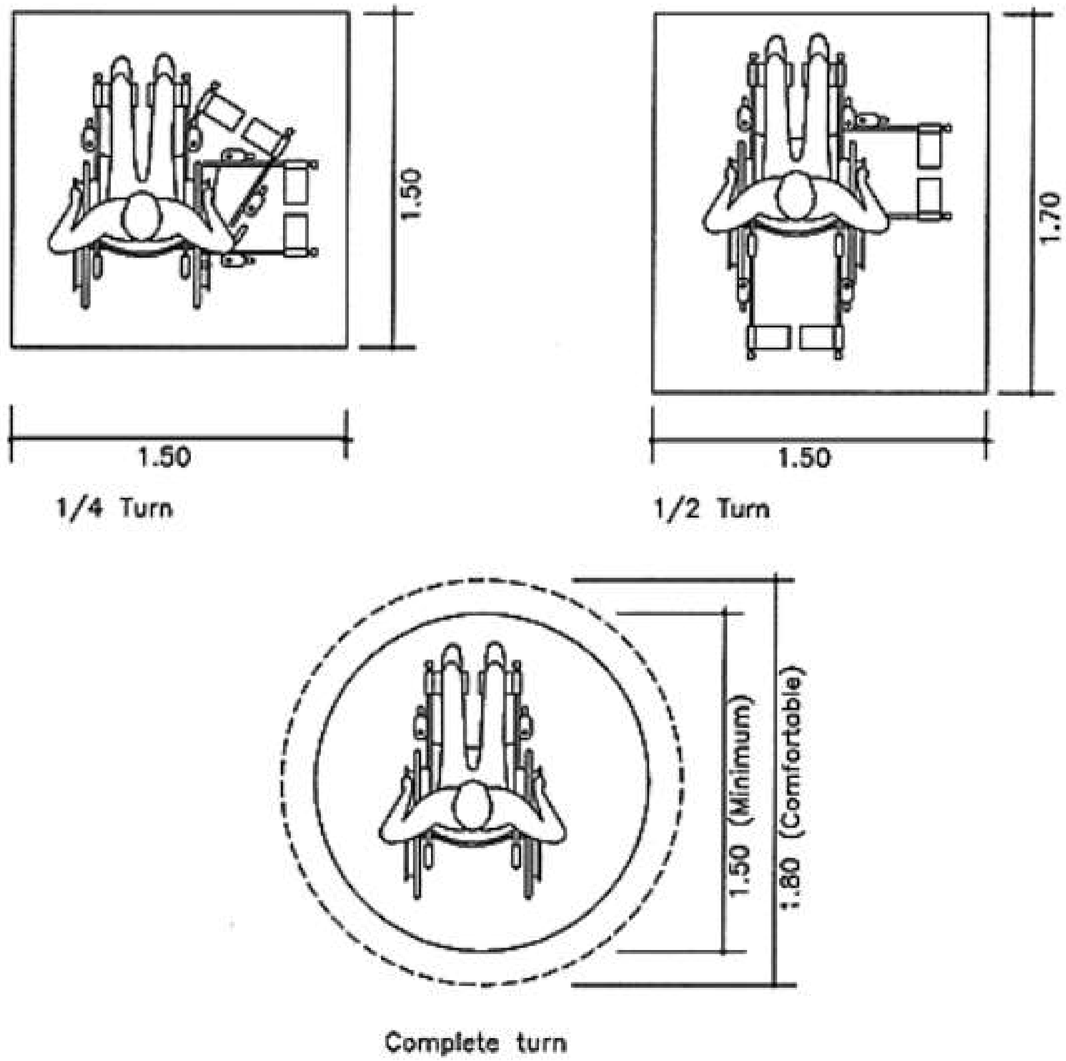


Pathway dimensions

ANTHROPOMETRY

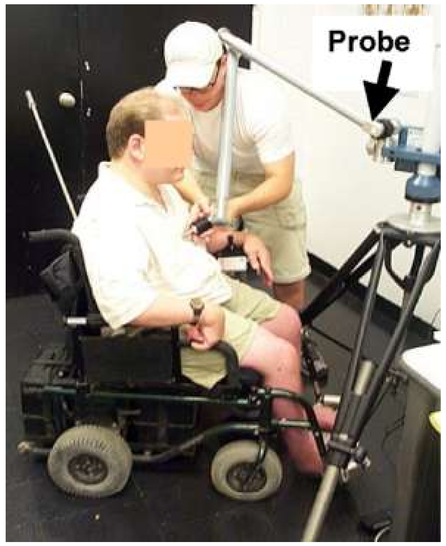


Wheelchair maneuvering space



Maneuvering at doors

ANTHROPOMETRY



Data collection with an electromechanical probe to get quick and accurate measurements of electric mobility wheelchairs and body dimensions.

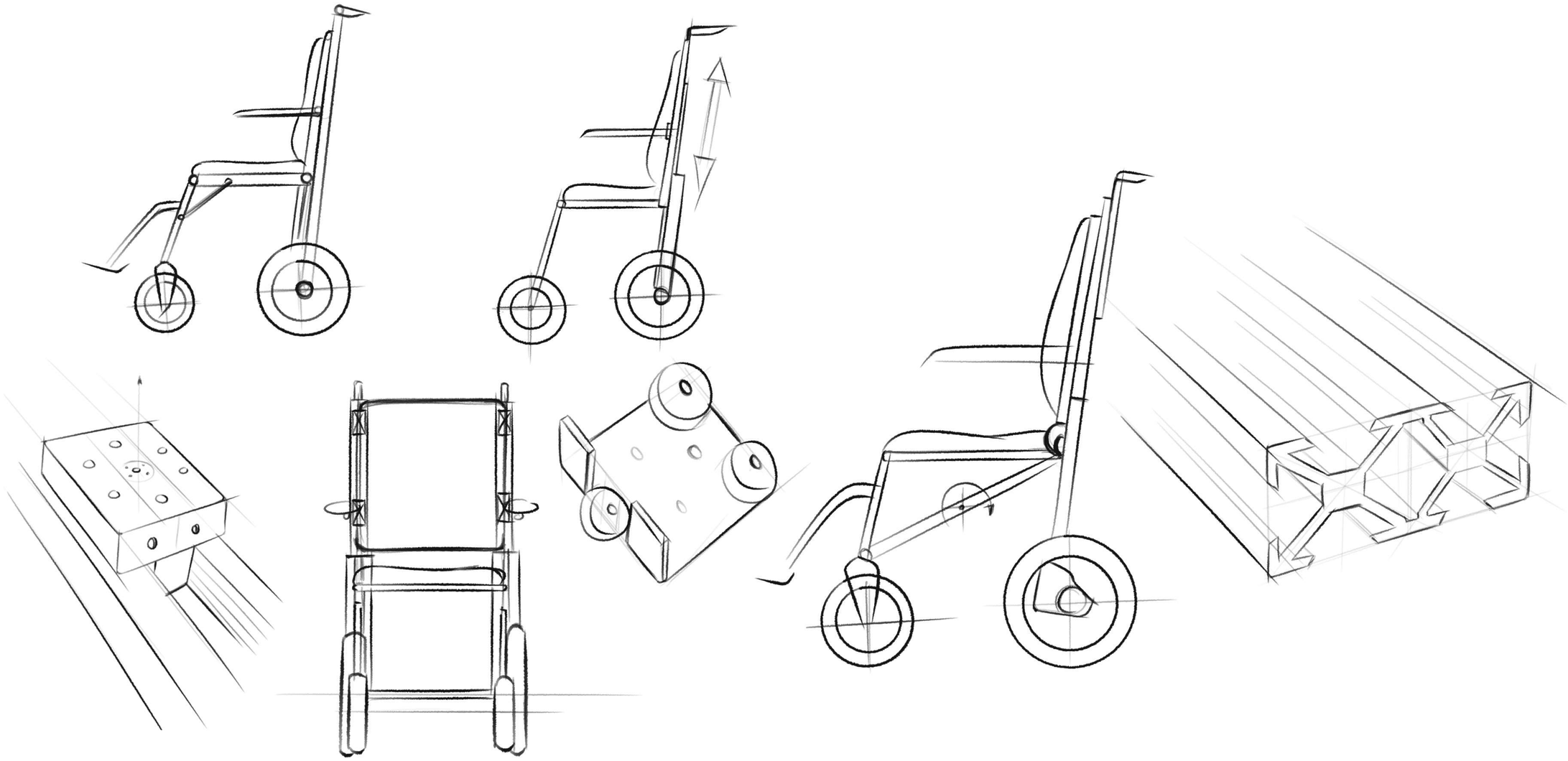
Female wheelchair users

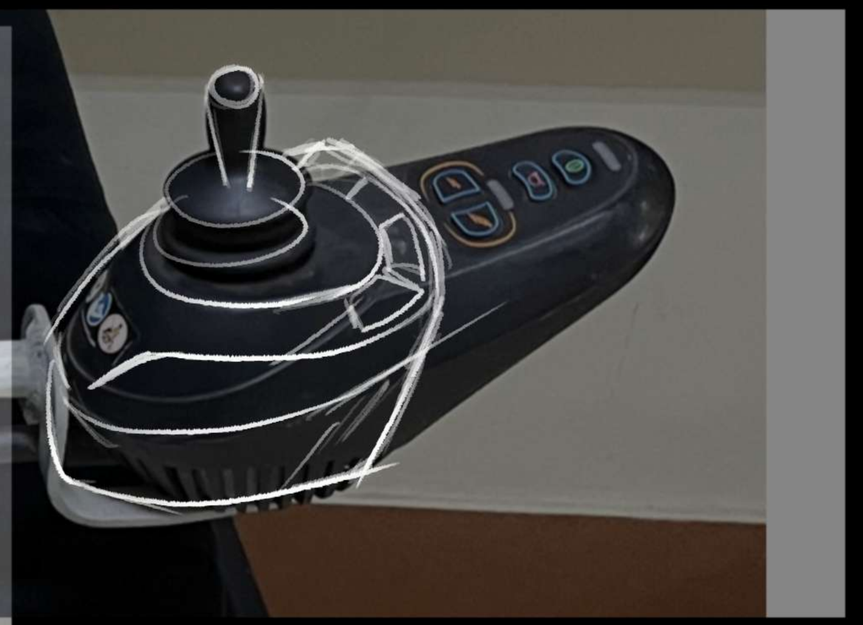
Dimension	Overall sample (n = 46)					Manual chair users (n = 28)					Power chair users (n = 18)				
	Mean	SD	5th	50th	95th	Mean	SD	5th	50th	95th	Mean	SD	5th	50th	95th
Age (years)	49.5	15.0	28	48.5	74	53.1	15.2	33	51	82	44.0	15.0	22	41	72
Heights															
Overall height	125.1	6.3	113.9	125.8	134.3	125.4	5.8	113.9	125.5	134.3	124.6	7.0	113.2	126.1	135.5
Eye height, left	113.9	6.3	104.3	114.7	123.7	113.6	5.4	104.8	114.7	123.7	114.3	7.6	99.6	115.4	124.1
Eye height, right	114.2	6.5	103.0	115.0	125.5	114.0	5.6	104.6	114.9	125.5	114.7	7.9	102.0	116.1	125.7
Acromion height, left	99.7	5.2	91.3	100.5	106.9	99.3	4.9	91.8	99.4	106.9	100.3	5.7	88.6	100.7	109.9
Acromion height, right	99.8	5.4	92.0	99.6	109.7	99.5	5.1	92.3	98.9	109.9	100.3	5.9	90.3	100.9	109.7
Elbow rest height, left	73.4	4.9	65.8	73.4	80.5	71.9	3.9	65.8	73.0	77.6	75.6	5.5	64.3	76.6	86.2
Elbow rest height, right	72.9	4.1	66.4	73.7	80.1	71.8	4.0	65.8	72.4	76.0	74.6	3.8	68.7	74.2	81.3
Wrist height, left	77.1	6.6	64.9	77.0	88.2	75.7	6.5	62.6	76.8	87.2	79.4	6.3	70.2	79.7	90.6
Wrist height, right	78.2	9.5	63.3	77.4	93.1	75.1	8.1	62.2	75.4	90.1	83	9.6	66.6	84.9	101.6
Sitting height	73.6	6.3	62.1	74.1	83.3	75.3	4.9	66.3	74.9	83.3	71	7.3	58.9	73.0	86.8
Knee to footrest height, Left[m]	45.3	7.5	30.8	45.8	55.8	47.8	6.4	32.8	48.4	56.2	41.3	7.6	23.0	42.0	55.5
Knee to footrest height, right[o,m]	44.8	7.8	30.0	45.0	55.5	46.8	7.5	30.0	47.4	55.5	41.7	7.4	25.4	42.4	56.6
Knee height, left[p]	62.1	5.4	53.9	61.4	70.8	60.4	5.2	53.8	59.4	70.4	64.6	4.6	58.3	63.9	74.1
Knee height, right	62.8	5.8	54.6	62.3	71.5	61.2	5.3	53.2	60.9	71.0	65.2	5.7	55.5	64.3	81.0
Breadths															
Overall breadth[o,m]	70.8	7.9	61.3	68.9	85.2	69.6	7.6	60.8	67.5	84.4	72.8	8.2	61.6	72.1	90.6
Bideltoid breadth	50.6	6.8	39.2	49.9	63.2	51.2	6.5	39.1	50.6	62.0	49.6	7.4	39.2	48.4	63.9
Biacromial breadth	33.5	4.1	26.9	33.7	40.5	33.6	4.3	26.9	33.8	40.6	33.4	4.0	25.5	33.3	40.5
Forearm to forearm breadth	59.9	8.1	44.8	59.7	72.6	58.5	7.8	44.9	59.2	72.6	61.0	8.5	42.4	61.2	76.5
Hand breadth, left	8.0	0.8	6.6	8.1	9.4	8.1	0.8	7.1	8.1	9.5	7.9	0.7	6.2	7.9	9.3
Hand breadth, right	8.1	0.6	7.0.	8.1	8.8	8.1	0.6	7.0	8.1	8.8	8.1	0.6	6.9	8.2	9.1
Hip breadth[o,p]	27.7	5.2	21.6	26.1	38.3	27.9	5.2	21.6	26.8	38.3	27.4	5.4	21.2	25.3	41.8
Waist breadth	43.1	5.1	36.6	43.0	51.9	43.1	4.6	36.6	42.7	50.8	43.2	6.0	32.4	43.7	53.8
Thigh breadth	44.4	8.2	33.8	43.2	60.3	43.6	7.6	33.8	42.8	59.6	45.5	9.1	31.7	43.6	65.5
Bimalleolar breadth, left	8.1	1.4	6.3	7.9	10.5	7.9	1.4	6.2	7.7	10.5	8.4	1.4	6.5	8.2	11.5
Bimalleolar breadth, right	8.4	1.4	6.7	8.1	10.6	8.2	1.4	6.4	7.9	10.6	8.6	1.3	6.7	8.4	10.7
Depths and lengths															
Overall depth	119.0	10.0	104.8	118.9	134.0	116.8	9.3	102.5	116.1	132.9	122.4	10.4	106.8	122.2	152.9
Abdominal extension depth	36.5	5.6	28.4	35.8	45.7	36.1	5.8	26.4	34.9	45.7	37.2	5.5	27.3	36.5	46.3
Buttock–knee length, left[p]	62.5	6.8	55.2	62.9	76.0	63.5	4.9	55.2	63.7	69.2	60.9	9.1	34.7	61.0	76.1
Buttock–knee length, right[o]	62.4	6.2	54.8	62.5	74.4	62.8	4.0	56.5	62.8	67.4	61.9	8.7	38.7	61.3	77.9
Buttock–popliteal length, left	52.1	5.2	45.1	51.9	58.9	52.7	4.1	46.9	51.8	58.9	51.2	6.7	35.1	51.8	65.4
Buttock–popliteal length, right[o,m]	52.8	7.2	41.5	52.6	46.4	53.6	6.7	43.4	52.9	64.6	51.5	8.0	31.7	52.6	67.2

Male wheelchair users

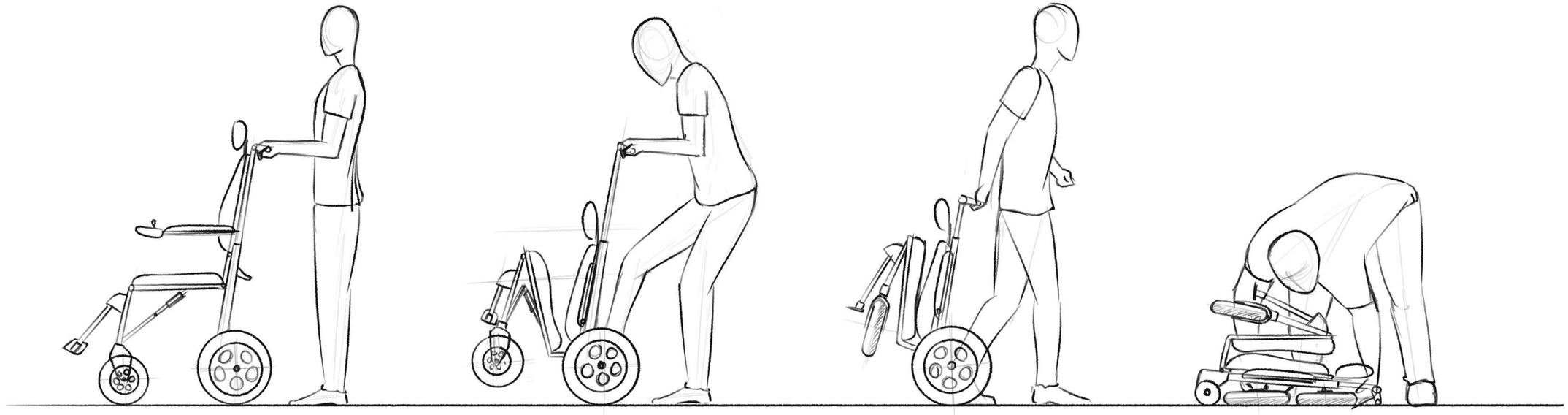
Dimension	Overall sample (n = 75)					Manual chair users (n = 37)					Power chair users (n = 38)				
	Mean	SD	5th	50th	95th	Mean	SD	5th	50th	95th	Mean	SD	5th	50th	95th
Age	52.0	15.6	23	52	80	57.3	15.6	33	57	81	46.5	13.8	22	46	70
Heights															
Overall height	130.9	6.0	121.6	131.2	139.4	130.6	4.7	123.6	131.0	137.9	131.2	7.1	121.4	131.2	149.4
Eye height, left	119.6	5.7	111.0	119.5	127.2	119.2	4.4	111.8	119.5	126.0	120.0	6.7	110.9	119.9	137.8
Eye height, right	119.4	5.8	110.5	119.3	127.0	118.8	4.7	112.5	119.0	126.6	120.0	6.6	109.8	120.0	136.7
Acromion height, Left[o]	104.2	5.4	94.1	104.6	114.0	103.8	3.8	94.1	104.6	109.6	104.6	6.6	93.6	104.4	120.3
Acromion height, right[o,p]	104.3	5.0	94.6	104.6	113.4	103.8	4.2	93.0	104.3	109.9	104.8	5.6	94.6	104.7	119.1
Elbow rest height, left	74.1	5.8	63.9	73.5	84.0.	73.1	5.1	63.9	73.3	80.4	75.1	6.2	62.3	75.8	84.8
Elbow rest height, right	74.1	4.9	64.7	73.7	83.7	72.8	4.1	64.2	72.8	79.3	75.2	5.3	65.7	73.9	85.1
Wrist height, left	77.7	7.2	66.7	77.7	91.5	76.5	6.6	66.4	76.2	94.3	78.9	7.7	67.9	78.3	91.5
Wrist height, right	77.5	7.7	64.8	77.0	89.2	75.4	6.3	63.5	74.9	87.3	79.5	8.5	64.8	79.3	90.2
Sitting height[o]	77.3	6.0	67.8	78.6	85.0	79.6	4.7	69.4	80.3	86.7	75.0	6.3	60.1	75.6	84.5
Knee to footrest height, left[o,m]	50.5	7.1	37.8	52.5	59.0	51.9	7.4	37.8	53.2	59.4	49.1	6.6	37.8	50.3	57.8
Knee to footrest height, right[o,m]	49.6	8.1	35.9	51.6	57.3	49.7	9.8	22.5	52.7	58.9	49.6	6.2	38.2	50.8	56.8
Knee height, left	62.8	6.0	53.7	63.5	73.5	61.4	6.2	51.5	61.0	72.4	64.2	5.5	56.3	63.6	75.2
Knee height, right[o,m]	64.5	6.7	55.0	64.2	74.8	63.9	7.8	52.1	63.9	85.7	65.0	5.4	55.0	64.9	74.8
Breadths															
Overall breadth[o,m]	71.3	8.2	60.4	70.9	83.9	69.8	6.8	58.9	69.0	83.9	72.8	9.2	60.8	72.6	88.5
Bideltoid breadth	52.2	6.0	41.5	52.1	61.1	53.4	5.2	46.7	52.5	63.3	51.0	6.5	39.7	51.9	60.4
Biacromial breadth	37.1	3.6	30.6	37.5	42.3	38.6	2.8	33.8	39.0	42.4	35.75	3.8	27.7	36.6	42.2
Forearm to forearm breadth	60.1	8.2	47.5	59.3	73.7	59.0	6.5	49.2	57.9	70.1	61.2	9.5	39.1	60.7	74.7
Hand breadth, left	8.9	1.0	7.0	8.9	10.6	9.0	0.9	7.2	9.0	10.4	8.8	1.1	6.8	8.7	10.9
Hand breadth, right[m]	9.0	0.9	7.2	9.1	10.5	9.2	0.8	7.2	9.3	10.4	8.8	0.9	7.1	8.8	10.5
Hip breadth	27.0	4.1	20.7	26.7	33.9	26.3	3.9	22.4	28.0	38.7	25.8	4.0	18.4	25.5	32.8
Waist breadth	42.9	6.1	30.4	43.5	53.0	44.3	5.4	30.8	44.7	53.6	41.7	6.6	29.2	42.0	53.0
Thigh breadth	44.1	9.1	27.0	44.0	62.5	45.1	6.7	30.8	46.1	52.9	43.2	11.0	25.2	42.5	69.6
Bimalleolar breadth, left[o,m]	8.5	1.3	6.6	8.4	11.0	8.6	1.3	7.1	8.4	11.0	8.5	1.4	6.4	8.4	11.2
Bimalleolar breadth, right[o,m]	8.8	1.5	6.9	8.5	11.2	9.0	1.4	7.2	8.6	12.3	8.7	1.5	5.7	8.5	11.1
Depths and Lengths															
Overall depth[p]	122.5	10.1	109.2	123.0	141.9	123.5	10.9	107.1	124.0	146.5	121.6	9.4	109.6	118.9	138.1
Abdominal extension depth	37.1	5.5	28.2	36.1	47.4	35.6	5.0	27.0	35.5	43.7	38.5	5.7	30.6	37.6	48.8
Buttock–knee length, left[o,m]	62.3	7.4	48.9	63.8	73.2	62.4	6.1	51.1	63.8	71.2	62.2	8.5	44.9	63.8	73.6
Buttock–knee length, right	62.5	7.0	51.4	62.8	73.6	63.2	5.0	54.7	63.2	70.5	61.8	8.5	47.0	62.1	74.3
Buttock–popliteal length, left	51.8	7.1	39.4	52.4	62.6	51.7	5.8	40.5	52.7	59.8	51.8	8.2	34.6	52.0	63.9
Buttock–popliteal length, right[o]	52.0	7.4	37.0	53.0	62.9	52.2	6.8	39.2	53.1	60.9	51.8	7.9	35.1	53.1	63.1

DESIGN DETAILS

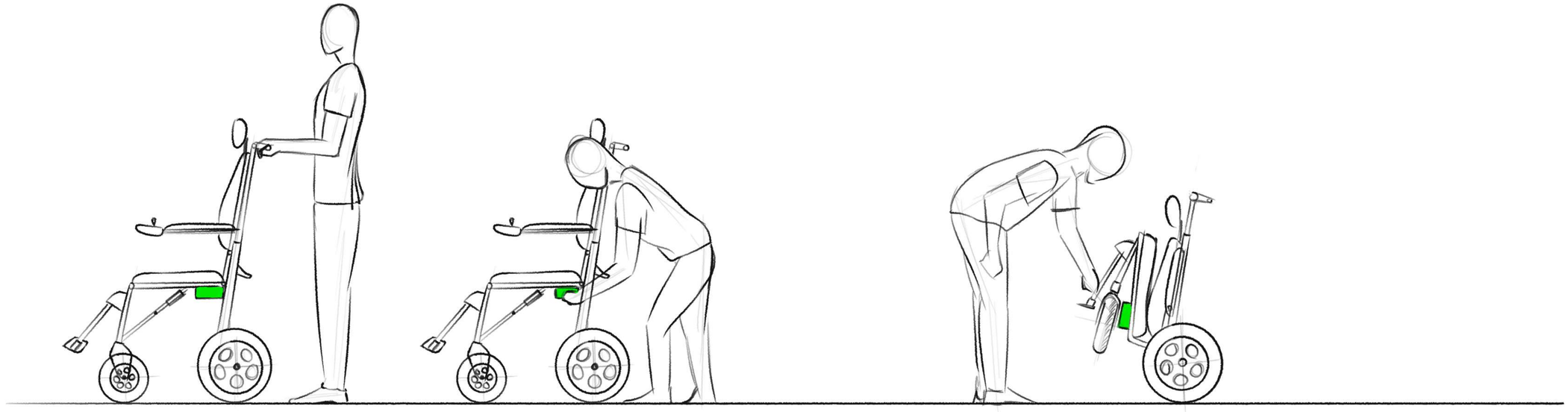




Folding steps for caregiver



Battery removing



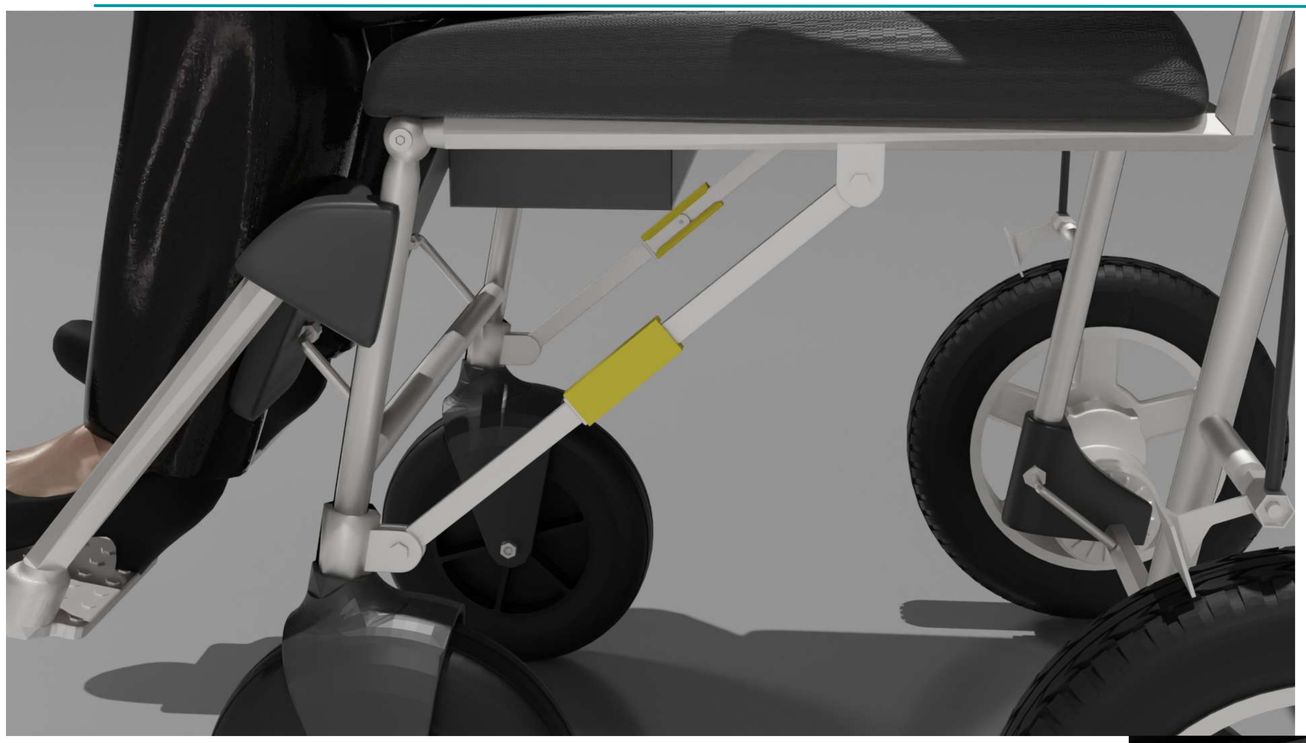
RENDERS

REVIEWS

For the first trial, I discussed the design with Dr. Bhandari and received the following suggestions for improvement:

- Placing your batteries on the front side of the seat will provide balance to the wheelchair and the weight will aid in the seat readily slipping down while unfolding
- The wheelchair's adjustable handle height is pretty useful, since it will be useful for various caretakers of varying heights
- Because of the dead weight of the patient's body, we can provide rest to calves when dealing with als mnd patients
- The slider mechanism will be quite heavy, therefore the lock or mechanism must be quite sturdy to support all weight

RENDERS

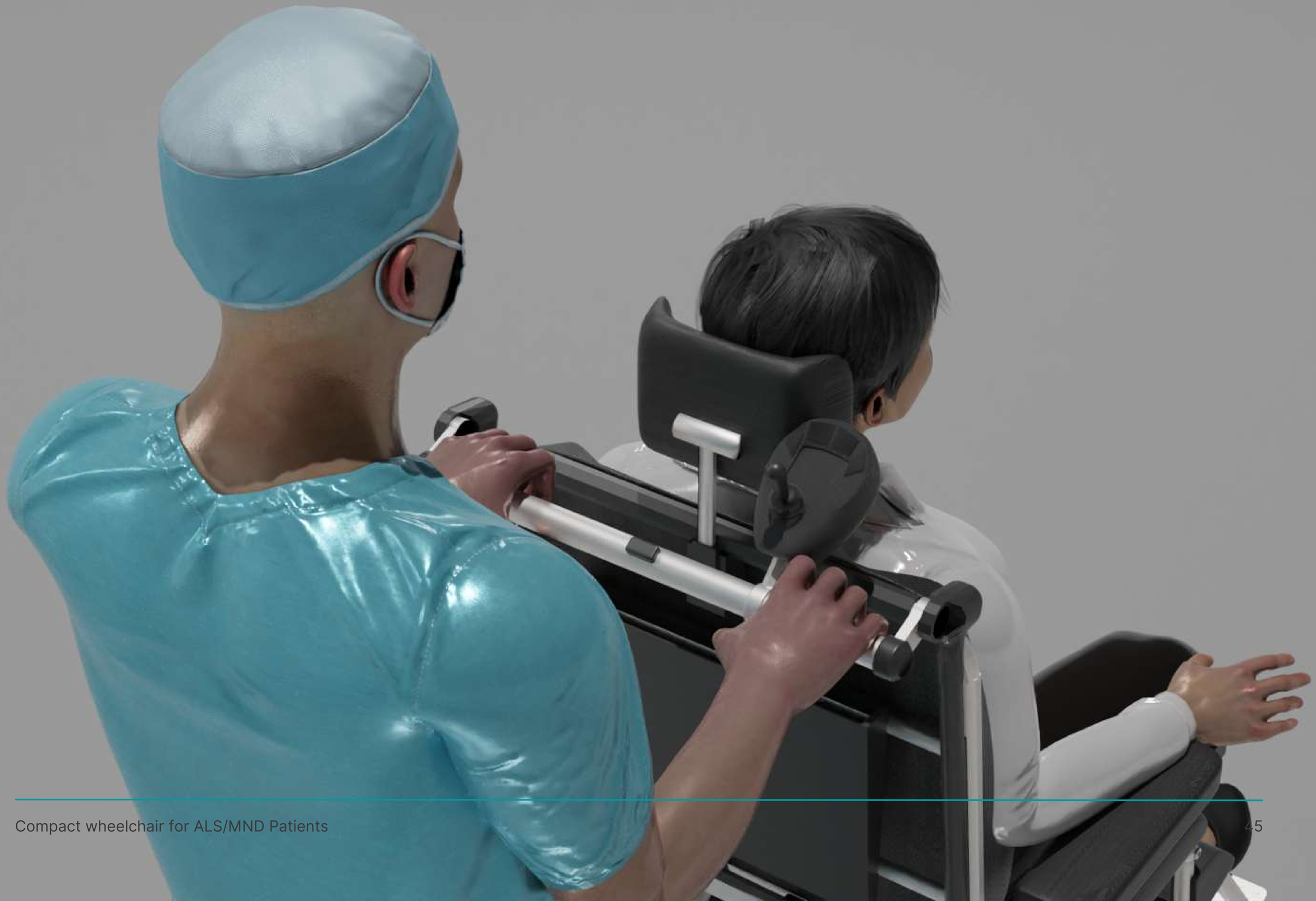


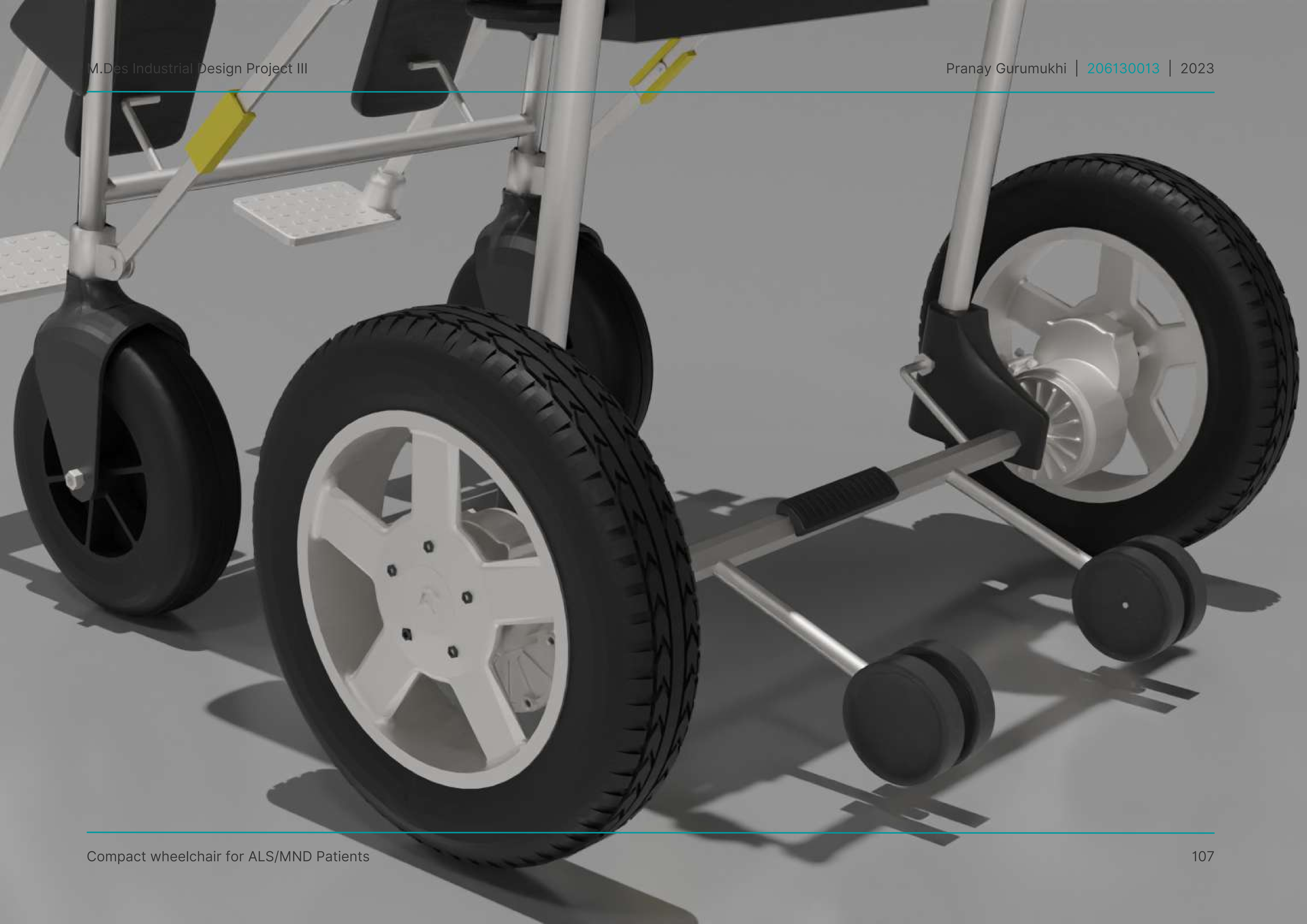
REVIEWS

For the second trial, I discussed the design with Dr. Hemangi Sane and received the following suggestions for improvement:

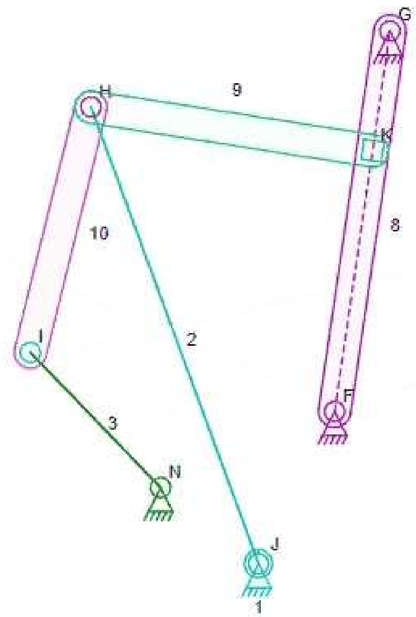
- Batteries should only be placed on the back side, where they can be easily removed
- What if a female user is wearing a saree? It will be impossible to remove it from the front.
- Giving control to the caretaker allows him or her to maneuver effortlessly from behind.
- Headrests should be removable because some patients do not require them.
- These manual brakes will not function; instead, electric brakes that perform as a good stopper in electric wheelchairs must be provided.
- Or magnetic brakes/auto-brakes
- My hand tends to fall on the control, so the palm rest will be useful, and because it is adjustable, it will be beneficial to users.
- Your wheelchair proposal appears to be functional, and I am confident that it will serve its purpose.
- The cushioning on the hand rest needs to be enhanced because my hands tend to fall down due to the lack of cushioning.

RENDERS





LINKAGE MECHANISM



FOLDING STEPS

DIMENSIONS

Overall Length (mm)

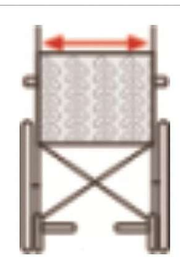
1140

Overall Width (mm)

630

Overall Height (mm)

980



Seat Width (mm)

450

Standard electric wheelchair

Overall length

1041

Overall width

810

Overall length

1182

Overall length

530

Electric wheelchair concept

TECHNICAL DETAILS

Electric motor

- MY1016ZL Electric Wheelchair Motor
- Model: MY1016ZL
- Working voltage: 24V
- Wheelchair motor output power: below 1100W
- Operating speed: un-load 75 rpm or 120rpm;
- Installation structure: end face
- Function type: wheelchair
- Protection form: IP44
- Insulation class: E
- Power supply type: DC
- How it works: permanent magnet DC
- Product Description: With small size, low speed high torque output, low noise, high reliability, easy maintenance etc

TECHNICAL DETAILS

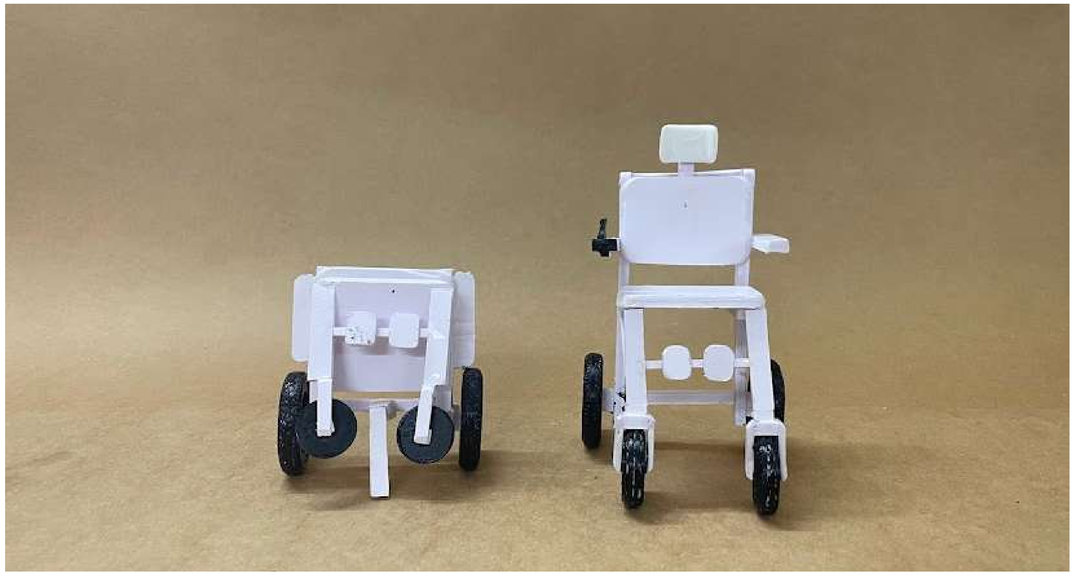
Battery

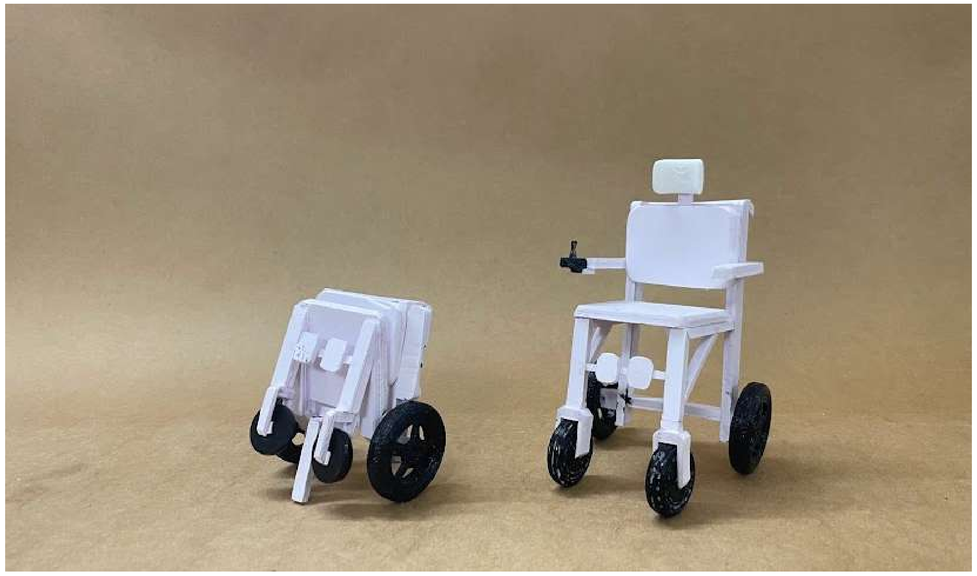
- Battery cells Details -
- Cell - Roofer 2500 mah 3C EV Grade
- Total no of cells used - 7x5=35pcs
- Charge Cycle with full Capacity - 1200 aprox
- BMS Specification - 7s20A, with Heat Sink protection
- Maximum Battery Capacity - 12.5AH or 12,500 mah
- Battery Energy – 300wh
- Maximum Power Motor you can attach – 480 watts
- Battery standard voltage - 24v
- Back up on 250 watts E cycle Motor -
- On full charge 35Km aprox Back Up time of battery(tested with a 55 kg person)
- Charger Voltage- 29v
- Charger Current – 3Amps max

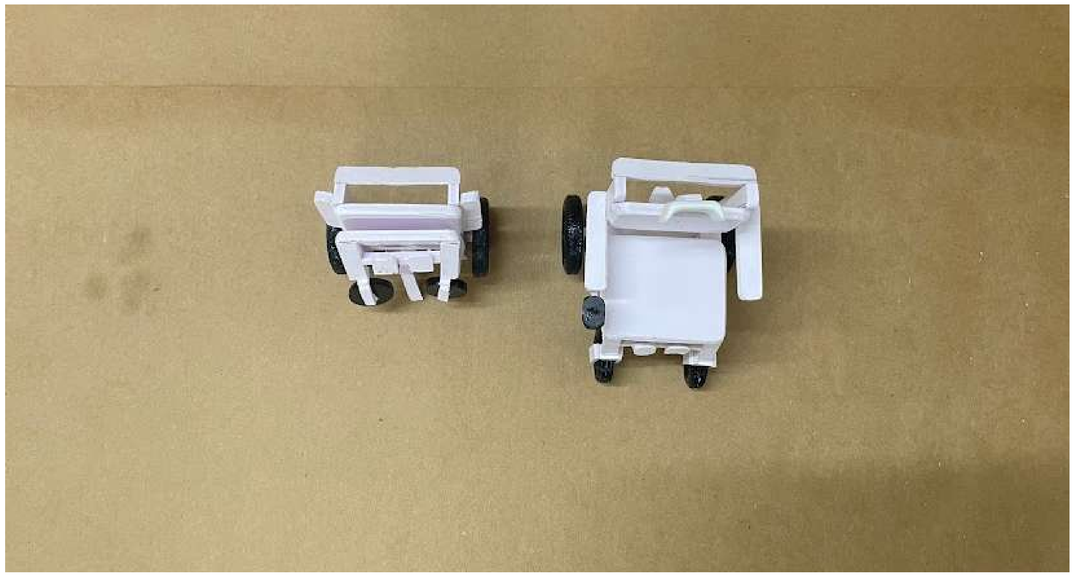
MANUFACTURING PROCESS

- Stage 1: Building upper frame with lengths of extruded aluminium are cut, drilled and shaped for components
- Stage 2: CNC machines for bars, angle and plate stock
- Stage 3: Seat, back, and footrest plastic blanks are drilled at workstations set up with jigs for multiple drilling to ensure maximum adjustments. The steel chassis frames complete with front jockey wheels are assembled with seat units, footplates and brake units to form complete chairs
- Stage 4: Wheelchairs are put through an alignment checking process and front pivot wheel bearings are checked and adjusted if necessary. A wheelchair is tested to WHO guidelines, including one which performs timed duration tests on simulated rough terrain and the other drop / impact testing.
- Stage 5: Packing and Ancillary items
- Stage 6: Testing to International Standards ISO7176

SIZE COMPARISION

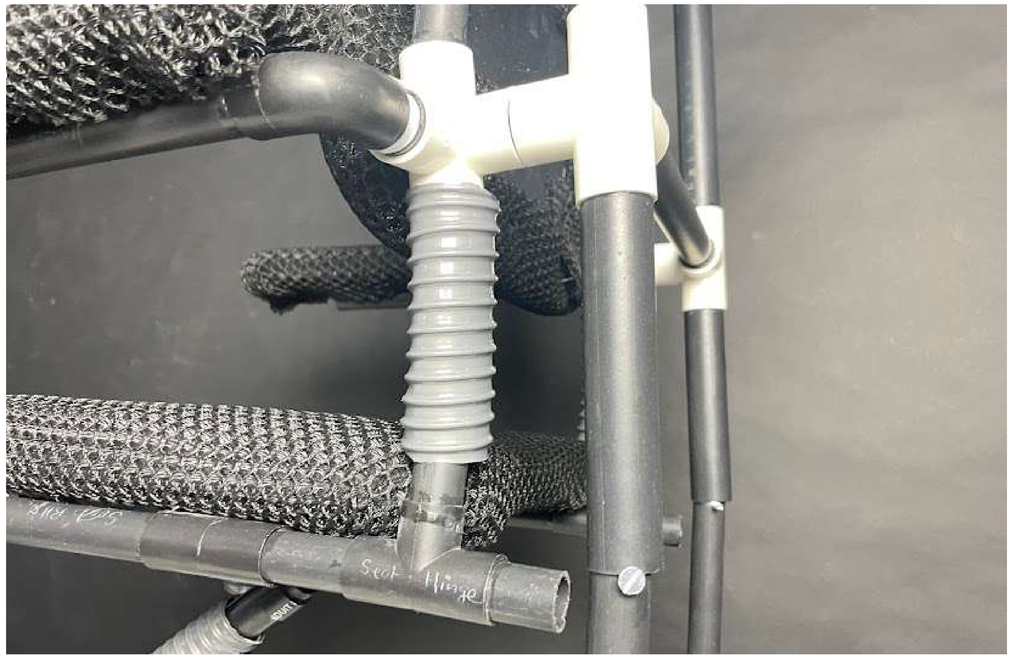


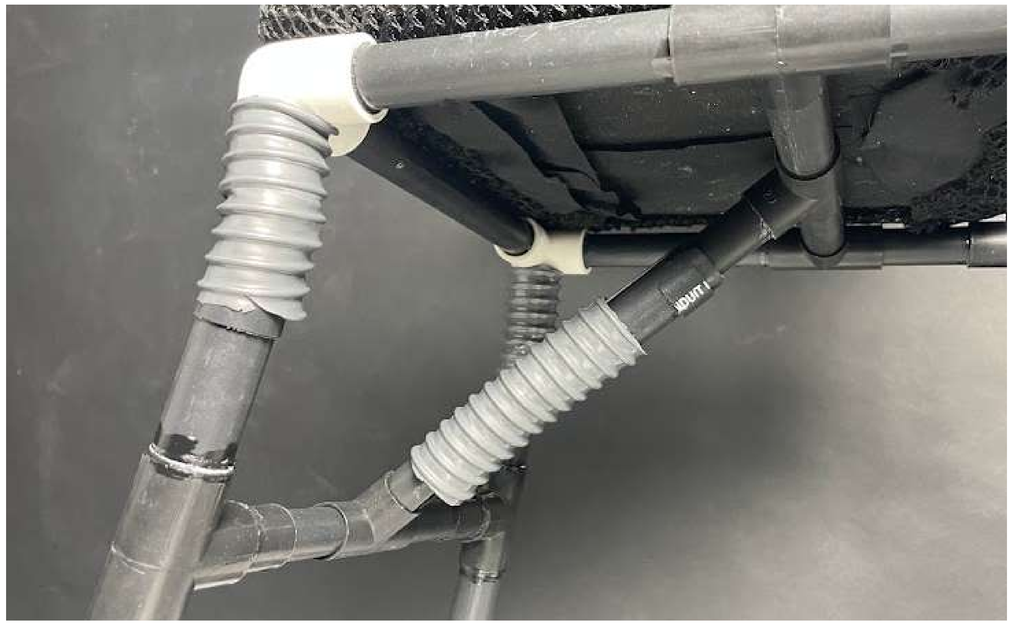




PROTOTYPE DEVELOPMENT

- Material Selection: factors such as strength, weight, durability, and cost.
- Design iterations
- 3D modeling and CAD
- Rapid prototyping
- Component assembly
- Testing and validation: performance, functionality, and ergonomics of the prototype.
- User feedback: feedback from potential users, caregivers, and healthcare professionals.
- Cost optimization
- Documentation





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THANK YOU