limba

Mari Ferguson MEng 5 2022

pde

the problem

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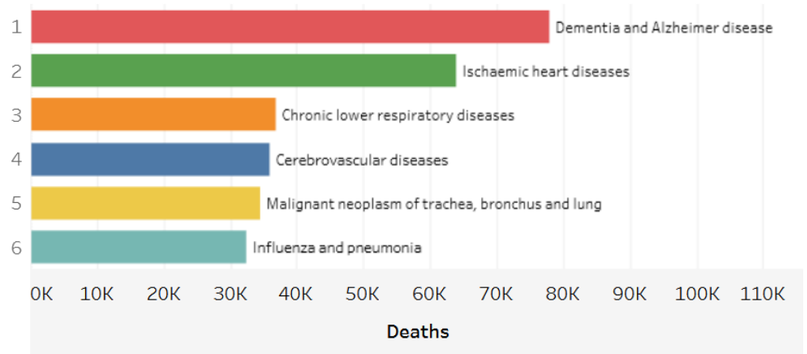
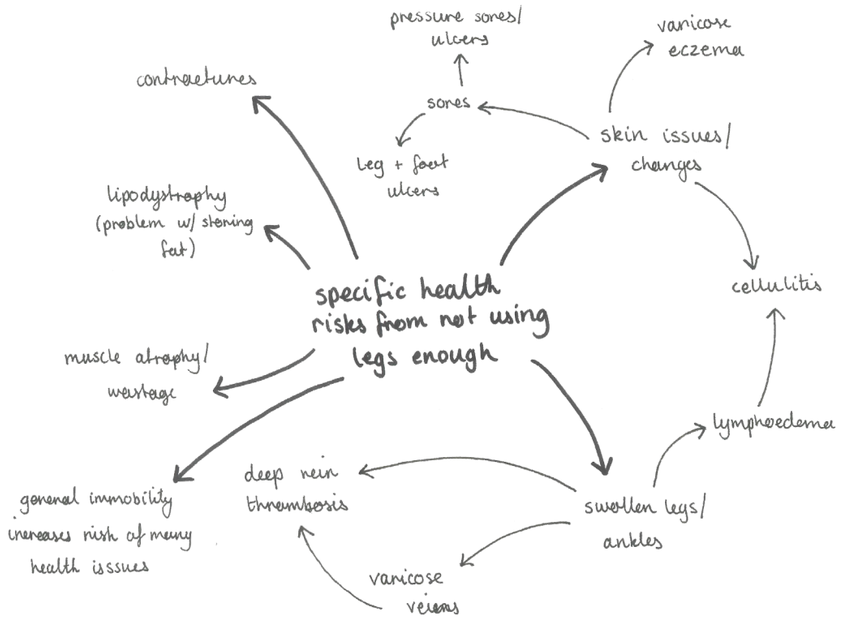
Around 100,00 people in the UK suffer from a stroke each year, and consequently will have to go through a long rehabilitation process.

Mobility issues are extremely common in stroke survivors, with 80 percent of patients suffering from Hemiparesis, a type of muscle weakness on one side of the body. This affects a patients ability to walk, resulting in them losing independence.

Regaining this ability is therefore a high priority for many patients. To do this, a physiotherapy program is required, which involves regular sessions with a physiotherapist even after discharge from hospital.



Stroke is classed as a Cerebrovascular disease, and is a leading cause of death in the UK. Graph from https://www.stroke.org.uk/what-is-stroke/stroke-statistics



A series of exercises will be prescribed to be carried out daily. This program is tailored to each individual and will change as the patient goes through ups and downs in their recovery.

Moving limbs regularly is very important to maintain healthy blood flow and of course there is many benefits to keeping as fit as possible. Above shows an example of health risks coming from not moving lower limbs enough. Regular exercise can also be a benefit for many health problems, for example it is highly encouraged for stroke victims to aid recovery and help prevent further strokes.

There are some barriers to exercise, such as many exercises requiring aid or supervision from carers. Fatigue is another common problem for stroke victims, and this can mean exercises are missed due to the carer not being there in periods of high energy.

Often, the patient is not yet able to walk independently, but can carry out seated exercises. There is not a good method for adding difficultly to these exercises in order to improve strength. The aim of this project is to create a solution for this.

research

conversations with physiotherapists

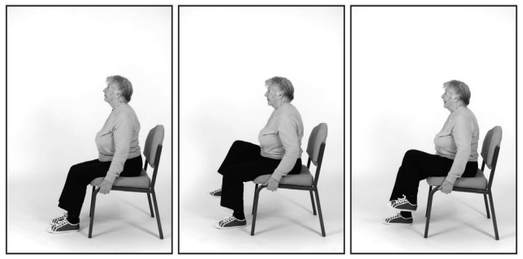
By speaking to a number of physiotherapists working with stroke patients, I got an insight into the current methods used. Examples of exercises given to patients can be seen below. I analysed these to see what muscle groups were being used, so I could make sure to include the right movements in my design.

These conversations were also used to verify concepts and gain a better understanding what would benefit the target user the most.

I also spoke to other stakeholders, such as people who have been through a similar rehabilitation process, or work with people in a similar situation. This allowed me to get a wider range of views on what works in terms of encouraging and designing for exercise.

- Lift your feet one at a time off the floor – as if you were marching (but sitting down).

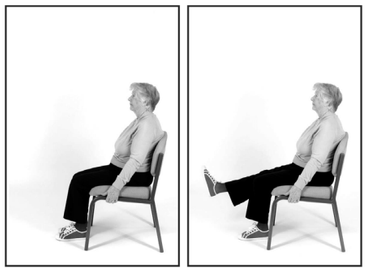
Repeat 10 times on each leg (or repeat ___ times).



- Straighten your leg as much as you can – keeping your foot off the floor.

Repeat 10 times on each leg

(or repeat ___ times).



parallel products

There was not too much in this area, but some interesting finds were HUR exercise machines. Using pneumatic damping technology to allow smaller increments between resistance levels, they claim to be more beneficial for patients going through rehabilitation. I also looked into technology such as CPM machines, and recumbent bikes.

issues with current solutions

I tested both generic weights and resistance bands, as these are sometimes used alongside exercises. This aims to add an extra level of difficulty, to try to get the patient up and moving around faster.

A perceived issue with both of these methods was that in order to slowly increase the level of resistance, a large variety of weights or bands would be required. This adds complication for the user, and requires planning from the physiotherapist. Storage space is not always readily available in a patients home.

Resistance bands also require a lot of dexterity in order to set them up properly, which is not ideal for stroke victims.

insights

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From watching the process myself, I noticed a big issue in that a patient usually required a carers help to go through an exercise program prescribed by a physiotherapist. Because the patient has little control over when this is, they are often too tired at the time and end up not doing them.

By making it so that the patient could go through the whole process themselves, without worrying about whether they were doing the exercise properly, I could design out this issue.

The following four requirements summarise insights taken from all of my research.

» Should allow patients to exercise without need for assistance whilst reducing any fears that may come with exercising independently

» Uses movements approved by a qualified physiotherapist and integrates with current physiotherapy strategies

» Integrates easily into an average home without obstructing current furniture

» Has varying levels of difficulty which can be increased or decreased with ease

The ability of the patient was also important to consider when considering requirements of the product. I elected to design for a specific set of symptoms.

» Muscle weakness in one leg in particular

» Fatigue

» Little to no movement in one hand (same side as weaker leg)

» Foot drop, due to muscle weakness in the ankle, requiring support to stay in position through exercises

» Although retaining good cognitive ability, this may still be affected, and patients are likely to be elderly so all user interaction should be kept simple

concept development

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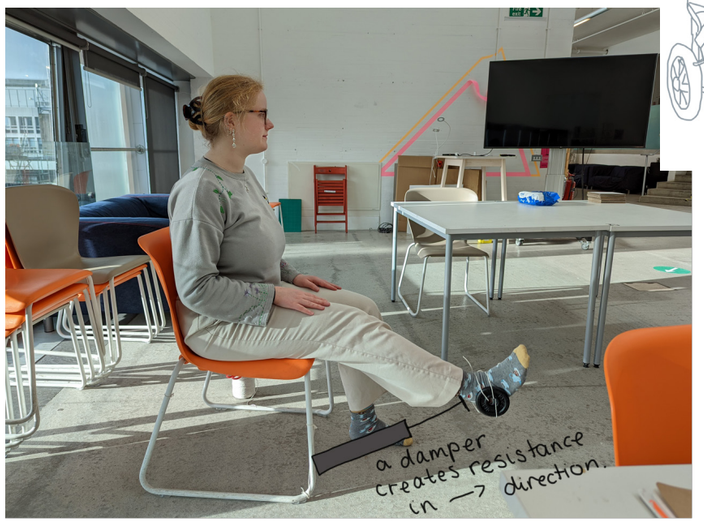
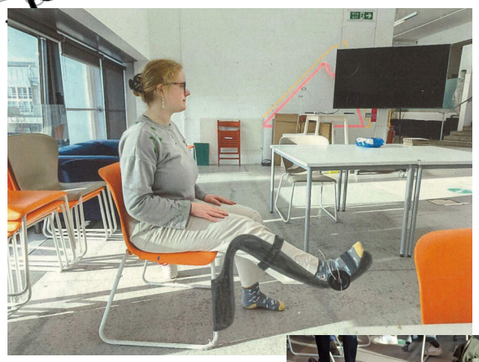
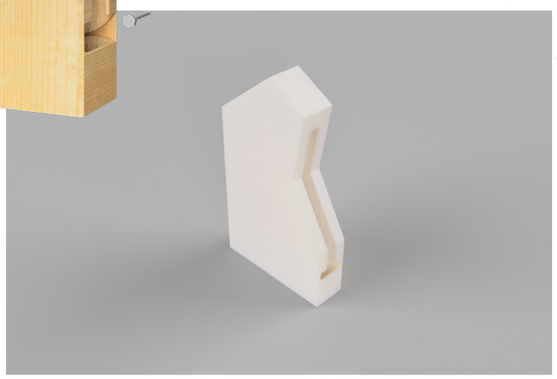
I drew over pictures of myself carrying out exercises to think about where I could apply resistance. This allowed me to figure out where the product would be placed. I calculated the range of motion for different exercises to design mechanisms accommodating this.

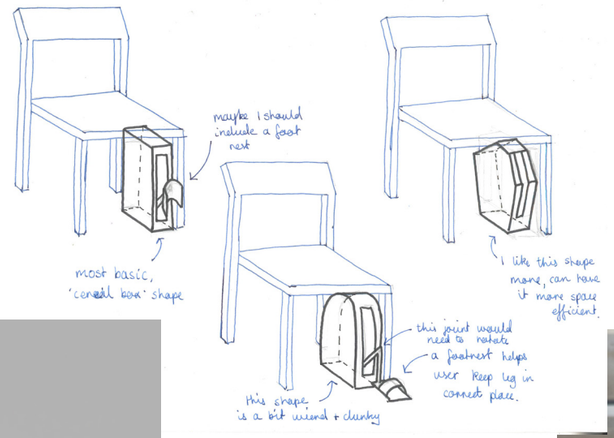
I considered an exoskeleton inspired aesthetic, but this was rejected as it may be more complex for the patient to use. I looked into assistive technology used in the home, and tried to design something less obvious, to allow the patient to feel more comfortable.

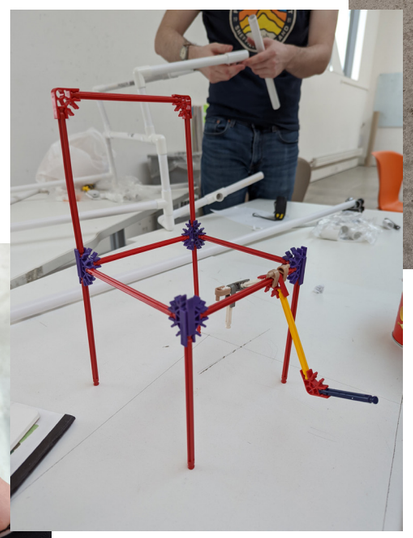
I researched into damping technology, carrying out tests on a steering damper purchased, to work out how this could be integrated in my design.











product overview

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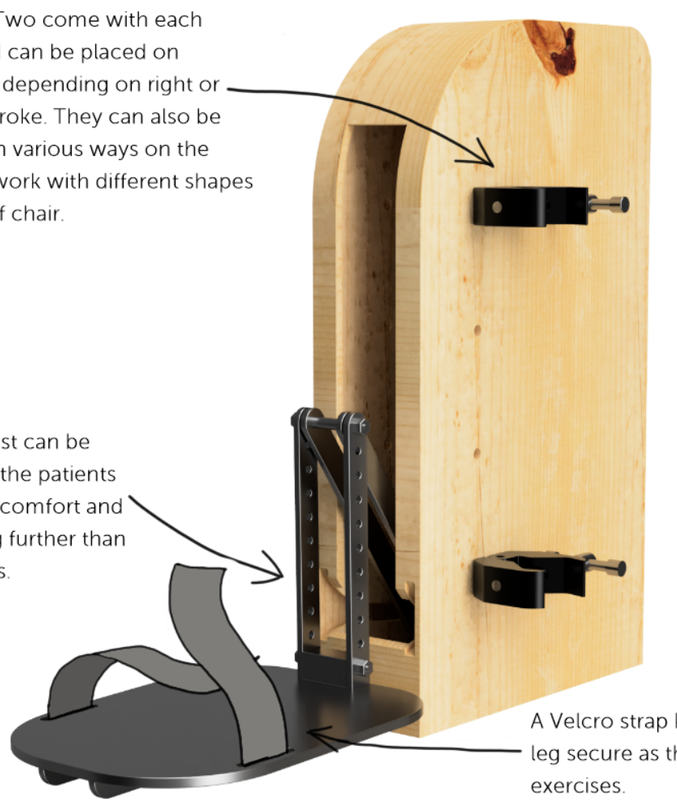
Clamps are used to fix limba to a chair. Two come with each device, and can be placed on either side, depending on right or left brain stroke. They can also be attatched in various ways on the device, to work with different shapes and sizes of chair.

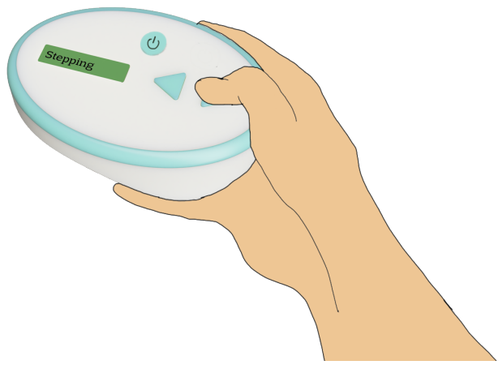
The height of the footrest can be adjusted to fit best with the patients leg length, to maximise comfort and ensure they aren't going further than needed for the exercises.



A Velcro strap keeps the patients leg secure as they go through exercises.

Damper adding variable resistance to exercises. This can be easily accesed by a physio to increase or decrease the level as the patient needs.

Plywood is used to blend in with wooden chairs/flooring. This could be varnished in various shades to match a patients home better.



Alongside the device, an app is used to view progress and follow the given exercise routine. Information on the different exercises can also be viewed. If the patient doesnt have access to an app a remote can also be used.

how it works- movement

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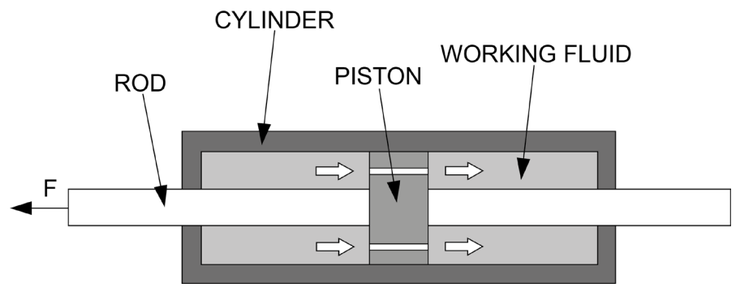
As the ranges of motion for the two exercises are quite different, mechanical advantage and virtual pivot points have been used to design the mechanism. The images to the right show how the mechanism moves for the leg lift exercise. In this formation, the device can achieve up to 560mm of extension. Below, the images show how the same mechanism moves for the stepping exercise.

To hold the struts and joints in place as they move, sliders have been created in the plywood base. Nylon wheels attached on the ends of the joints slide in these spaces, creating smooth motion for the patient.

The only part of this the patient will interact with is the footrest when they strap their foot into place. This has been design to comply with British Standards for wheelchair design to ensure safety and comfort.

To add variable resistance to the exercises, a hydraulic damper has been used. This gives an equal resistance to the movement in both directions, and varies depending on the users' speed of movement. The schematic below shows the basic working principle of a damper.

The chosen damper is variable, so the level of resistance can be changed as the patient goes through stages in their recovery.



how it works- switching

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As the joints need to be in different positions for the two exercises, a way of switching between them was needed. A system using sliding ‘gates’ was created.

The configurations of these gates for the two exercises can be seen below. The existing slots for the movement of the wheels were expanded to accommodate for the gates when not deployed.

These gates have been designed to take all of the force required to push the damper up if needed.

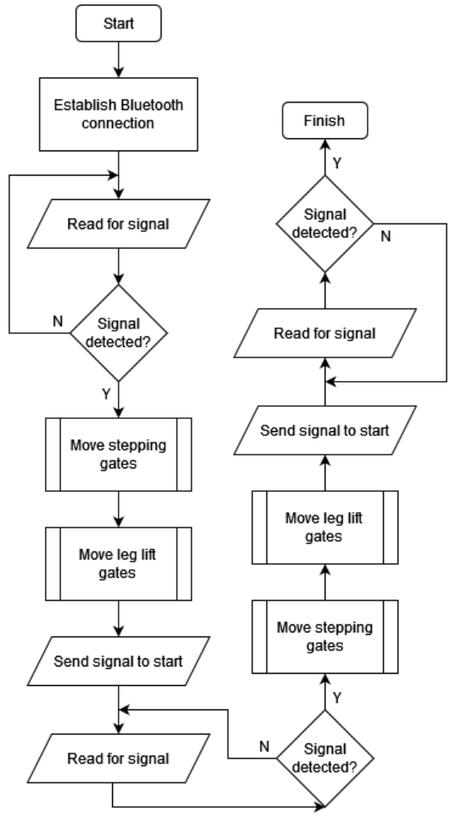
Small motors will be used to move the gates. This was all designed to be automated as other options explored required too many complex user interactions.

With this design, all the user does once they start their exercises is press a button on an iPad or equivalent. If the patient does not have access to one of these, they can use a simple remote which retains the functionality.

A flowchart detailing the steps the device would go through when switched on was created. For this, it was decided that the leg lift exercise would always come before the stepping exercise, so that the switching would be in the same order in the program each time.

Also, as the device does not have buttons or switches on it, it is looking for a signal to be sent rather than a button press.

When the device has successfully switched between configurations, it will send a signal to the iPad or remote that the user is able to begin their exercises.



user journey- patient

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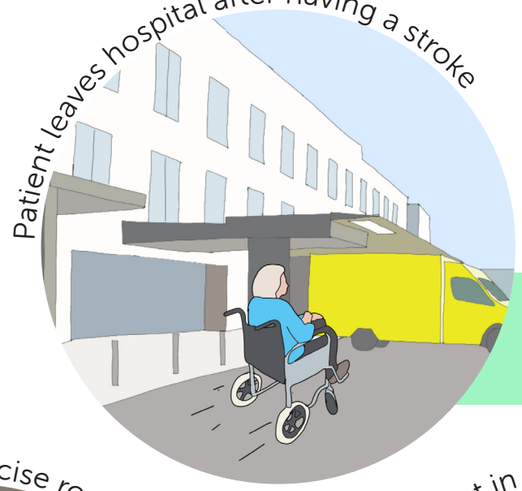

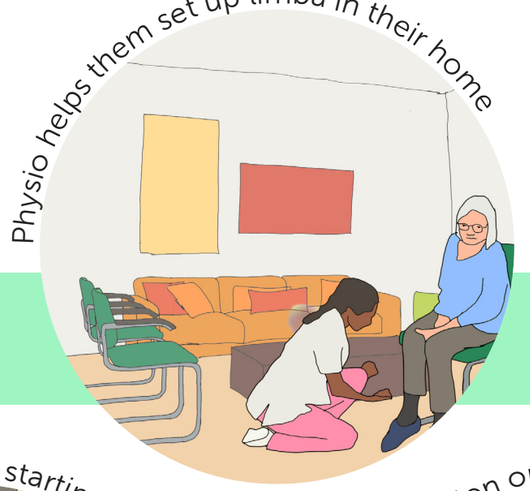

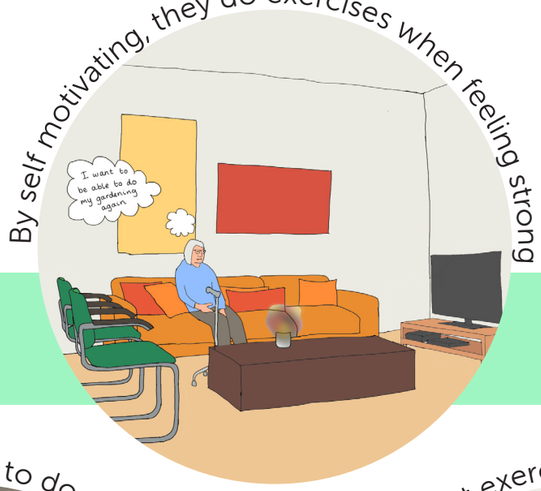

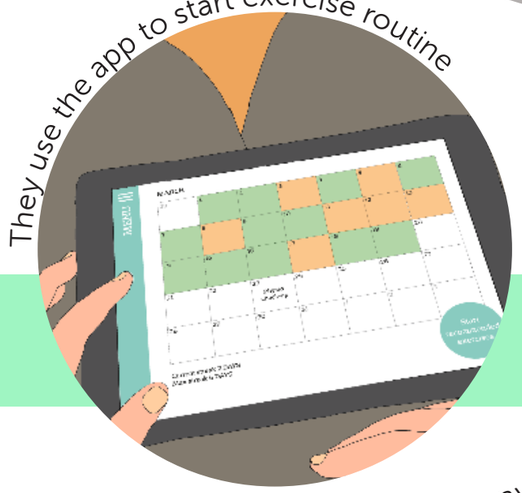

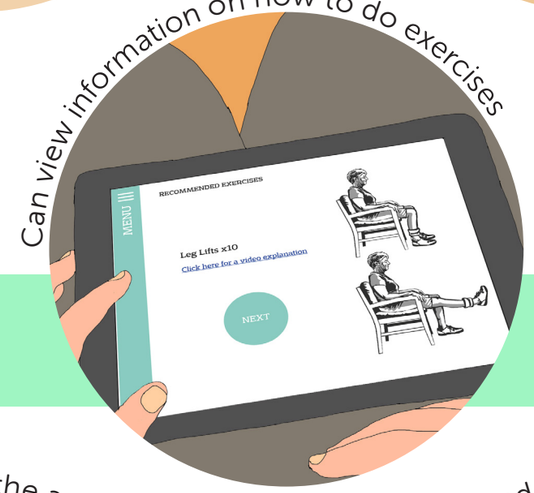

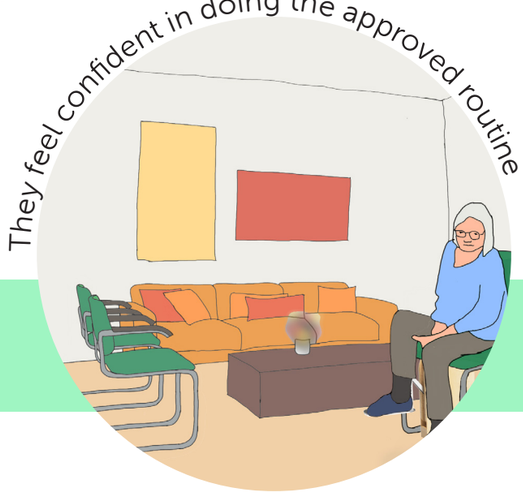

user journey- physio

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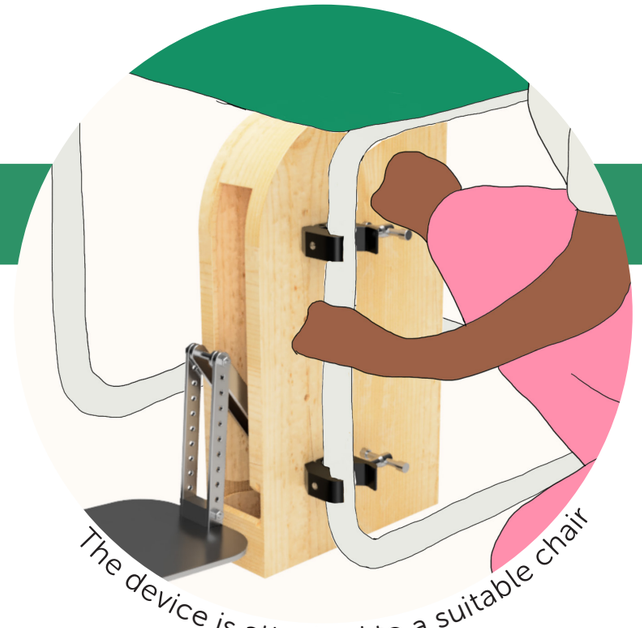
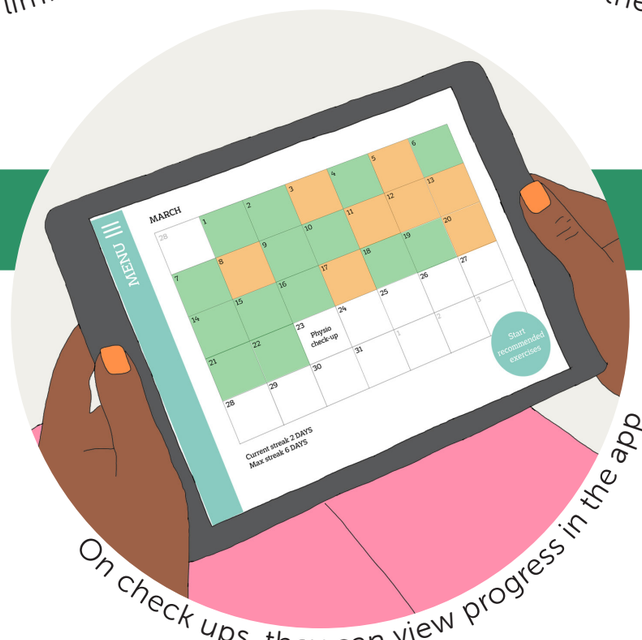
Physio helps to set up limba

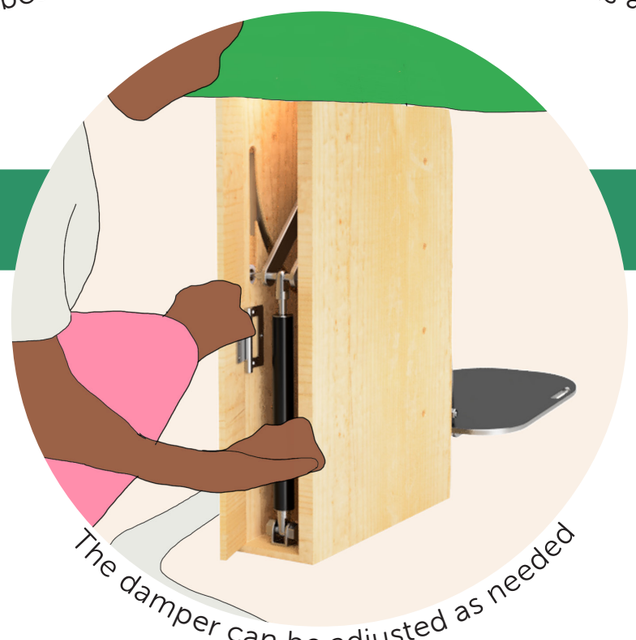
They input their prescribes exercises on the app



The device is attached to a suitable chair



On check ups, they can view progress in the app



The damper can be adjusted as needed