

# SMART RECOVER



Executive Summary  
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# The Problem

## Popular recovery methods?

**There is not a 'one cap fits all' method to perfect recovery.** It is achieved by simply increasing blood flow to tired muscles which increases muscle metabolism and reduces waste products such as lactate. This can be achieved by many different methods, with efficiency down to personal preference. There are various recovery methods used today, with **ice baths being perceived as the most effective.**

## Why are ice baths so effective?

Ice baths are so effective **due to two main components.**

Physically, ice baths **effectively increase the amount of blood flowing to tired muscles.**

**Ice baths also elicit a mental response.** There is a markedly different feeling before and after an individual enters an ice bath. Before entering, the user feels sluggish and tired. The ice bath acts as a shock to the system and leaves them feeling reinvigorated and energised. In an interview, one user compared this effect to 'washing your face in the morning' thus highlighting the refreshing effect of an ice bath.

**It is the combined effect of both these components which makes ice baths so effective as a recovery tool.**

## What about the other methods?

Trigger point therapy is an active recovery method which involves a foam roller. It is painful and seen as a lot of effort after prolonged physical activity. **Users prefer passive recovery methods like ice baths, to active ones like the foam roller.** Compression garments are also a passive recovery method but there are scientific doubts around their effectiveness.

## Why are ice baths such a hassle?

The difficulty with having an ice bath boils down to two things: the **ice** and the **vessel**.

Ice is **difficult to work with due to the fragility of its chemical state** meaning it has to have suitable storage facility but very few changing rooms around the UK have a freezer.

Futhermore, the common vessel that is widely used is simply a **wheelie bin**. These are seen as impractical for many reasons: users feel silly getting in and out of bins; they are **difficult to get in and out** increasing risk of injury, they are difficult to transport, they are **difficult to set up and require a lot of preparation** such as how and when is best to fill the bin. The literature states that ice baths are most effective the quicker you use them after finishing exercise. This is difficult to achieve as they take time to fill up and often an inconvenience to clean up.

Football teams also all tend to use the **same bin and ice one after another**, this is **extremely unhygienic and risks the spread of infection.**



Using a wheelie bin as an ice bath is dangerous, inefficient, unhygienic and time consuming.

# Key Insights & Demand

## Key Insights from Research Phase

- Ice baths are extremely impractical. This is due to two things. The ice and the vessel. Ice is a hassle to source and maintain at an appropriate temperature. A suitable vessel is difficult to source and quite often simply not available
- Difference in feeling before and after ice bath is so important to make the user feel like they have achieved enhanced recovery
- There is no scientific evidence that one recovery method is more effective than another, however people perceive certain methods more effective than others due to how they are marketed
- Slight discomfort is ok, even slightly desired by the user. This is due to the fact that users feel like the more uncomfortable a recovery method is, the greater effect it has
- Passive recovery methods are preferred to active ones
- Although there are various recovery methods, they are all just different ways of getting increased bloodflow to the muscle
- Placebo effect has a major influence on recovery

## The Demand

There are 2.5 million footballers registered with an association in Britain, competing in games weekly and training. For these individuals to continue playing regularly, it is advised they take part in at least one recovery session a week. Figure 1a is a survey completed by 56 footballers of all levels, from amateur to professional. 75% of those surveyed in figure 1a stated that they only have had an ice bath once, or never had one at all. This is due to poor facilities or too much effort associated with preparing an ice bath. **With 96% of those surveyed stating their desire to have an ice bath at least once a week**, it is clear there is scope for design to improve this process.

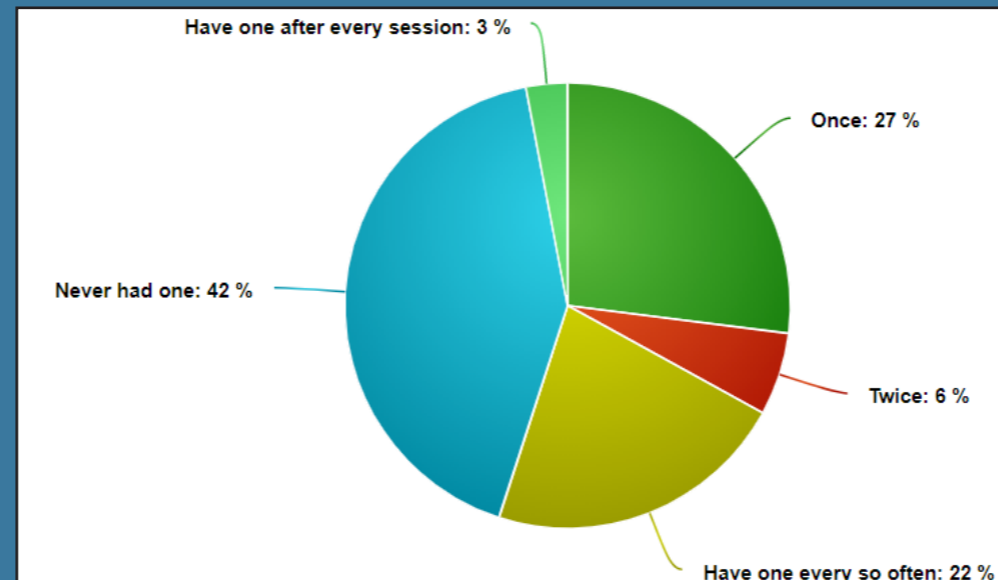


Figure 1a

## Goals



Convenience



Customisation



Portability

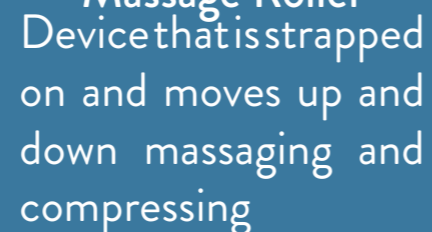
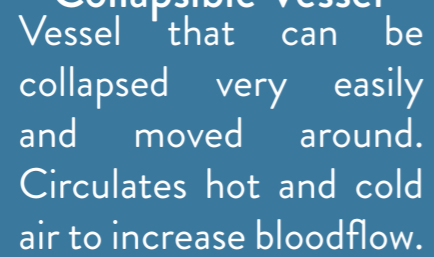
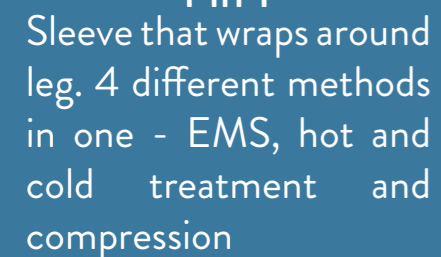
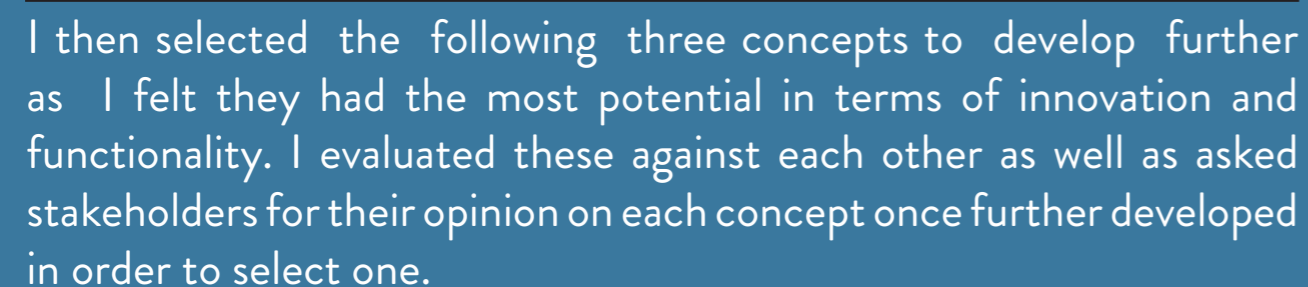
**“..96% of those surveyed stated their desire to have an ice bath at least once a week...”**



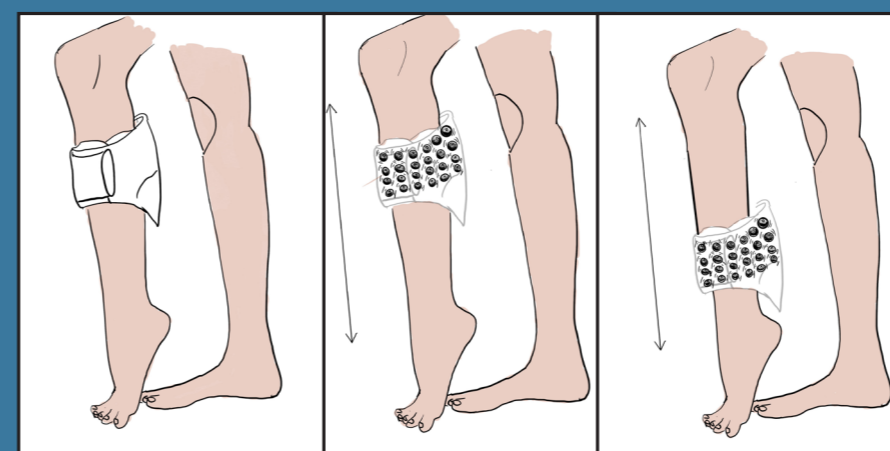
## The Brief

Design a recovery system that effectively increases blood flow to tired muscles whilst being easy to set up, use and carry around. The product will also use the placebo effect to its advantage by having a noticeable physical effect on the user, thus adding to its effectiveness.

By examining and analysing current proven methods of increasing bloodflow and enhancing recovery, I was able to devise multiple concepts which potentially could solve the problem. I attempted to productise these methods in novel and unique ways.



It was close between this concept and the 1st one. Users liked how this was similar yet different to current methods. It was suggested however that the use of cold and hot air could irritate the skin. This concept also does not possess the portability or customisability that the 1st has.



This concept has pads that control temperature and transmit electricity. Three different settings include: heat, cool down and electrical stimulation, as well as utilising compression. This was eventually the selected concept due to stakeholders praising its ease of use, portability and the ability to select various different settings.

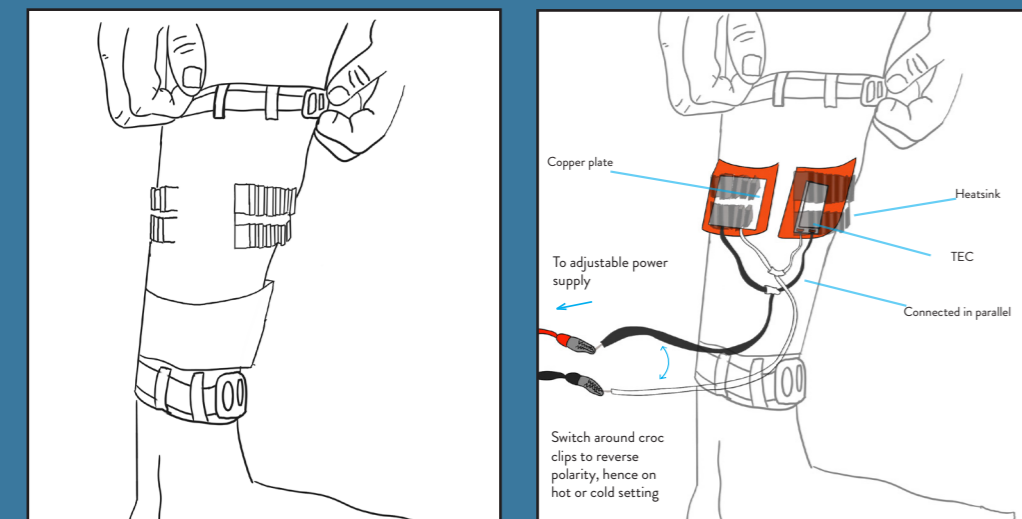
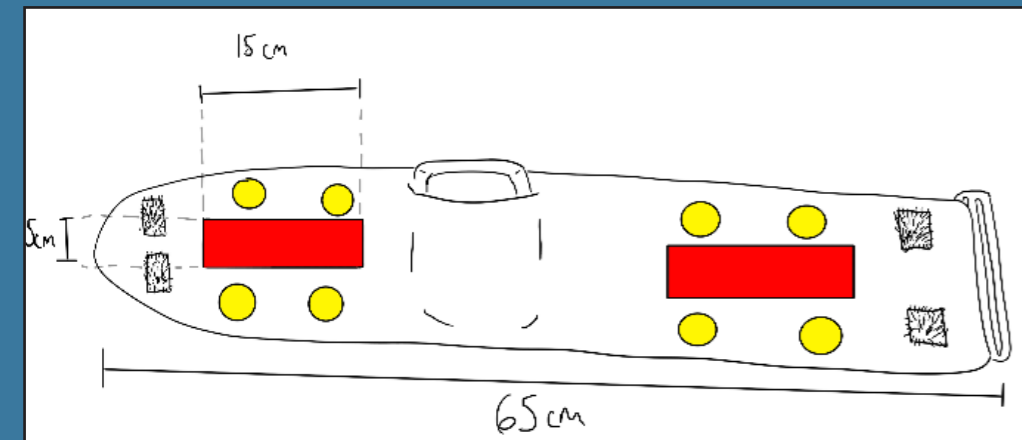
This was the worst received concept out of the three. Users did not like the idea due to concerns about comfort and convenience. They felt that if they had a device moving up and down their leg would be strange and uncomfortable.

# Prototyping, Testing & Refinement

## Design

It was important to allow the user to put on and take off the product as quick and easily as possible, whilst still being secure and not just falling off when the user gets up and moves around. As the device makes use of thermoelectric coolers it was also vital that there was no overlap of the device on itself so that heat could be dissipated efficiently.

I used the anthropometrics software 'People Size' to advise the dimensions of the design, using the 5th the 95th percentile rule I was able to ensure the device will fit the majority of the population comfortably. Key dimensions such as average thigh circumference, knee height and calf circumference advised the design of first prototype's dimensions.



Some prototype plan sketches

## Build

I used the sewing machines at GSA, as well as the 3D printing machines where appropriate to make the prototypes. By sewing the prototypes myself I was able to evaluate different stitching methods and decide the best manufacturing method for the product.

The device originally started out as a 'wrap' like device, however as the project progressed it evolved into a compressive sock that outer modules are clipped onto.

Testing out different orientations, dimensions and features such as zips or buckles, I was able to build and test a wide range of different options and find the preferred design.



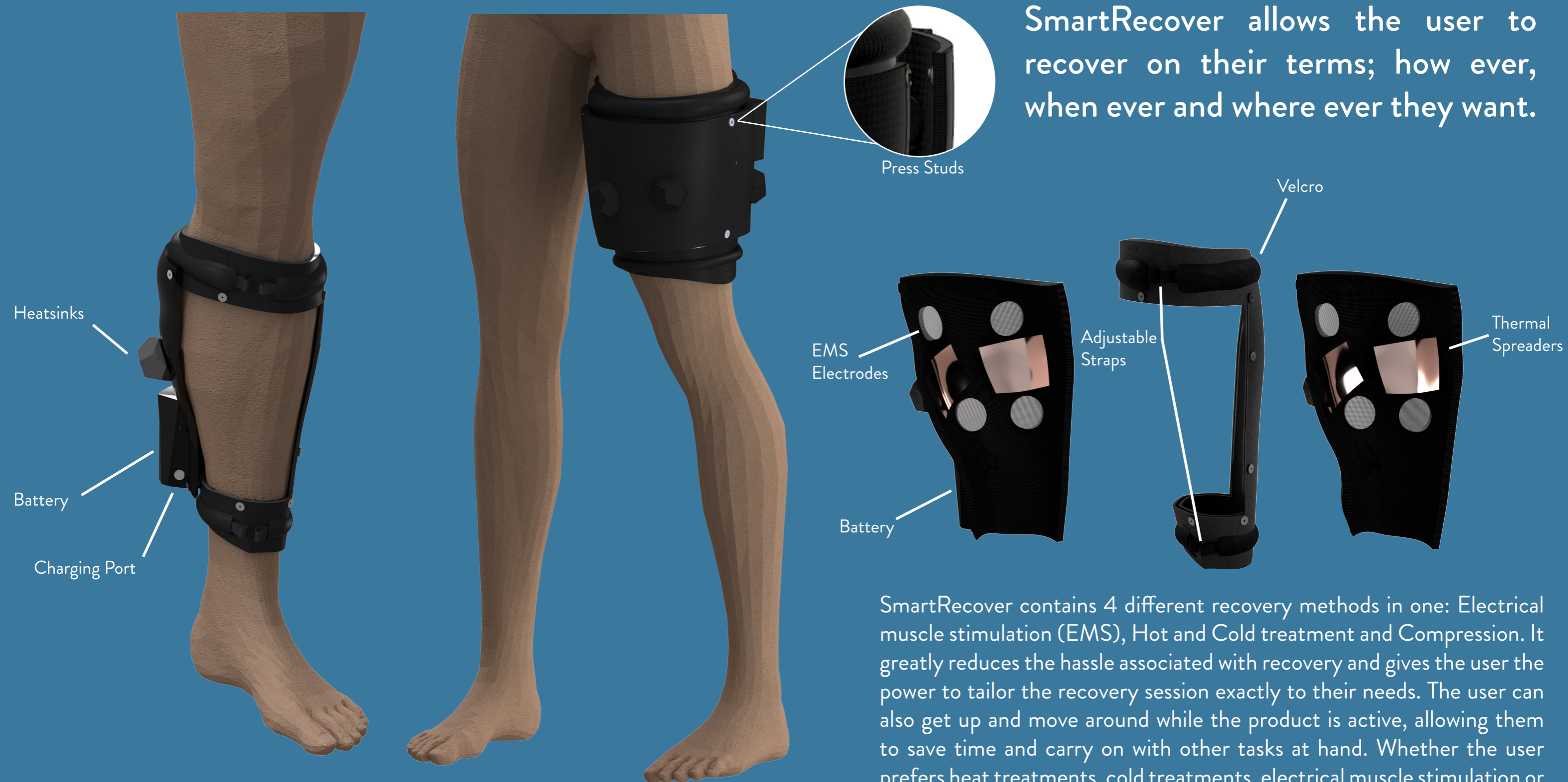
## Test

An initial prototype was created with cardboard and velcro and taken to a football match. The players were encouraged to play around with the product and try it on after the match, when the real product would be in use. Observations were made on how the users interacted with the product and feedback was obtained advising the next steps of the project. For example, in the second prototype (2nd row) users disliked how they had to thread the buckle everytime they wanted to put the product on. The large buckle was replaced with a new adjustable system in the next prototype.

This process was repeated with each iteration of the product until a consensus was reached on form, fit and comfort.



# Product Overview



SmartRecover allows the user to recover on their terms; how ever, when ever and where ever they want.

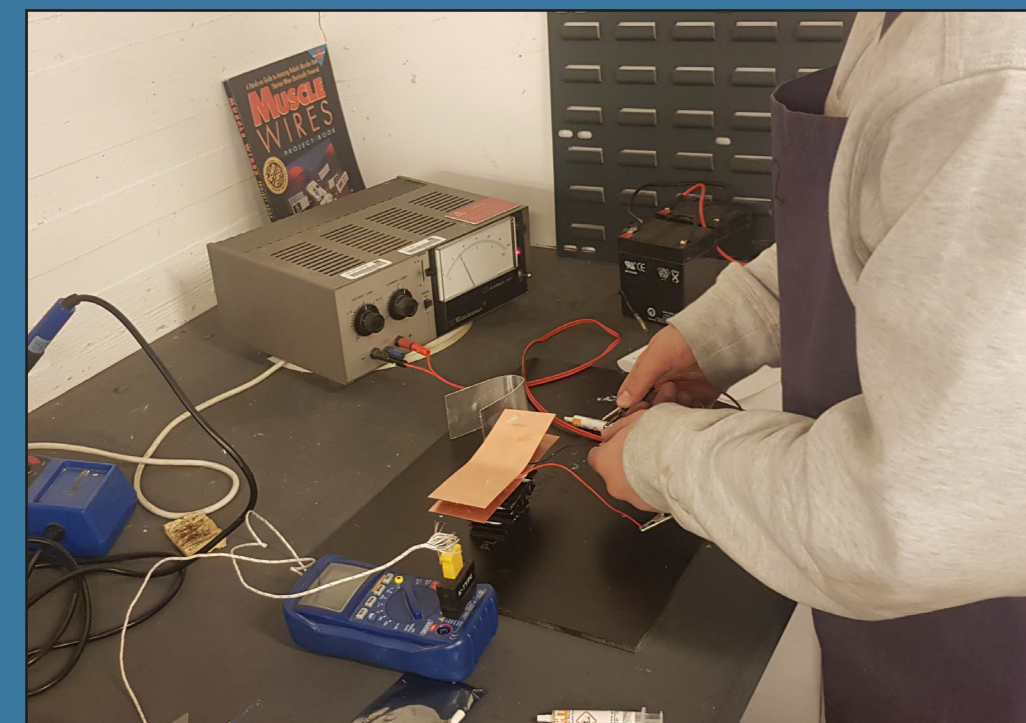
SmartRecover contains 4 different recovery methods in one: Electrical muscle stimulation (EMS), Hot and Cold treatment and Compression. It greatly reduces the hassle associated with recovery and gives the user the power to tailor the recovery session exactly to their needs. The user can also get up and move around while the product is active, allowing them to save time and carry on with other tasks at hand. Whether the user prefers heat treatments, cold treatments, electrical muscle stimulation or compression – or all of them alternating one after another, this product makes it quick and easy to do so.

# Technical Challenges

## Thermoelectric Coolers (TECs)

As EMS is already an established method of achieving enhanced recovery, my primary technical challenge was preparing the peltier modules so that they could be used in the product.

Heat transfer is an extremely complicated topic, one where it is hard to put theory into practice as there are so many 'moving parts' that can affect a thermal system being able to conduct effective heat transfer. It was a challenge for me to find the most effective system – testing out different metals, heatsinks, heatsink orientations and so on. It was particularly difficult getting the TECs to extract enough heat from the cold side to make the cold side cold enough so that they would effectively cool the muscle inducing increased bloodflow. The solution is to ensure that all the parts have good 'thermal contact' using a thermal gel, utilise heatsinks effectively and ensure that you have selected the correct TEC for the application. If the wrong TEC is selected, the whole thermal system becomes inefficient.



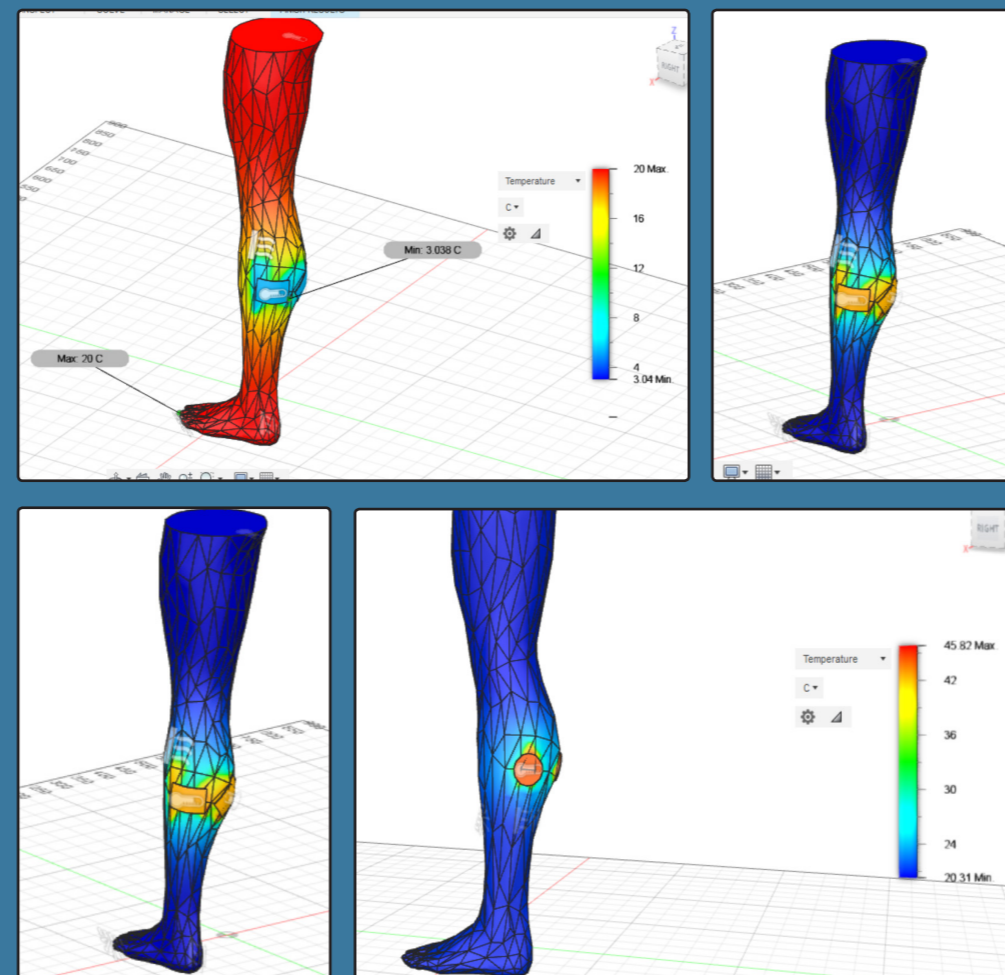
Experimenting with different thermal systems

## Thermal Simulations

Through creating a thermal model of the system on FEA (Finite Element Analysis) software, I was able to optimise the heat transfer between the TECs and the leg.

As TECs are quite small, it was decided that the device will make use of a 'thermal spreader' in order to spread the temperature change over a larger area, thus more effectively increasing bloodflow to the targeted region.

The simulation allowed me to test out different shapes, sizes and material of the 'thermal spreader,' thus finding the most efficient system in terms of cost and efficient heat transfer. It was eventually found that two copper plates, each of area 375 mm squared was the optimum 'thermal spreader' orientation.



## Power Consumption Considerations

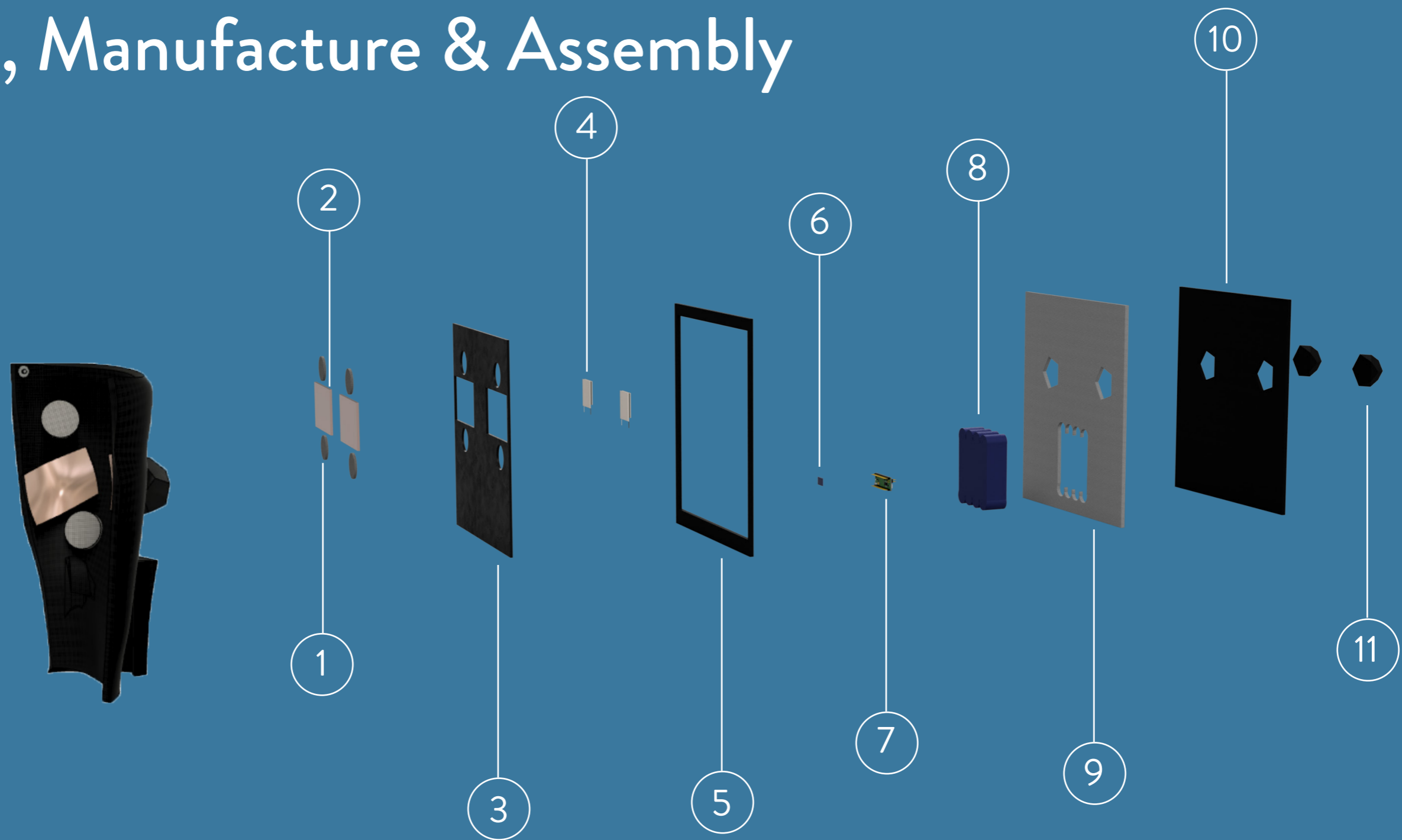
An important aspect of the device is its portability. It is therefore powered by a lithium ion rechargeable battery. TECs consume a lot of power when running at full capacity and therefore it was essential for me as the designer to account for this.

The most power consuming setting is by far the cold setting. This is due to the fact it is more power consuming (almost 50% more) to cool things down than to heat them up. It was found in the lab using an adjustable power supply that each of the TECs consume 6V at 1.5A when connected in parallel and running at the coldest setting (4 degrees celsius). Hence with 4 TECs running at this setting the device will consume 6V at 6A.

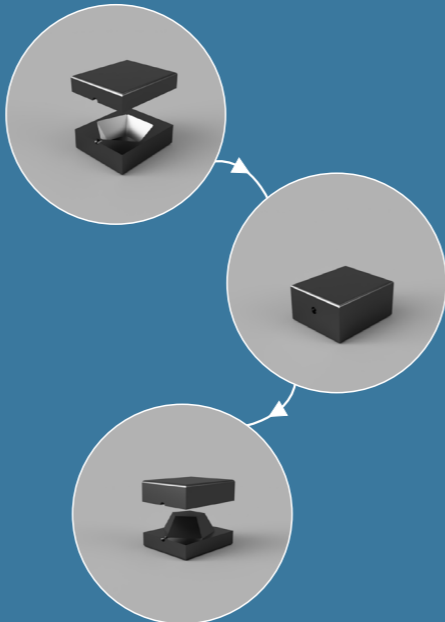
From user feedback and research it was determined that if users had to recharge the device after anything less than three uses it would become annoying for the user. A lithium ion battery of 6V 14Ah was therefore selected. This allows the user to have at least four recovery sessions before having to recharge. **This is for the most power hungry setting** of max power consumption and duration. Depending on duration and setting selected, usually the device will last for far longer.



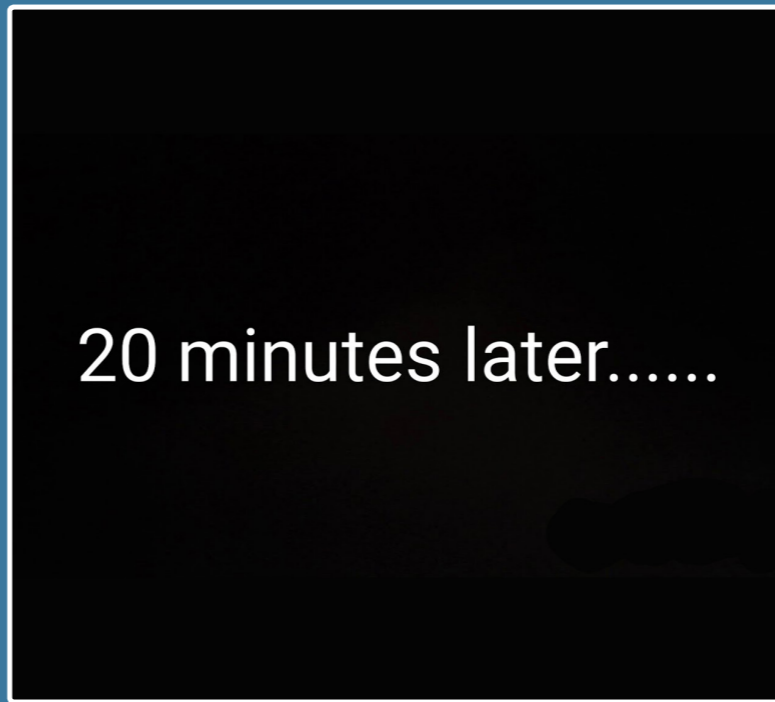
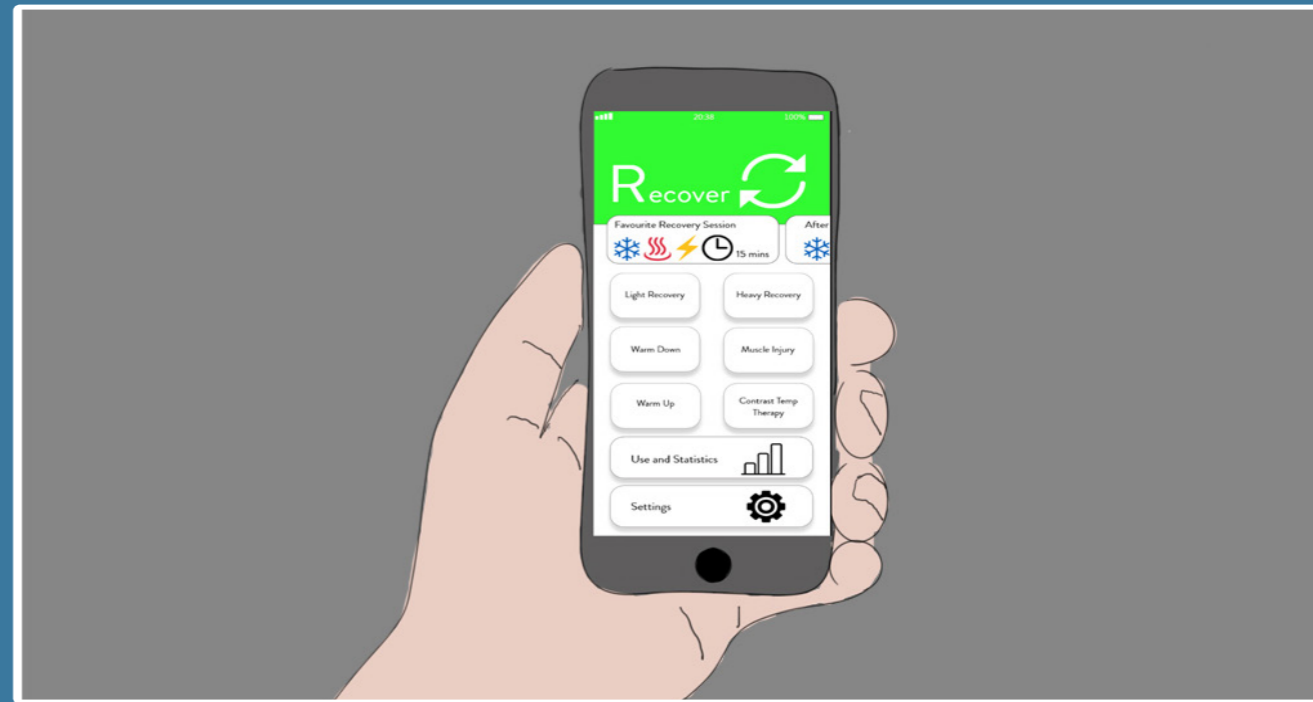
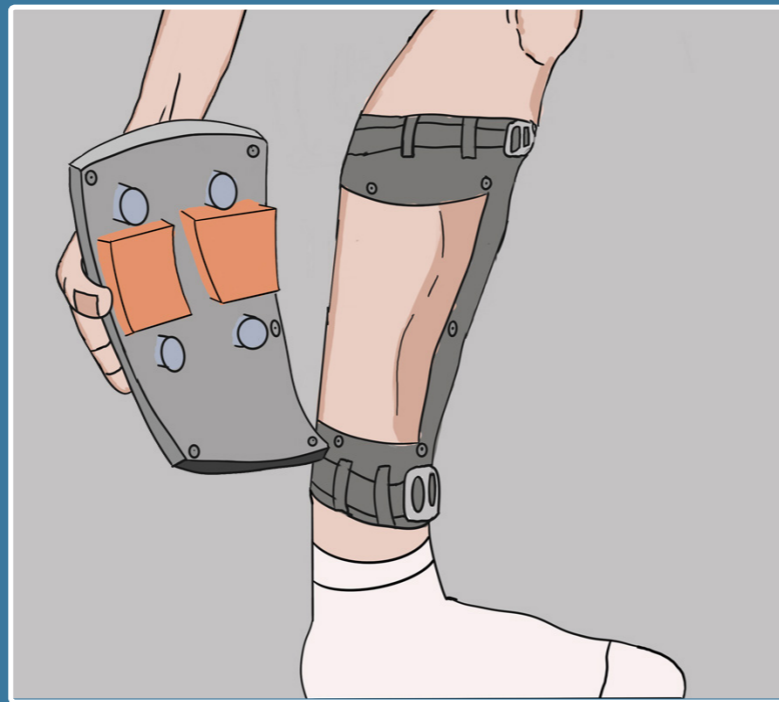
# Materials, Manufacture & Assembly



Firstly, the thermal spreader (2) and EMS electrodes (1) are attached to the neoprene sheet(3). The copper plates are ultrasonically welded on to the sheet and the electrodes are sewn on. The Peltier modules (4) are then attached to the copper plates using a thermally conductive epoxy. The outer edge fabric (5) is then sewn on to the neoprene sheet. With the peltier modules in place, the back fabric (10) is then sewn on to the outer edge fabric, enclosing the battery (8), filler material (9), bluetooth chip (6) and MCU (7) inside the device. The heatsinks (11) are then attached to the peltier modules using a thermal epoxy. The device is then coated in polyurethane, sealing it, making it waterproof. The only custom parts of the device are the heat sinks and the thermal spreaders. The rest can simply be bought as components. The heatsinks are cast in a steel mould (shown on the right) and the thermal spreaders are simply cut from a sheet of copper (0.5mm thick) and sanded.



Item	Qty	Part Name	Description	Material
1	2	EMS electrodes	Electrical muscle stimulation pads	E-textile
2	2	Thermal Spreader	Spreads temp. change over larger area	Copper (0.5mm)
3	1	Inner Sheet	Material for recovery modules to be attached to	Neoprene
4	2	Pelter Module	Thermoelectric coolers that control temp.	Composite
5	1	Edge Fabric	Edge for inner sheet to be attached	Polyester+Elastane
6	1	Bluetooth Module	Allows for coms. between app and product	Composite
7	1	MCU	Microcontroller Unit	Composite
8	1	Battery	Lithium ion power supply	Composite
9	1	Filler Material	Material to enhance 'feel' of product	Polyurethane+Elastane
10	1	Back Fabric	Fabric to close product	Polyester+Elastane
11	2	Heatsinks	Highly conductive objects to dissapate heat	Aluminium



# Key Features



## Convenience

SmartRecover can be used at any time, simply just put the device on and activate it with the app. No need to do any preparation or set up beforehand. The device is also wireless, allowing users to carry out other tasks while in use.



## Customisation

The user can create their own recovery session, controlling every aspect of it. The time, setting and intensity are all adjustable through the app. As recovery efficiency is mostly down to personal preference, users can mix and match to their hearts content, finding what truly works for them.



## Portability

The product is small enough that it can fit in any regular sports bag or backpack. It is also powered by a lithium ion rechargeable battery, allowing the user to take part in a recovery session where ever they please, whether that be in the car home or in the changing room, the choice is theirs.



# Key Features

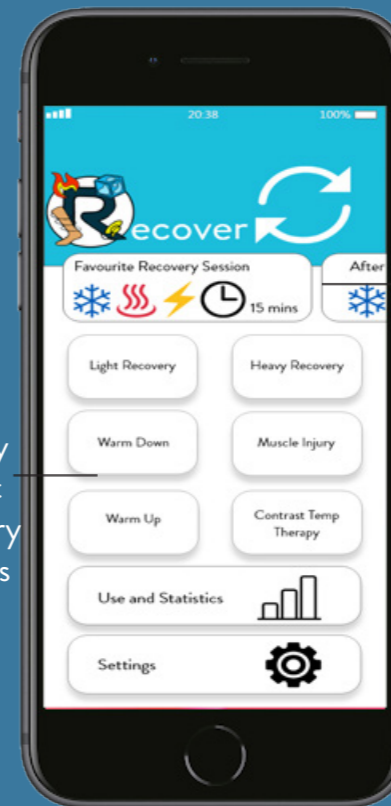


## In the box:

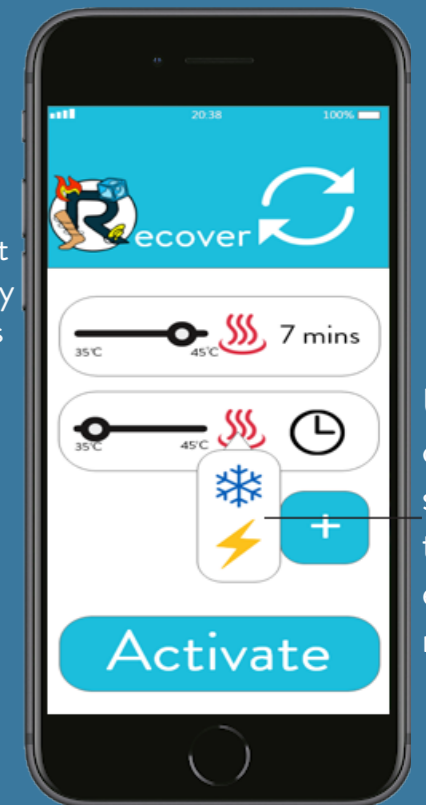
- x1 Charging plug and cable
  - x1 Safety and Instruction manual
  - x1 Adjustable inner compressive tubing
  - x1 Access to app platform
  - x2 Outer recovery modules
- RRP: £249



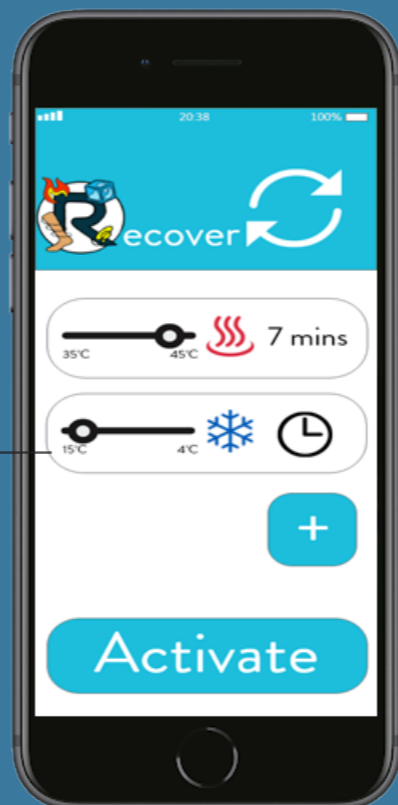
Factory pre-set recovery sessions



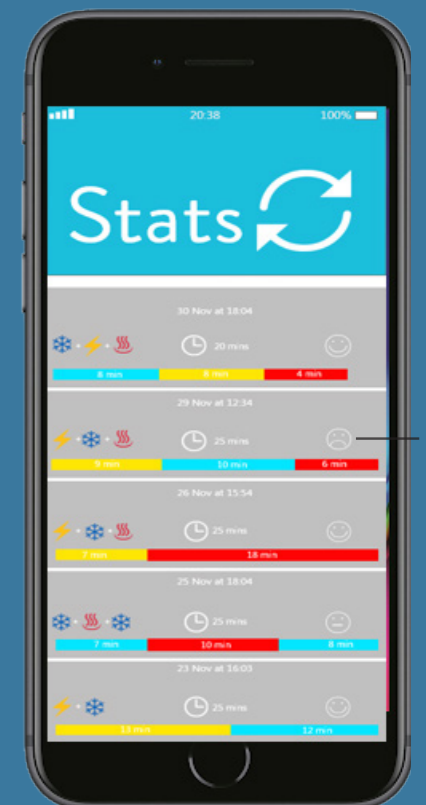
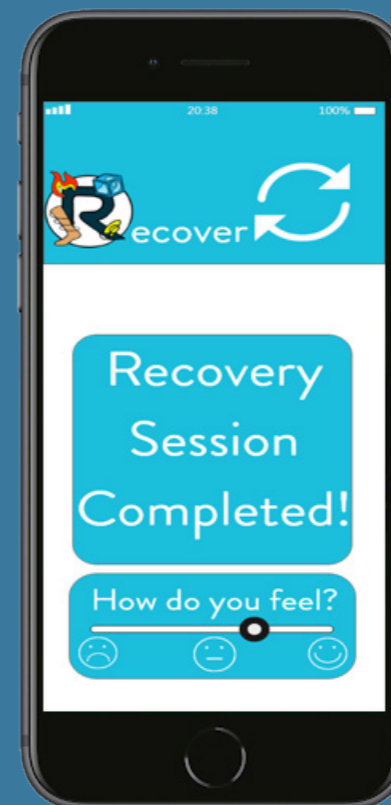
User set recovery sessions



Users can customise sessions to their exact needs



In-built limits for safety



Track and record sessions