

# Masters Design Project.

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# List of Abbreviations

## TBI

Traumatic brain injury

## mTBI

Mild traumatic brain injury

## MDP

Master Design Project

## GPs

General Practitioners

## SAC

Standardised assessment of concussions

## CBF

Cerebral Blood Flow

## GPA

Grade point average

## CCE

Catastrophic Cerebral Edema

## CTE

Chronic traumatic encephalopathy

## TDP

Tar DNA-binding Proteins

## CNS

Central nervous system

## RPQ

Rivermead post concussion symptoms questionnaire

## mRPQ

Modified rivermead post concussion symptoms questionnaire

## MPAI

Mayo-Portland adaptability inventory

## SCAT

Sports concussion assessment tool

## EMT

Emergency medical technician

## ER

Emergency room

## HIIT

High intensity interval training

## CES-D

Center of epidemiologic studies depression scale

## BDI-II

Beck depression inventory ii

## GDS

General depression scale

## HADS

Hospital anxiety and depression scale

## PHQ

Patient health questionnaire

## PHQ - 9

Patient health questionnaire - 9

## HIA

Head injury assessment

## MIPS

Multi-directional impact protection system

## BMX

Bicycle motocross

## ESPY

Excellence in sports performance yearly award

## AMA

American motorcyclist association

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# Needs Statement

A statement that describes the initial need or issue that sparked the start of the research into solutions

## Initial Need Statement

The need for a design solution to reduce the risk of extreme and action sports athletes suffering from concussions and/or repeat/secondary concussions using design principles and state of the art research.

# Abstract

The recent global awakening towards the dangers of concussion and the constantly evolving landscape of research has opened new opportunities in design solutions within the area of concussion detection and prevention. The main aim of this master's design project is to explore design solutions to reduce the risk of repeat / secondary concussion for extreme sports athletes using state of the art research and user centered design principles.

The findings of this master's design project (MDP) indicate that there is definite need and opportunity to improve the detection, protection, and treatment of concussions for action sports athletes.

The most recent literature on the biomechanical and neurological implications were reviewed to better understand the dynamic and complex nature of concussions. The state-of-the-art technologies, clinical methods, and systems surrounding concussion detection and/or prevention were also researched in order to get a holistic view of the current and potential future landscape of concussion detection and/or prevention. This research concludes that there are a number of pathways to potentially test for concussions that involve multiple methods of detection. The information was gathered through a number of means such as literature reviews, case studies and patent searches to develop the background secondary research. Primary research in the form of interviews and a detailed questionnaire was also carried out in order to get usable data to answer further questions regarding concussions.

Due to time constraints, a full multi-variable regression analysis was not possible on the data set collected through the survey which may hold insights to the relationship between concussion severity, frequency, amount, and emotional degradation. A limited number of interviews were also conducted due to both scheduling and time constraints. Despite the limitations of time and resources, a comprehensive questionnaire was conducted that encompassed a wide variety of action sports and allowed for in depth analysis of athletes experiences when dealing with concussions.

# Introduction

The aim of the introduction is to introduce the research topic and to give a brief outline of the initial project aims and objects, and the methods used along with providing a background to concussions.

## Research background

The state of the art in concussion detection and prevention has leaped forward with new advances in biomarkers (O'Connell, et al. 2018) and the affordability of gps and accelerometers (Brennan, et al. 2016) have allowed for more accurate recognitions of concussions. Knowledge around concussions is constantly being updated and challenged. There is still an unmet need to develop a system of concussion recognition that takes into account current research and can be utilized by athletes and clinicians alike.

## Aims and objectives

The main objective of this MDP was to design a non-intrusive, affordable, portable and multifaceted concussion detection system for athletes in extreme / action sports or those who may partake in sports on an individual level. A Secondary aim of this research was to explore the design process in a clinical setting, taking and applying appropriate rigger to the research and develop an accompanying design history file.

## Research methodology

Prior to the design stage, primary research was conducted in the form of semi structured interviews with a leading researcher in concussions, a paramedic with first hand experience dealing with concussed athletes and of an athlete with a history of multiple concussions. This was accompanied by a questionnaire to better gain an understanding of the emotional and behavioral stability of action sports athletes who have suffered from concussions along side their awareness of the dangers of concussions.

A Literature review was conducted to examine the latest research in the area of neurology, neurocognitive effects, emotional and behavioral effects, long term issues related to concussions and the current methods of detects and/or prevention of concussions.

Case studies were constructed to better understand the vast array of modes of concussion and their often drastic effects on emotional regulation and behavioral normalities.



# Research Chapter.

# Secondary Research.

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# Extreme Sports

Extreme sports are a form of action and adventure sports, consisting of an inimitable person-environment relationship with exquisite affordances for ultimate perception and movement experiences, leading to existential reflection and self-actualization as framed by the human form of life (Immonen, et al., 2018). It is also classified as an activity that involve the continuous application of highest-level skills and concentration in order to avoid any error, and any failure is likely to prove fatal, unless the participant is especially lucky (Buckley, 2018). There are 7 prime motives for action/extreme sport athletes which were discovered by (Zhou, et al., 2020) which are described as mastery, enjoyment, psychological condition, physical condition, affiliation, their expectations, and competition/ego.

Further motivations may include chasing invigorating experiences and experiences of transcendence as they become totally absorbed in the experience (Brymer & Schweitzer, 2017). This has led researcher to believe that many of the participants in extreme sports are that of the type T personality has been described by various psychologists as a thrill seeking or risk-taking personality (Self, et al., 2006).

## Airborne

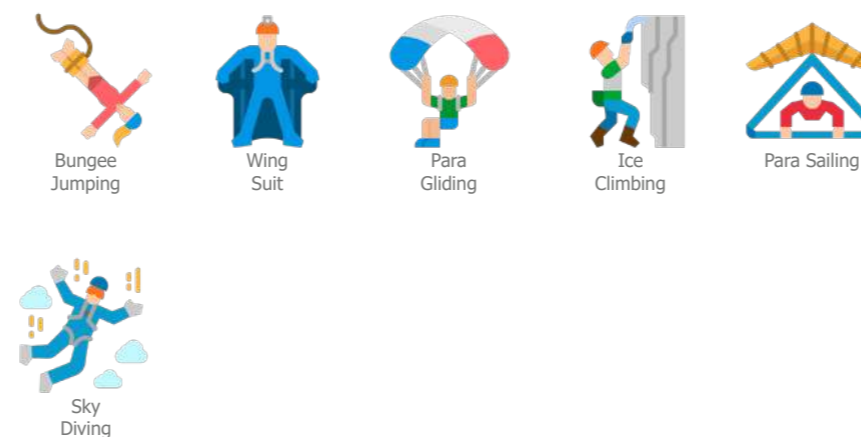
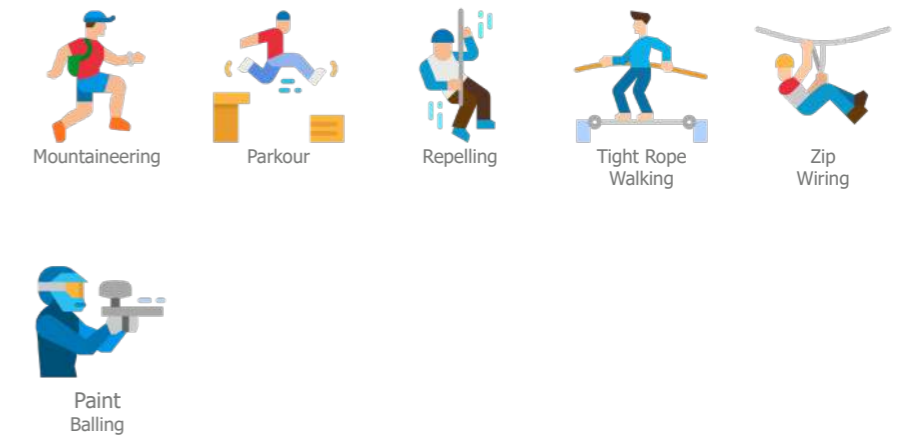


Figure 4 - Examples of Extreme Sports

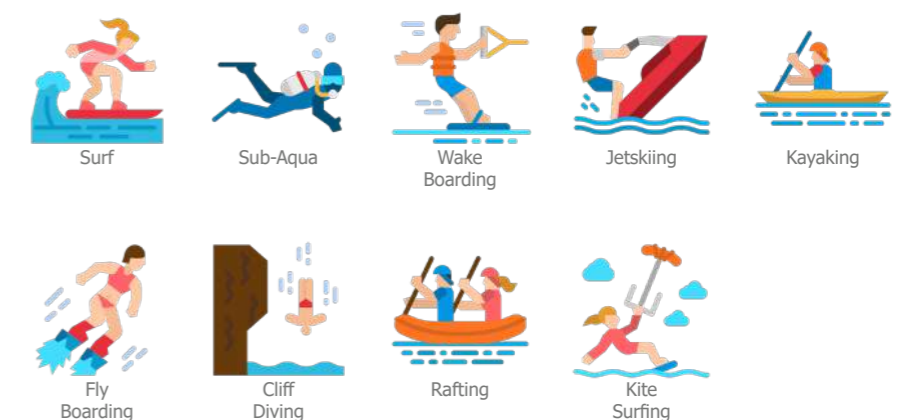
## Person Centered



## Ridden Sports



## Aqua Focused



# Extreme Sports

Due to the nature of Extreme/action sports, there is always an inherent risk involved with participating, but this risk is outweighed by the perceived emotional and physical benefits for the athletes involved (Brymer & Schweitzer, 2017). Because of this, there is very few non-intrusive ways to mitigate the risk of concussions whilst participating in the sports but, there is opportunity to mitigate the risk of repeat or secondary concussions in the sports whilst the athletes is not fully cognitively or emotionally capable of making precise skills due to their prior concussion.

Extreme sports athletes are at very high risk not only of concussions, but due to the psychology of people who take part in the sports, there is also a very high risk of repeat concussion.

## Pre Concussion



## Post Concussion



Figure 5 - Risk, Reward and Skill balance pre and post concussion

# Concussions



Figure 1 - Representation of concussions

A concussion is a traumatic brain injury (TBI) induced by an impulsive force transmitted to the head resulting from a direct or indirect impact to the head, face, neck, or elsewhere (Herring, et al., 2006). This can arise from a large array of situations and circumstances which cannot be fully accounted for.

The basic premise of a concussion is the rapid acceleration and deceleration of the brain causing cellular damage, more accurately, upon the bio-mechanical forces impacting the brain, the brain initially is delayed in its acceleration compared to the skull from being suspended in cerebral fluid but the rebounds towards the direction of the impact, colliding with the inner skull and then returning to its initial state (Edwards & Bodle, 2014).

All modes of concussions have some induced, direct, or indirect bio-mechanical forces transmitted to the brain. The most likely of which to cause a concussion is bio-mechanical forces that cause angular acceleration rather than linear acceleration as it is more likely to cause "brain slosh" (Abel, et al., 1978) (McGinn & Povlishock, 2016).

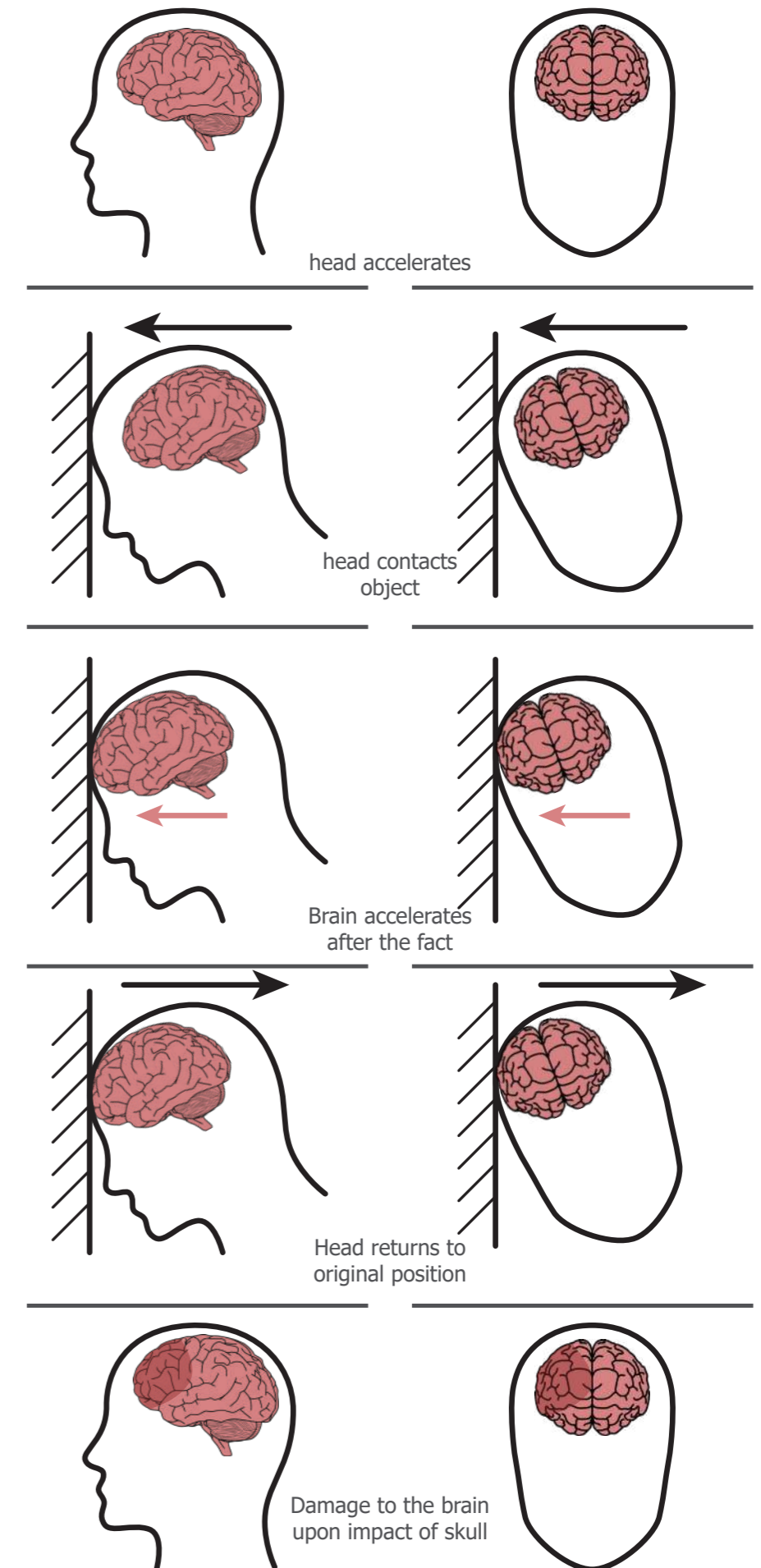
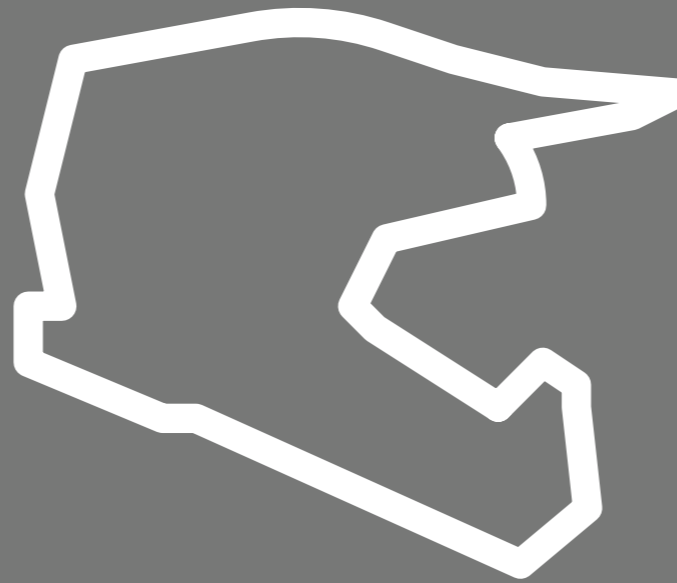


Figure 2 - Description of the bio-mechanical modes of concussion

# Concussions

Further causation is the imposed air of invincibility many people feel when wearing a helmet or full-face helmet, leading to an increase in reckless or risk-taking decisions, increasing the risk and likelihood of concussions (Finch, et al., 2003) (Patton & McIntosh, 2016).



## Greater Confidence

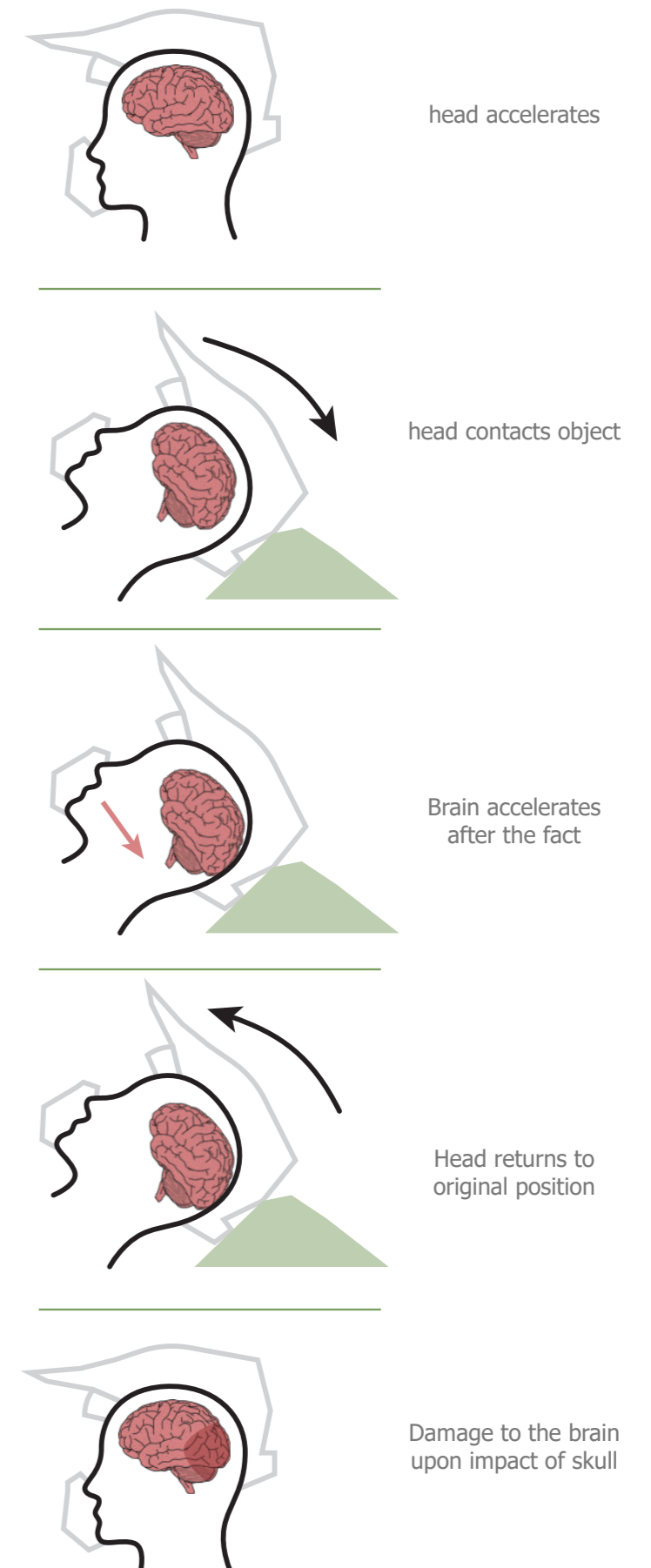
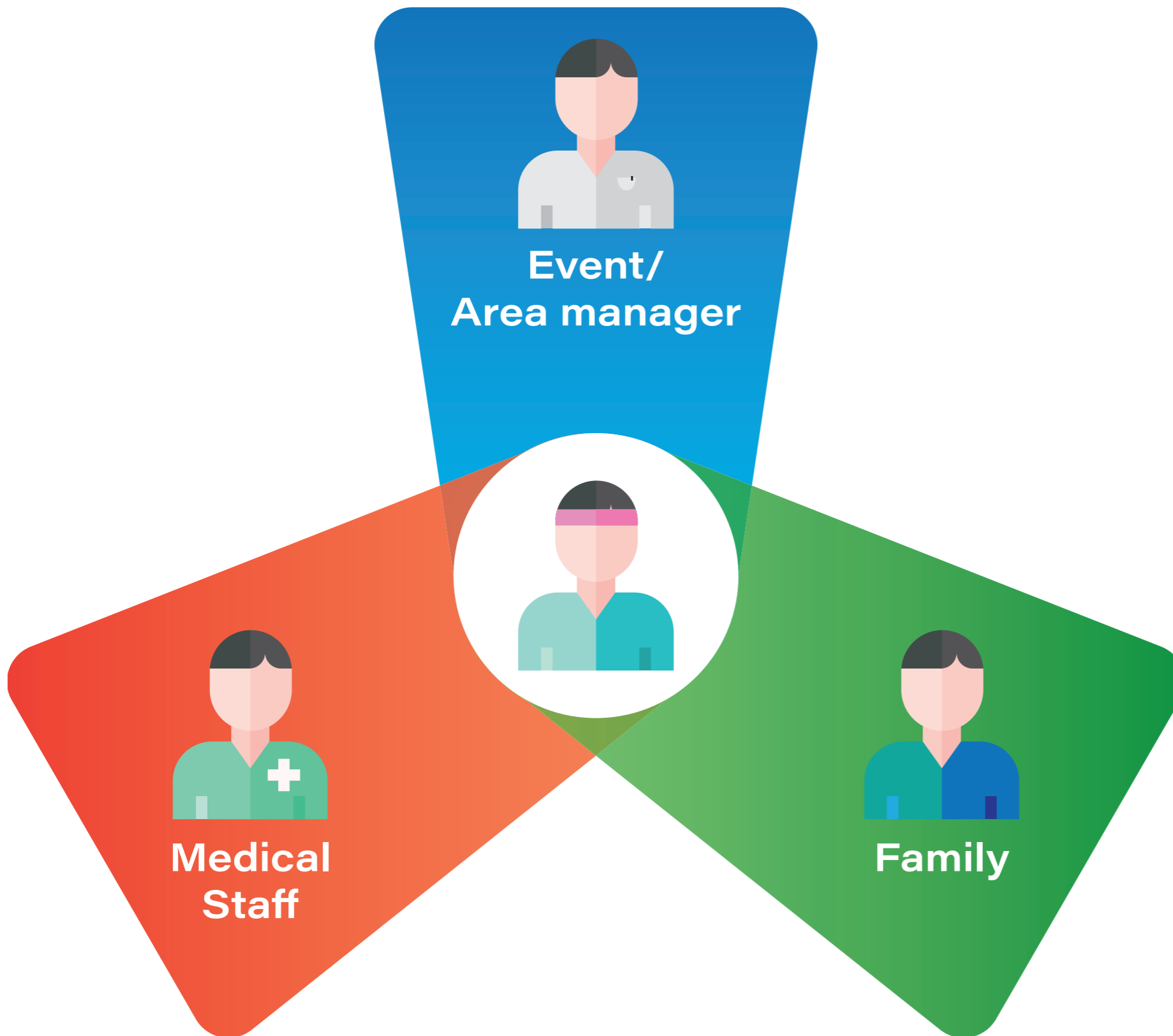


Figure 3 - Description of Bio-mechanical mode of concussion with helmet

# Stakeholders



## **Athlete / Patient**

Injured athlete  
Non injured athlete

## **Family**

Family members  
Partners  
Friends

## **Medical Staff**

First Responders  
Hospital Staff  
General Practitioners

## **Event / Area Manager**

Event Manager  
Land Owner  
Employer



# Stakeholders

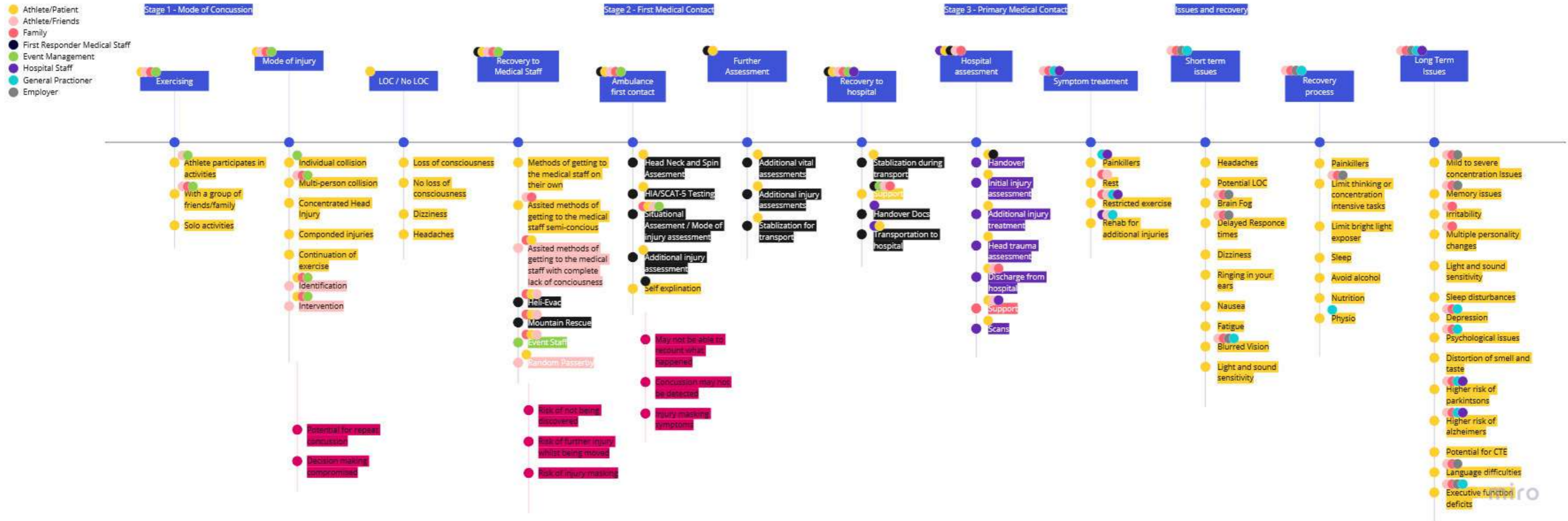


Figure 6 - Stakeholder / Journey Map

# Effects of Concussions

## Secondary Headaches

Reduced ability to function day to day, reliance on pain medication. Decrease in productivity and increase in frustration. May rely on family to help

## Fatigue

Reduced ability to function day to day, lack of motivation to do activities. Decrease in productivity and increase in frustration. May rely on family to help

## Noise Sensitivity

Decreased ability to withstand loud noises causing discomfort for the subject. May not be able to work in noisy office

## ringing in the ears

Difficulty concentrating, listening to peers and working. Discomfort for the subject.

## Blurred vision

Difficulty concentrating, reading, looking at screens and functioning day to day with obscured vision

## Dizziness

Difficulty concentrating on tasks, walking, looking at screens and functioning day to day. May require assistance moving

## Visual Disturbances

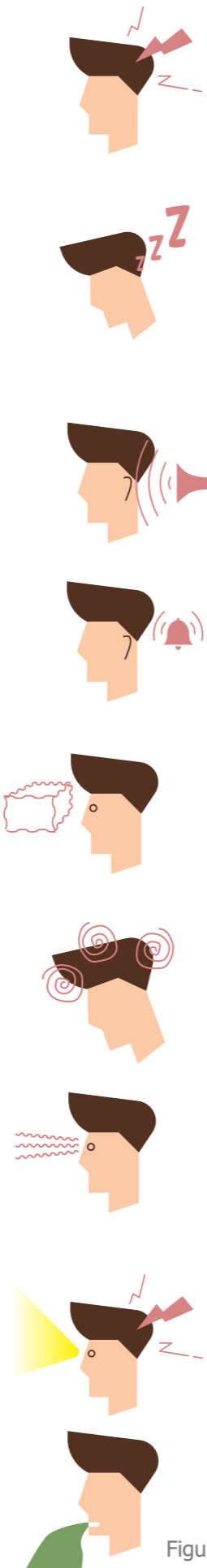
Difficulty concentrating, reading, looking at screens and functioning day to day with visual disturbances. lack of distinguishing whats real or not

## Light Sensitivity

Difficulty concentrating, looking at screens and functioning day to day, especially when near windows or under direct lighting.

## Nausea

Difficulty concentrating, listening to peers and working. Discomfort for the subject.



## Memory Deficits

Inability to recall information effectively or accurately. May cause confusion for peers or subject

## Concentration Deficits

Inability to concentrate on work or life tasks and may render issues in the workplace or life

## Attention Deficits

Inability to concentrate on work or life tasks and may render issues in the workplace or life

## Executive Function Deficits

Inability to do day to day tasks, become reliant of family or friends to get through days.

## Depression

Reduced motivation to do day to day tasks. Emotional instability and vulnerabilities.

## Anxiety

Reluctance to interact with people or to take on new tasks.

## Irritability

Reluctant to interact with people, reluctant to engage in tasks.

## Mood Instability

Inability to regulate emotions. infavourable interactions with people or tasks.

Figure 7 - Infographics of the effects of concussions

# Effects for Stakeholders

## Secondary Headaches

Increased reliance on medication for pain relief and so greater interactions with GP and potential reliance on family members to get medication or administer it.

## Fatigue

Reduced ability to function day to day, lack of motivation to get daily tasks completed which may impact their professional relationships and personal relationships

## Noise Sensitivity

May get annoyed at family members for making noise, putting strain on relationships. this could also be applicable in a work setting.

## ringing in the ears

Difficulty concentrating, listening to peers and working. Discomfort for the subject and may cause annoyances for family members.

## Blurred vision

Difficulty carrying out day to day tasks which may put strain on family members and professional relationships.

## Dizziness

May not be able to partake in events with family or at work, putting strain on family members

## Visual Disturbances

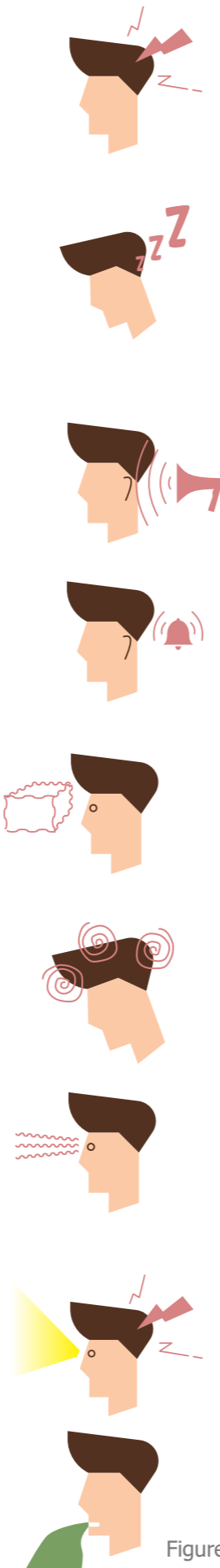
May not be able to partake in events with family or at work, putting strain on family members

## Light Sensitivity

May get annoyed at family members for making opening windows or turning on lights, putting strain on relationships. This could also be applicable in a work setting.

## Nausea

May not be able to partake in events with family or at work, putting strain on family members



## Memory Deficits

Inability to recall information effectively or accurately. May cause confusion for peers, family and friends. They may forget things like birthdays and other important events.

## Concentration Deficits

May not have the same ability to finish work, putting stress on their professional relationships or personal ones if they can't concentrate on conversations

## Attention Deficits

May not have the same ability to finish work, putting stress on their professional relationships or personal ones if they can't concentrate on conversations

## Executive Function Deficits

Inability to do day to day takes, become reliant of family or friends to get through days. May not be able to work during these times.

## Depression

Puts immense stress on family and friends as the person is not their selves and in need of support. May require a therapist.

## Anxiety

Reluctance to interact with people or to take on new tasks. May not be able to present in work or meet friends, stress on those relationships  
May Require a therapist.

## Irritability

Reluctance to interact with people or to take on new tasks. May not be able to present in work or meet friends, putting stress on those relationships

## Mood Instability

Puts immense stress on family and friends as the person is not their selves and in need of support.

Figure 7 - Infographics of the effects of concussions

# Neurocognitive Effects

In a 2017 paper it was found that injured subjects who were tested prior and post injury had a lower than baseline SAC (Standardized Assessment of Concussion) (McCrea, et al., 2000) scores in areas of immediate memory, concentration, and delayed recall. Adversely, no subjects scored greater than their baseline score and 84% scored below the population mean of non-injured players (McCrea, et al., 2002). Subject's score did not return to baseline after 15min, but no significant impairment was found beyond 48hrs-90 days (McCrea, et al., 2002) (Iverson, et al., 2017).

Causation of concussion symptoms is not yet fully understood but theories such as cerebral blood flow – glucose metabolism uncoupling (Doberstein, et al., 1992) and axonal diffusion (Pettus, et al., 1994) (Giza & Hovda, 2014) may be the cause of many neurocognitive

symptoms in concussions. The latter of which may explain the persistent symptoms and long-term issues athletes develop from repeat and severe concussions.

Symptom-free subjects who have had more than 2 prior concussions performed similarly to the subjects who has recently experienced a concussion in cognitive testing (Moser, et al., 2005). These subjects also notably scored lower in their academic GPAs than subjects who had not received a concussion which is speculated to suggest that there is a cumulative effect caused by multiple concussions over an extended time period (Moser, et al., 2005). Traumatic injuries to the developing brain can lead to long lasting changes in cognitive potential, even with minor symptoms during the incident or little initial deficits. This is especially true for repeat traumatic injuries

within the hyperglycolytic phase (Giza & Hovda, 2001) (Yoshino, et al., 1991) (Giza & Hovda, 2014). Cognitive deficits and micro-structural damage are detectable with recurrent injury as well as an increase in amyloid precursor proteins and plaques which are primarily linked with Alzheimer's.

# Neurocognitive Effects

## CBF

Cerebral blood flow glucose metabolism is the rate at which the blood brain barrier can transfer and metabolize blood glucose to restore or provide energy to axons and neurons in the brain. Cerebral blood flow glucose metabolism uncoupling (CBF) occurs when there is a disruption to this process, either chemically or in the case of concussions, bio-mechanically. The reduction in CBF by up to 50% despite increase demand for CBF and metabolic systems causing potentially damaging energy crisis post mTBI (Doberstein, et al., 1992) (Tagge, et al., 2018).

## Diffuse Axonal Injuries

The mechanical stretching of axons via bio-mechanical force transfer within the skull resulting in membrane disruption and potentially depolarization which both increases axolemmal permeability immediately post injury but also can lead to the formation of axonal bulbs from intra axonal cytoskeletal abnormalities (Pettus, et al., 1994)(Povishock&Christman, 1995) (Bramlett & Dietrich, 2015).

## Repeat Concussion

Glucose metabolism - CBF uncoupling as noted about is most dramatically during the hyperglycolytic phase which lasts until 30min post initial injury whereby cerebral metabolism is already at its limits and any further damage causing excess demand for metabolic action or further reduction in the ability to metabolize CBF causes irreversible neuronal injuries as seen with many extreme sport athletes (Yoshino, et al., 1991) (Doberstein, et al., 1992) (Tagge, et al., 2018).

A secondary traumatic brain injury during this time can also cause catastrophic cerebral edema (CCE) and neurologic collapse (Giza & DiFiori, 2011) but many studies have also show that the injury could be a delayed onset cerebral edema which is not associated with structural brain injuries (Bruce , et al., 1981) (Broglia, et al., 2015).

# Long Term Issues

Sports concussions result in chronic sub-clinical motor system dysfunctions that are linked to intracortical inhibitory system abnormalities which suggests that intracortical inhibitory interneuron receptors of the motor system may be particularly vulnerable to the effects of sports concussions (De Beaumont, et al., 2007).

Studies have also found that children with no prior history of psychiatric issues are significantly more likely to develop psychiatric issues within 3 years of mTBI in comparison to those who are uninjured (Daneshvar, et al., 2011).

Due to the neurological damage done during a concussive force transmitted to the brain, proteins such as amyloid precursor proteins are produced and released into the cerebral membrane which cause the plaque build-up commonly associated with Alzheimer's and Parkinson's disease (Yoshino, et al., 1991) (McGinn & Povlishock, 2016) which unfortunately affect many retired action and extreme sport athletes and has taken the lives of many, notably Mohamad Ali and Louis Roy Groza.

Mild to severe concentration issues

Memory issues

Irritability

Multiple personality changes

Light sensitivity

Sound sensitivity

Sleep disturbances

Smell and taste distortion

Language difficulties

# Long Term Issues

## Mild-Severe concentration issues

Depending on the severity of concentration issues, this may have a major impact on both personal and professional life. It may also affect a persons ability to perform at a high standard academically. This can also impact relationships as the subject may not be able to engage in conversations in the same way as before

## Memory Issues

Abilities to recall information or remember key days may introduce issues in relationships or employment. This can impact day to day conversations.

## Irritability

Ability to interact with people or take on new tasks may be effected as the subject may just get annoyed and give up or set away from the social interaction. Pressure may aggravate the subject and compound the issue

## Multiple personality changes

People may become more aggressive or distant depending on their emotional degradation, they may also start to become more irrational in their behavior and actions causing difficulty in relationships and potentially recommended to a therapist for it.

## Light sensitivity

Difficulty concentrating, reading, looking at screens and functioning day to day especially in the modern era of smartphone and now remote learning and work.

## Sound sensitivity

The subject may find it difficult to work or concentrate on tasks due to the irritability of sounds around them, can also effect sleeping patterns.

## Sleep disturbances

Sleep disturbances can cause issues day to day and effect the persons ability to work, concentrate and regulate emotions. This is especially prevalent when sleep is one of the 3 pillars of mental health

## Smell and taste distortions

This can change a persons enjoyment of day to day things that they may have enjoyed before such as food or beverages. This may also become an issue regarding health and safety if the user cannot tell the difference between safe or not

## Language difficulties

This may cause difficulties in communication between peers, family and employers. The person may also then find it difficult to express themselves due to the new language barriers which may have adverse effects on the persons mental health.

# Long Term Issues

## CTE

Chronic traumatic encephalopathy is a spectrum of hyperphosphorylated tau pathology that has a large range in severity from focal perivascular epicentres of neurofibrillary tangles in the frontal neocortex to severe tauopathy affecting widespread brain regions which may include the medial temporal lobe (McKee, et al., 2013).

## Stage I

Characterized by focal epicentres of perivascular p-tau neurofibrillary and astrocytic tangles.  
Symptoms – reported to be headache and loss of attention, concentration, short-term memory difficulties, aggressive tendencies, depression, executive dysfunction and explosivity.

## Stage II

Characterized by TDP-43 abnormalities as neuronal and glial inclusions and neurites in widespread regions of the CNS, including the cerebral hemi-spheres, basal ganglia, diencephalon, brainstem, anterior horn cells and white matter tracts of the spinal cord. There may also be Degeneration of lateral and ventral corticospinal tracts and markable loss of anterior horn cells for the spinal cord.

Symptoms - depression or mood liability, explosivity, loss of attention and concentration, short-term memory loss and headache. Less common symptoms included executive dysfunction, impulsivity, suicidality, and language difficulties.

## Stage III

Characterized by moderate depigmentation of the locus coeruleus, mild depigmentation of the substantia nigra, atrophy of the mammillary bodies and thalamus, sharply convex contour of the medial thalamus, thinning of the hypothalamic floor and thinning of the corpus callosum. Microscopically, neurofibrillary tangles were widespread throughout superior frontal, dorsolateral frontal, inferior orbital, septal, insular, temporal pole, superior middle and inferior temporal and inferior parietal cortices.

Symptoms – Memory loss, executive dysfunction, explosivity and difficulty with attention, concentration, depression or mood swings, visuospatial difficulties, aggression, impulsivity, apathy, headaches, and suicidality. Many also classify and cognitively impaired with onset cognitive or behavioural abnormalities.

## Stage IV

Characterized by macroscopic brain changes included atrophy of the cerebral cortex and white matter and marked atrophy of the medial temporal lobe, thalamus, hypothalamus, and mammillary body along with ventricular enlargement, sharply concaved contour of the third ventricle, cavum septum pellucidum size differences and septal perforations or complete absence.

Symptoms - Dysfunction and memory loss, severe memory loss with dementia, profound loss of attention and concentration, executive dysfunction, language difficulties, explosivity, aggressive tendencies, paranoia, depression, gait and visuospatial difficulties, impulsivity, dysarthria, and parkinsonism.

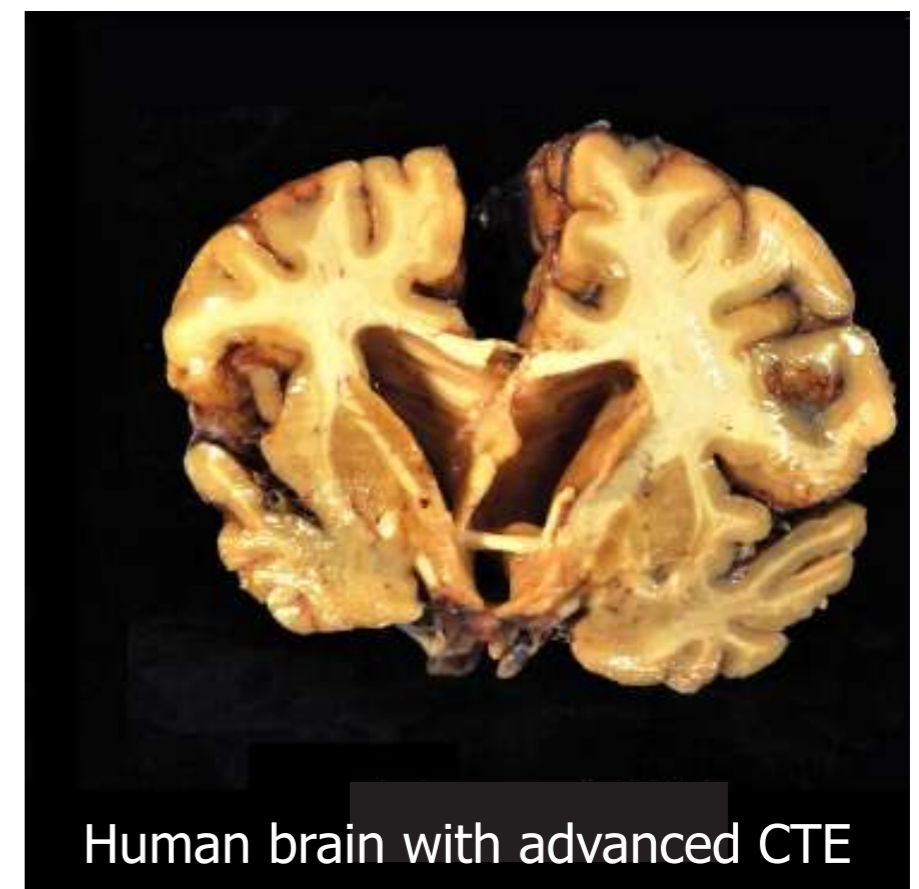
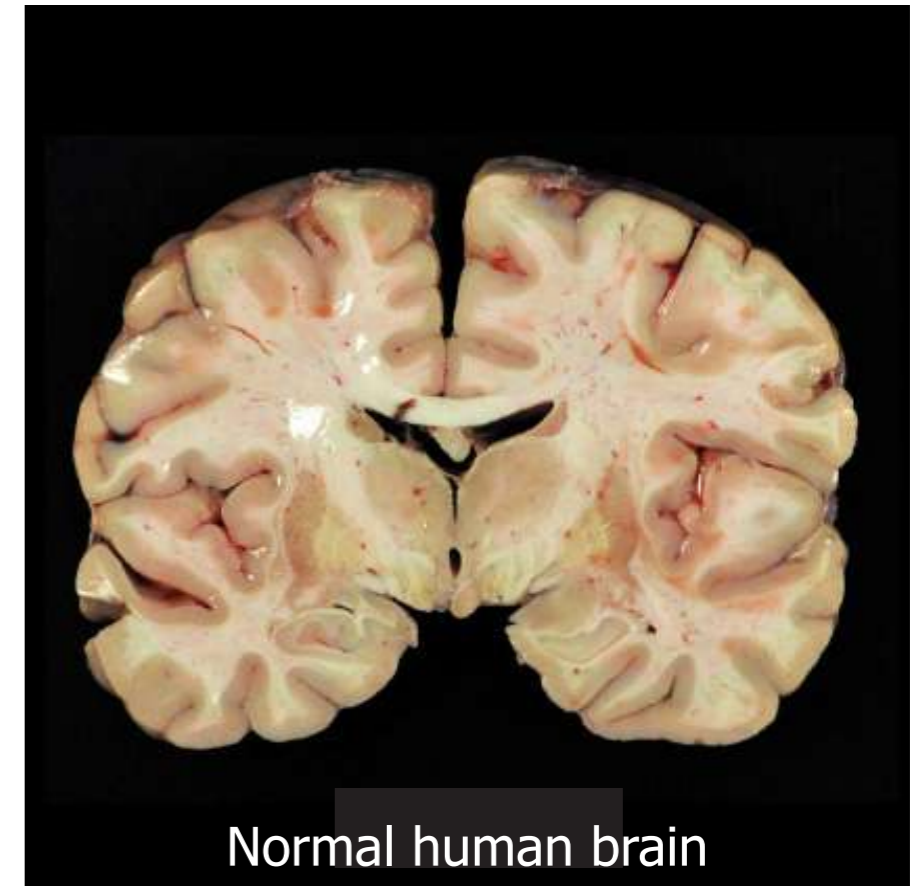


Figure 8 - Effects of CTE on the human brain



## Personal Changes

Concussions can produce emotional and behavioral disturbances beyond what can be expected due to the general injury factors such as pain, disruption, and fatigue (Gornall, et al., 2019). Furthermore, Pre-injury mood disturbances have been found to be not predictive of post injury mood (Leddy, et al., 1994) (Putukian, 2016) and depressive symptoms are elevated beyond that expected from general removal from competition in high level athletes (Mainwaring, et al., 2004) and is more likely as consequence of transient biochemical disturbances or impairment of normalized neuronal metabolism causing a metabolic cascade of dysfunctional neurotransmitters following the brain injury (Giza & Hovda, 2001) (Hovda, et al., 1992) (Oresic, et al., 2016).

Differences between sexes have been found regarding emotional and behavioral changes with male behavioral domain relating more to substance abuse in depressive symptoms whilst female behavioral domain relating more to suicidal thoughts and actions and decision making but physical violence was found across both sexes (Knell, et al., 2020). Those who have had a concussion are significantly more likely to self-harm, have depressive symptoms, attempt suicide, and or be injured from a suicide attempt (Yang, et al., 2019).

# Current Methods

## Rivermead Post-Concussion Symptoms Questions (RPQ)

What: Questionnaire

Strengths: Clinically accurate and verified multiple times in independent lab studies

The current system of review, including the RPQ are subject to a multitude of result altering factors, including fatigue, mood, anxiety disorder, motivation, effort, and potential preexisting expectation of poor performance which may come from stereotype threat or self-schema, These can also be cheated once the sequence is known (Pavawalla, et al., 2013). Can take upwards of 15 minutes of constant cognitive involvement (Maruta, et al., 2018). Developed in 1994 for dementia and adapted to concussions rather than being an independently developed system. Requires self-evaluation despite the possibility of cognitive impairment and the participant's responses reflect the subjective assessment and perception of the injured person regarding his/her condition and how it affects his/her life (Kay, et al., 1992)

## Modified Rivermead Post-Concussion Symptoms Questions (mRPQ)

What: Questionnaire

Strengths: Clinically accurate and verified multiple times in independent lab studies

The current system of review, including the RPQ are subject to a multitude of result altering factors, including fatigue, mood, anxiety disorder, motivation, effort, and potential preexisting expectation of poor performance which may come from stereotype threat or self-schema, these can also be cheated once the sequence is known(Pavawalla, et al., 2013). Can take upwards of 15 minutes of constant cognitive involvement (Maruta, et al., 2018). Requires self-evaluation despite the possibility of cognitive impairment and the participant's responses reflect the subjective assessment and perception of the injured person regarding his/her condition and how it affects his/her life (Kay, et al., 1992).

## MPAI-4 Questionnaire

What: Questionnaire

Strengths: Clinically accurate and verified multiple times in independent lab studies and can assess an array of brain injuries

Time and reliance on applicator of the test aside from the (Tennant and Conaghan, 2007) computer adaptation but accurate and useful in clinical settings (Malec, et al., 2003). multitude of result altering factors, including fatigue, mood, anxiety disorder, motivation, effort, and potential preexisting expectation of poor performance which may come from stereotype threat or self-schema (Pavawalla, et al., 2013).

## SCAT 5 Questionnaire

What: Questionnaire

Strengths: A fast list of questions that can quickly assess if a person may be concussed.

Requires additional medical staff to conduct, as well as prior testing for an individual baseline. These can also be cheated once the sequence is known.

## HIA Questionnaire

What: Questionnaire

Strengths: A fast list of questions that can quickly assess if a person may be concussed.

Requires additional medical staff to conduct, as well as prior testing for an individual baseline. These can also be cheated once the sequence is known.

# Cognitive Methods



Figure 9 - Representation of clinical survey

# Current Methods

## Head Impact Detection Devices

What: Accelerometer

Strengths: Clinically accurate and verified multiple times in independent lab studies

Measurements collected by impact monitors provided real-time data to estimate player exposure but did not have the requisite sensitivity to concussion. Head-impact-monitoring systems have limited clinical utility due to error rates, designs, and low specificity in predicting concussive injury on their own and still require clinicians to monitor athletes (O'Connor, et al., 2017).

## Novel Eye Tracking Devices

What: Visual Eye Tracker

Strengths: Clinically accurate and verified multiple times in independent lab studies

Both pupil dilation and tracking can be affected by a large number of factors, including adrenaline, stress (Pedrotti, et al., 2014) and excitement which may not be controlled for in lab conditions but is present in abundance in extreme sport situations and therefore may give false reports.

## X2 Patch

What: Accelerometer

Strengths: Clinically accurate and verified multiple times in independent lab studies and can assess an array of brain injuries

Head-impact-monitoring systems have limited clinical utility due to error rates, designs, and low specificity in predicting concussive injury on their own and still require clinicians to monitor athletes (O'Connor, et al., 2017).

## I-Portal Eye Movement Goggles

What: Visual Eye Tracker

Strengths: A fast list of questions that can quickly assess if a person may be concussed.

Both pupil dilation and tracking can be affected by a large number of factors, including adrenaline, stress (Pedrotti, et al., 2014) and excitement which may not be controlled for in lab conditions but is present in abundance in extreme sport situations and therefore may give false reports.

## Pupil Screening for Pupil Dilation

What: Visual Eye Tracker

Strengths: A fast list of questions that can quickly assess if a person may be concussed.

Both pupil dilation and tracking can be affected by a large number of factors, including adrenaline, stress (Pedrotti, et al., 2014) and excitement which may not be controlled for in lab conditions but is present in abundance in extreme sport situations and therefore may give false reports.

## CSX

What: Questionnaire

Strengths: A fast list of questions that can quickly assess if a person may be concussed.

No references when it comes to how they are measuring neurological deficits. Head-impact-monitoring systems have limited clinical utility due to error rates, designs, and low specificity in predicting concussive injury on their own and still require clinicians to monitor athletes (O'Connor, et al., 2017).

# Physical Methods



Fig 10



Fig 11



Fig 12



Fig 13



Fig 14

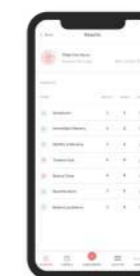


Fig 15

## N-Pro Safety Headgear

What: Helmet

Strengths: Clinically accurate and verified multiple times in independent lab studies

Helmets have inconclusive evidence as to whether they actually reduce the likelihood of concussions or the severity of them (Benson, et al., 2009). Several studies have provided bio-mechanical evidence that the use of specific headgear or helmets reduces the impact forces to the brain. However, in most sports, these results have not translated into observed differences in rate or severity of concussion (Daneshvar, et al., 2011). Head gear will reduce the risk of head injuries in general and therefore an important part of injury prevention, especially in sports which have the risk of contact with hard surfaces (Daneshvar, et al., 2011). Extra protection, especially head protection, also leads to an increase in reckless decisions and risk taking in children and adolescents, further increasing the rate of concussions as opposed to general injuries (Finch, et al., 2003) (Patton & McIntosh, 2016).

## Q - Collar

What: Compressive accessory

Strengths: Clinically accurate and verified multiple times in independent lab studies

Premise is based on jugular venous compression that is implemented by woodpeckers to increase blood pressure to the brain and stabilize the cerebral fluid, but there is no literature describing this process in woodpeckers or any other animal and was merely an idea promoted by the devices marketing campaign (Smoliga & Wang, 2019). All research done was done by interested parties and sponsored studies done by the devices company rather than independent testers.

## MIPS

What: helmet Insert

Strengths: Clinically accurate and verified multiple times in independent lab studies and can assess an array of brain injuries

Whilst angular acceleration of the head is linked to increased risk of concussion and MIPS is designed to reduce both the linear and angular acceleration, the patent was developed and released in early 2012 (US201261585976P). This is prior to the 2013 study done by (Benson, et al., 2013) shows that helmets and other head protection devices have little to no decrease in severity of concussions and in many cases increase the likelihood of getting one by promoting reckless decision making and risk taking (Finch, et al., 2003) (Patton & McIntosh, 2016).



Fig 16



Fig 17

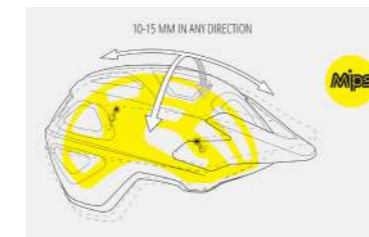


Fig 18

# Case Studies



Figure 19 - Profile of the late Dave Mira

## Dave Mira

### Place of Birth:

United States of America.

### Early life:

Dave was raised in Chittenango, New York in 1974. Dave grew up riding BMX and whilst attending East Carolina University, moved in with a number of other professional BMX riders who would ride and build ramps together.

### Career:

Dave had a highly successful career in both BMX and World Rallycross with a large number of accolades to his name.

### Personal Life:

Dave was married with two daughters and lived in Greenville, North Carolina. Dave was also a avid athlete, returning to boxing post retirement as well as being an active triathlete.

### Concussion Levels:

Dave suffered from "countless" concussions during his career and early life, specific numbers would be impossible to gather.

### Difficulties:

Dave suffered from depression, starting in the later years of his career until his untimely death.

Dave was posthumously diagnosed with chronic traumatic encephalopathy (CTE) and became the first action sports figure to be diagnosed with the neurodegenerative disease.

### Death:

Dave died from a self-inflicted gunshot wound to the head in 2016 in his home town, two months from his 42nd birthday.

## Career Highlights

Became a Pro BMX rider at the age of 13

24 time X Games Medalist (Record until 2013)

14 time Gold X Games Medalist (Second only to Shaun White)

Best Male Action Sports Athlete ESPY Award 2005

4th place in the 2013 Global RallyCross Championship

Developed the "Dave Mira Freestyle BMX" game

Qualified for the 2014 Ironman 70.3 World Championship



Figure 20 - Profile of the late Tyler Evans

## Tyler Evans

### Place of Birth:

United States of America.

### Early life:

Tyler was raised in Los Angeles in 1980. Tyler grew up riding bicycles and motocross bike from a young age, moving from state to state to compete in races.

### Career:

Tyler was highly successful as a Supercross rider during the 2000s who was renowned for his style and no care attitude.

### Personal Life:

Tyler had a daughter and lived in Los Angeles for the majority of his life.

### Concussion Levels:

Tyler suffered from "countless" concussions during his career and early life, specific numbers would be impossible to gather.

### Difficulties:

Tyler suffered from depression, starting in the later years of his career until his untimely death.

Tyler also turned to alcohol and substance abuse to deal with his mental illnesses.

### Death:

Tyler died from a self-inflicted gunshot wound to the head in 2018 in his home town after a confrontation with his then girlfriend involving the police.

## Career Highlights

Top Privateer of AMA Supercross

2nd in 1999 Dave Coombs East/West 125 Shootout

10th in the premier supercross class in 2004



Figure 21 - Profile of the late Brian Swink

## Brian Swink

### Place of Birth:

United States of America.

### Early life:

Brian was raised in Fenton, Michigan in 1972. Tyler grew up riding bicycles and motocross bike from a young age, moving from state to state to compete in races.

### Career:

Brian was highly successful as a Supercross rider during the 90s who was renowned for being one of the greatest 125cc riders to ever live.

### Personal Life:

Brian lived in Michigan for the majority of his life, moving from state to state during his career for racing but settled back in Michigan after his retirement.

### Concussion Levels:

Brian suffered from "countless" concussions during his career and early life, specific numbers would be impossible to gather.

### Difficulties:

Brian began having depressive symptoms after his retirement which continued until his untimely death. Brian turned to substance abuse and alcohol to deal with his condition.

### Death:

Brian died from self-induced kidney failure from alcohol abuse from a number of years in 2018.

## Career Highlights

Top Privateer of AMA Supercross

7 main event wins in 125cc class and the championship title in 1991

Over 100 top-ten finishes in his 7 year career

# Case Studies



Figure 22 - Profile of Graham Howes

## Graham Howes

### Place of Birth:

South Africa.

### Early life:

Graham lived in Johannesburg, South Africa surfing and kite surfing from a very young age which lead him to competing professionally.

### Career:

Graham is highly successful athlete as a big air kite surfer, artist and entrepreneur with his multiple businesses.

### Personal Life:

Graham has lived in South Africa for most of his life, moving around for competitions but always returning to his home.

### Concussion Levels:

Graham suffered from a large number of concussions during his career and early life, but much like other, there is no specific amount.

### Difficulties:

Graham began suffering from depression after a number of concussion during training and competitions.

### Current Life

Graham is currently managing his depression and seeking therapy for his condition, he is also a very active advocate for mental health in extreme / action sports around the world and is promoting it through his brand which he started in 2020

## Career Highlights

Infamous big air kite surfer who is famous for his relentless riding style.

Owner and manager of Dirty Habits, a platform of exploring the best aspects of extreme sports

Advocate for mental health in action sports with his brand beginning in 2020





Figure 23 - Painted profile of King Henry VIII

## King Henry VIII

### Place of Birth:

England

### Early life:

Henry was born in 1491 and raised to be the king of England. He was trained in many different sports including wrestling and jousting. Henry known as Henry the Generous for most of his younger years as king.

### Career:

Henry was the King of England from 1509 until his death in 1547. Henry had a very successful beginning of his reign but declined rapidly later in his career.

### Personal Life:

Henry was an avid athlete for the majority of his life until an unfortunate accident. Post accident, Henry had a number of behavioral and emotional issues which caused his renowned tyrannical nature later in life.

### Concussion Levels:

Henry would have suffered a number of sub-concussive forces during his athletic endeavors but suffered from a major concussive force during a jousting event which almost took his life.

### Difficulties:

The TBI likely caused the drastic personality changes which occurred post accident, this included irrational and explosive behaviors along with a lack of clear critical thinking towards the later part of his life.

### Death

King Henry VIII died in 1547 due to health complications caused by his stagnant nature post jousting injury.

## Career Highlights

King of England from 1509-1547

Founder of the Church of England

Reformed the English Parliament

# Case Studies Summary

Each of the case studies show the devastating effects that a concussion can have on a person's mental and subsequently physical health as well, ranging from mild personality changes to suicidal tendencies and megalomania.

In each study, the person became effected nearing the latter half of their careers and thus spilled into their personal lives.

These show the importance of concussion awareness in action sports and the necessity of intervention methods in modern action sports.



# Summary

There is a wide breadth of studies done and being completed in regards to concussions, from the biomechanical and neurological causations of them to the neurocognitive effects of them to the state of the art detection methods for concussions.

Neurologists are still breaking down potential biomarkers such as metabolic action within the blood and detectors of hyperglycolytic stages within axons.

The current methods of detection of concussions are currently either not accurate outside of clinical conditions or are not accurate enough to make a definitive diagnosis on their own. There is also very little evidence to show that any of the prevention methods reduce the severity of concussions and in the case of a number of devices, do not protect against concussions at all.

There is also a large number of extreme/action sport athletes who have unfortunately suffered from concussion and had adverse long term effects which deteriorated their quality of life through depression, anxiety and migraines to the point where many have chosen to end theirs.

There have been a number of opportunities to potentially innovate in the area of concussions that have arose from secondary research, many of these come from serving the need for an all inclusive, non-invasive concussion detection method that can be easily and quickly administered to a potentially concussed athlete.

Other opportunities for innovation include pre and post career education in concussions for action sport athletes

Another opportunity may arise in the long term care of athlete given the long term effects of concussions

# Detection

# Education

# Long Term Care

# Knows / Unknowns

## Knowns

- Concussions Effect Mental Health
- Concussions Effect Neurological Health
- Action sport athletes are at risk of concussions
- Concussions aren't confined to impact sports
- Concussions can cause long term damage to the brain
- Concussions may cause Alzheimer's
- Helmets don't always protect against concussions
- Theres a stigma around concussions
- Concussions are difficult to detect
- Athletes mask their injuries, especially head ones
- Concussions may cause parkinsons
- Detection methods don't always pick up concussions
- Detection methods can be cheated

## Unknowns

- The effectiveness of concussion detection methods
- Viability of non-invasive method of protection
- The relationship between repeat concussions and severity of symptoms
- The relationship between severity of concussion and emotional changes
- The relationship between concussion awareness and rate of concussions
- How concussions effect the brain
- The long term effects of concussions
- The medical protocol around concussions
- Current methods of detection
- Current methods of prevention

# Primary Research.

## Breakdown

Dot Code	pg 32
Interview Types	pg 33
Interview Findings	pg 36
Survey	pg 37
Quantitative Findings	pg 39
Qualitative Findings	pg 42
Summary	pg 43
Gaps and Opportunities	pg 44
Further Research	pg 45

## What the dots mean

Each dot represents one of the 10 final needs derived from the combined primary and secondary research.



# Interviews



Figure 24 - Representation of an EMT

## Profession:

EMT

## Definition of Profession:

A specially trained medical technician certified to provide basic emergency services (such as cardiopulmonary resuscitation) before and during transportation to a hospital

## Aim of Interview:

To gain an insight into the medical protocols and procedures used but first responders to concussions

## Background:

Young male EMT with multiple years of experience dealing with junior rugby events and other sports.

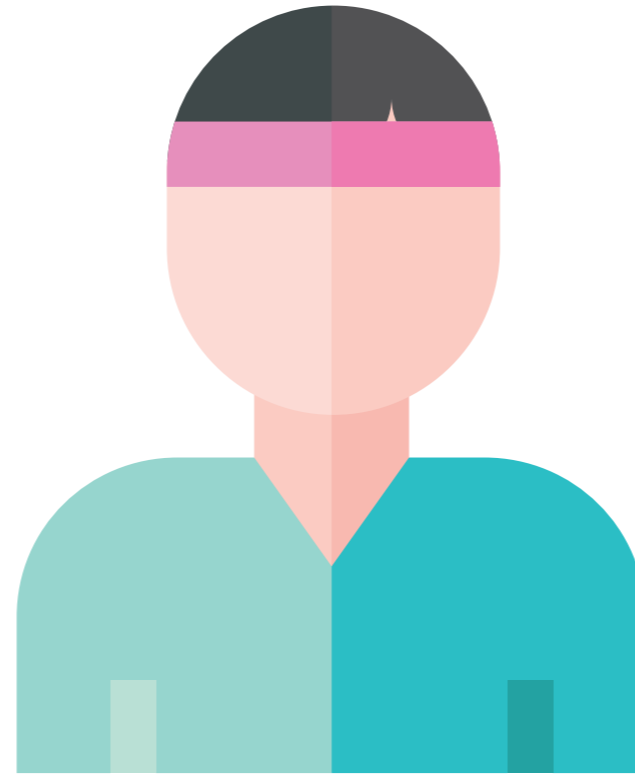


Figure 25 - Representation of an athlete

## Profession:

Athlete

## Definition of Profession:

A person who is proficient in sports and other forms of physical exercise.

## Aim of Interview:

To gain An insight into how action sports athletes deal with concussions and the culture surrounding injuries in action sports. This includes a personal account of how other athletes have reacted to concussions

## Background:

Young male Action sports athlete who has suffered multiple concussions whilst participating in various sports.



Figure 26 - Representation of a researcher

## Profession:

Leading Researcher

## Definition of Profession:

A person who carries out academic or scientific research and or discovers and verifies information form available sources.

## Aim of Interview:

To gain an insight into the future of concussion research, the future of concussion protection in sports. This included the current developments in research, current best practice for detection and the needs going forward for concussion detection and protection.

## Background:

Ireland's leading researcher in concussions with multiple decades of research and personal experience.

# Interview Findings

## EMT

Paramedics are woefully unprepared for head injuries, guidelines lack any clear instructions unless they pertaining to spinal injuries ●●●

Athletes can be fine and then have a rapid deterioration after a few minutes ●

Each paramedic has their own method of handover to ER ●●●

EMT is able to clear athletes to continue or not but have no guideline on how to assess concussions ●●●●●

EMT learn more on the job if they are lucky to be paired up with an experienced EMT but can also be paired with another inexperienced EMT ●

Will use a memory recall test along with other common methods to diagnose, differs from EMT to EMT ●●



Fig 24

# Interview Findings

## Athlete

Many athletes will continue to engage in an activities if they feel they are fit to do so, stating they will just “take it easy” for the rest of the activity



Athletes are far more confident when they have protective gear on, even if it doesn't protect against concussion



Many athletes don't know the dangers of concussions



Didn't feel the need to see a medical professional once they felt relatively okay



Athletes would rather “not waste the day/trip” and will continue to exercise or take part in order to “get the most out of the day/weekend”



Many athletes have a disconnect between what they say and what they do with regards to concussion, they believe they would sit out and be careful or protect a fellow athlete but often don't



Fig 25

# Interview Findings

## Researcher

There needs to be a drastic change in education and/or behavior towards concussions in sports since its hidden and not a visible injury ●●●●

There are many misconceptions around concussions such as a strong neck will protect the athlete... it won't ●

No one test can detect a concussion ●

Bio markers need to be used in conjunction with a system of emotional and cognitive tests to properly evaluate the athlete ●

Coaches need to manage the workload of the athletes in order to reduce the incidents of concussive and sub-concussive impacts athletes take in there lifetime ●●

Oxygen and cell metabolic testing is looking promising but relies on clinical equipment and environments ●●

Bio markers on their own can't tell the full picture as athlete can give the same readings after HIIT classes ●●

Many of the current tests such as the HIA can be cheated rendering them useless for actually detecting a concussion unless the player is willing to participate ●●●●●



Fig 26

Many athletes don't report concussions because they think they're going to be dropped, or they're contracts dependent or they're labels dependent ●●●

Vestibular ocular motor testing is a promising way to detect concussions but again must be used in conjunction with other means to be accurate ●

Concussions are often pigeon-holed into one sport, "rugby is responsible or American football etc etc" when it's every sport. ●●

# Survey Design

The survey is designed to gather information surrounding the experience of concussions.

Inclusion criteria:

Aged between 18-65

An extreme/action sports athlete

has suffered from a concussion whilst participating in sporting activities

The survey was constructed to extract information from athletes regarding their experience around concussion and the emotional and behavioral changes caused by concussions.

Many parameters were measured such as the amount of concussions, severity of concussions, if they had repeat concussions and if they had adequate medical advice post concussion.

The emotional and behavioral condition of the user was analyzed via the Center of Epidemiologic Studies Depression Scale (CES-D), many other scales were considered but the CES-D was chosen as it had been recently used in a research paper published by the University of Limericks psychology department.

## Alternatives

Beck Depression Inventory-II (BDI-II)

Center for Epidemiologic Studies Depression Scale (CES-D)

Geriatric Depression Scale (GDS)

Hospital Anxiety and Depression Scale (HADS)

Patient Health Questionnaire (PHQ)

Patient Health Questionnaire (PHQ-9)

The users recognition of concussions and the dangers of it was also measured using the Kurowski Concussion Awareness Scale, other surveys were considered but the Kurowski survey was used for its ease of application within a survey.

## Alternatives

(Conaghan, et al., 2020) Survey

(Kurowski, et al., 2015) Survey

(Kraak, et al., 2018) Survey

# The Survey

Information  
the Survey

Regarding

Data was collected from a diverse array of action sports athletes, ranging from bobsled teams to BMX riders. These were recruited from activity groups for the individual sports and from reddit activity boards to get the largest sample size possible

Diverse group of athletes  
from

Professional



Ex-professional



Elite Level



Sub-Elite Level



Amateur

311  
Responses

## Examples



BMX Riding



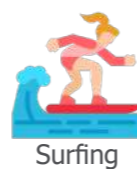
Mountain Biking



Parkour



Motocross



Surfing



Rock Climbing



Skate / Longboarding

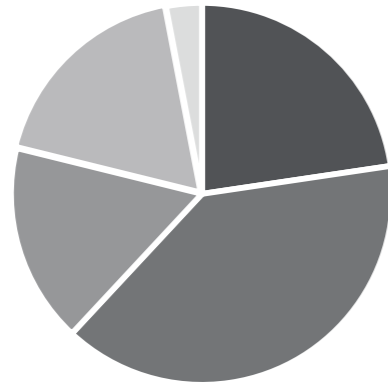


Kayak

Figure 27 - Representation of example extreme sports

# Quantitative Findings

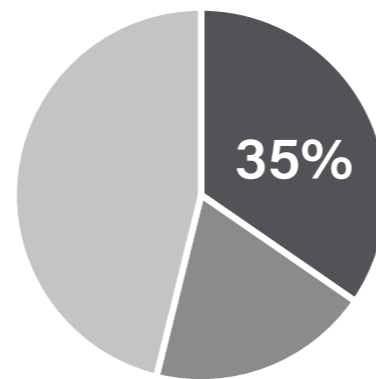
## Age Range



■ 18-20 ■ 21-30 ■ 31-40 ■ 41-50 ■ 51-60

Figure 28 - Graph representing age range

## Depression Rate in Extreme/Action Sports



■ Depressed ■ High Risk of depression ■ Not depressed

Figure 30 - Graph representing depression rates in extreme sports

## Number of Concussions



■ 1 ■ 2 ■ 3 ■ 4 ■ 5 ■ 6+

Figure 32 - Graph representing number of concussions suffered

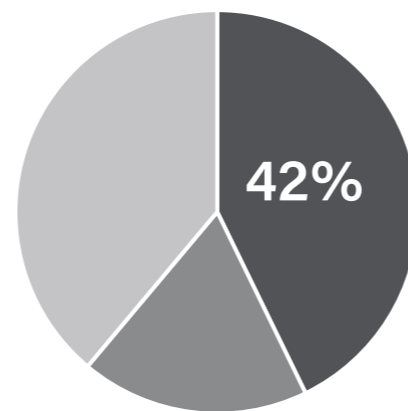
## Severity of Concussions



■ Mild ■ Moderate ■ Severe

Figure 29 - Graph representing severity of concussions

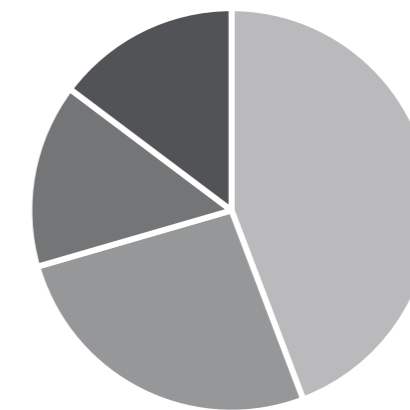
## Understanding of dangers



■ Poor understanding ■ Not great understanding ■ Good understanding

Figure 31 - Graph representing understanding of the dangers of concussions

## Duration of Symptoms



■ Days ■ Weeks ■ Months ■ Years

Figure 33 - Graph representing duration of symptoms

# Quantitative Findings

How the Athlete Managed their concussion which was suffered whilst alone

34  
Responses

Why the athlete felt their advice/treatment was inadequate

51  
Responses



# Quantitative Findings

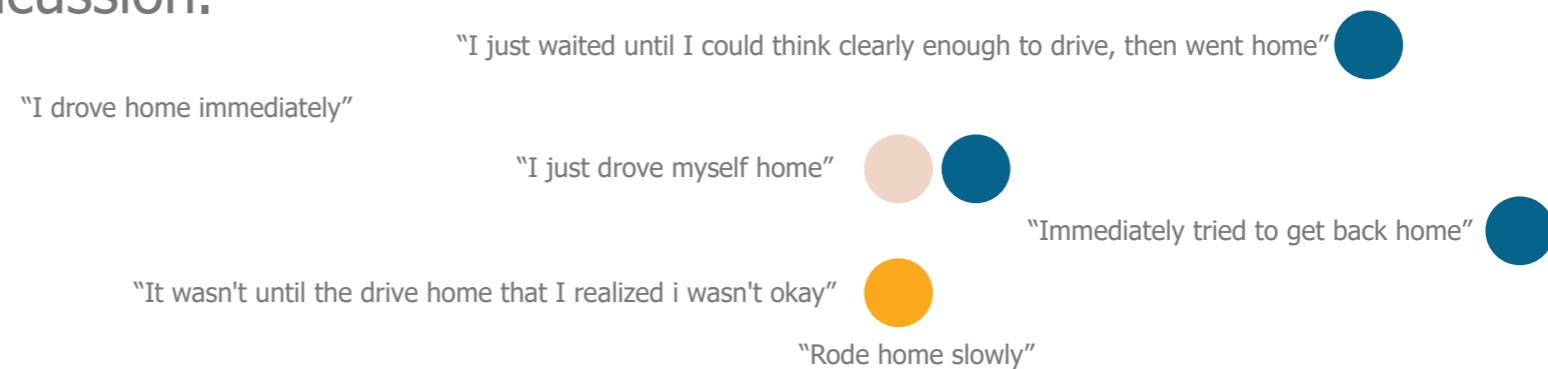
How the Athlete Managed their concussion which was suffered whilst alone

## Highlights

Many of the respondents simply waited until they felt better, or not dizzy at the very least and continued on with their activity at a supposedly lower pace or severity.



Just as worryingly, many of the respondents also did not ring a partner, family member or friend and decided to drive home alone after their concussion.



Interestingly, many of the respondents didn't realize they were concussed until after the fact, either by being told by a witness or form the lack of memory about the event.

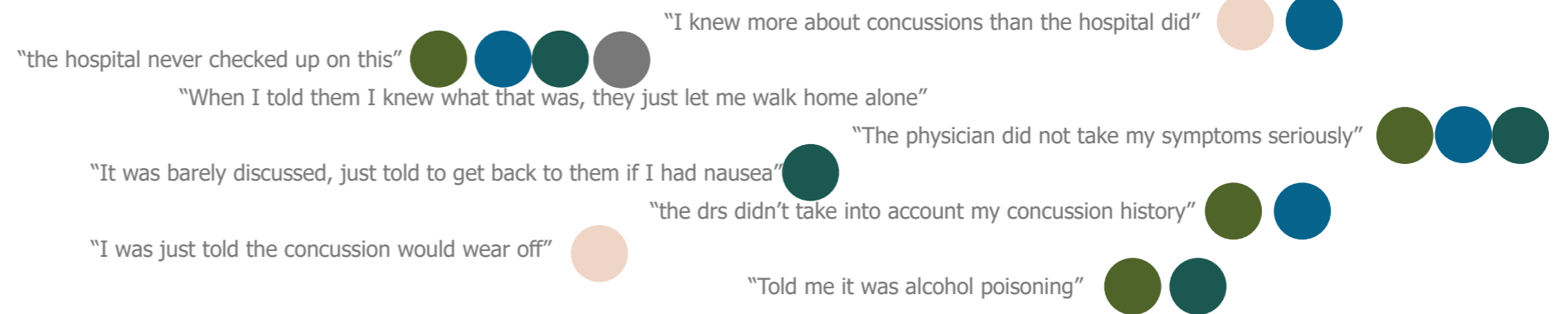


# Quantitative Findings

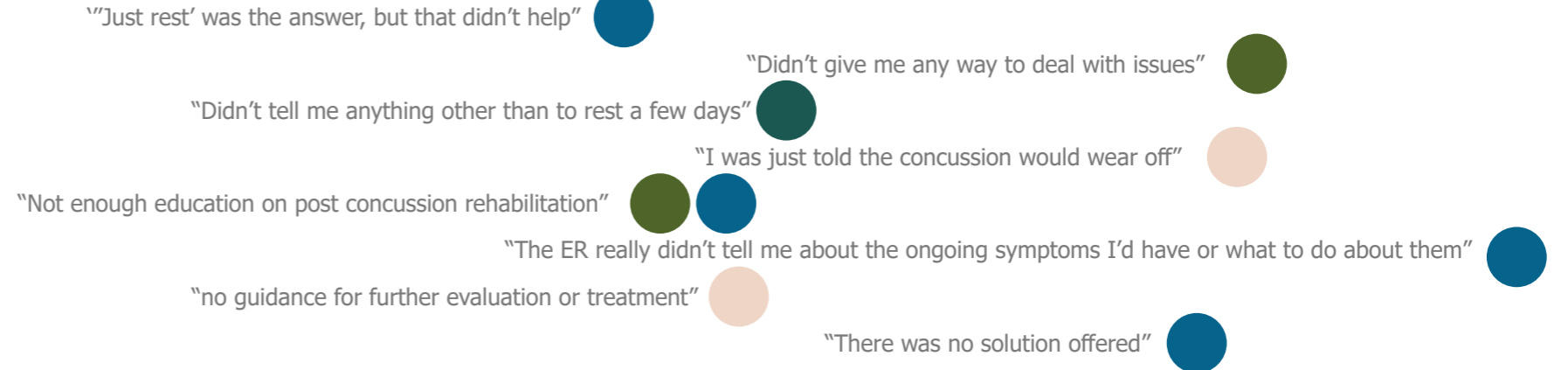
Why the athlete felt their advice/  
treatment was inadequate

## Highlights

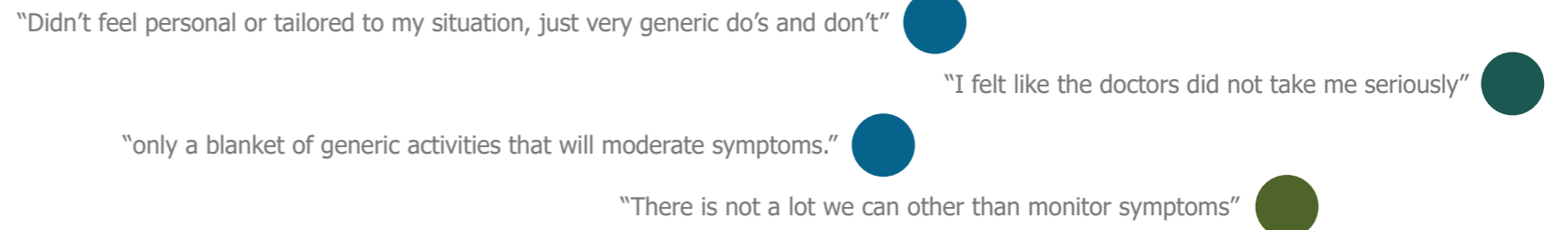
Many of the respondents described lack of awareness of concussions by medical staff in the ER or by Paramedics.



Many of the respondents described the lack of recommendations on what to do post concussion or how to manage it.



Some respondents also felt that the medical staff could not give them meaningful advice and instead just gave generic information around the area.



# Summary

Observations from the interview with a EMT highlighted there is a major disconnect between first responders and ER medical staff when it comes to concussions and their importance, there also seems to be a major lack of understanding of the dangers of concussions and how to treat them amongst medical staff. This was further backed up by the qualitative aspect of the questionnaire where by a large number of participants believed they did not receive adequate or relevant advice for their concussion

A large number of participants in the study who take part in action sports and have suffered concussions are also at high risk of depression 54% out of which, 64% could be classified as depressed as measured by the CES-D analysis.

Furthermore, over 42% of participants had a poor understanding of concussions and their dangers, likely leading to the high percentage of multiple concussion and high severity of concussions. This was backed up further by the qualitative aspect of the questionnaire where there were a high volume of participants that either continued with their activities or drove home alone.

Observations from the interview with one of Ireland's leading researchers highlighted the inability for a singular test to accurately detect concussions and how many of the official clinical tests carried out at professional level sports can be cheated to avoid suspension due to injury. This further highlighted the culture of masking injuries as sub-elite and elite level to prevent the loss of a contract or opportunity

There have been a number of opportunities to potentially innovate in the area of concussions that have arose from primary research, many of these come from serving the need for an all inclusive, non-invasive concussion detection method that can be easily and quickly administered to a potentially concussed athlete.

Other opportunities for innovation include creating a cultural shift towards concussion safety and understanding in action sport athletes

Another opportunity may arise in the medical procedure mandated by health authorities which is currently woefully inadequate

# Detection

# Cultural Shift

# Medical Procedure

## Further Research

Primary research led to new areas for exploration into the reduction in ability to regulate emotions and behaviours due to concussions and factors around it.

Other area such as regulatory standard for medical staff communications between paramedics and triage would also be keen areas of future research.

The area of interpersonal interactions surrounding concussions is another area that would benefit from further research via both secondary sources and primary means.

Difference in concussion management globally would also be an area of interest as there may be a discrepancy between how each country detect and treats concussions.

Immersion in rehabilitation centers for athletes who have suffered a concussion would have elicited greater depth of knowledge but due to Covid-19, this was not a possibility in the time frame allotted for the research.

Further interviews with elite level athletes from organizations such as Nitro Circus would have provided a wide breadth of insights into concussions at the highest level of sports but despite contact being made, the time frame did not allow for organising interviews although consultation on later stages of the project may still be feasible.

# Observations, Problems & Needs.

# 62

Observations obtained from both  
secondary and primary research

# Legend

## Catagories

### Health

The major component of the observation/idea/concept impacts the personal health of the athlete.

### Education

The major component of the observation/idea/concept relies on the education of the athlete/user.

### Detection

The major component of the observation/idea/concept relies on the detection of concussions when they occure

### Poor Understanding

The major component of the observation/idea/concept stems form missinformation or poor understanding of the risks involved

## Stakeholders

Athlete

Doctor

Friend

Health care service

Therapist

Nurses

Paramedics

Educator/Policy setters



# Observations

## Observations

Severe physical effects for days-weeks post concussion which need to be managed

Severe emotional effects for days-weeks-years post concussion which need to be managed

Severe behavioural effects for days-weeks-years post concussion which need to be managed

Severe cognitive effects for days-weeks-years post concussion which need to be managed

Reduced ability for the neuron to metabolise

increased demand for neuronal metabolic actions

With the rise in popularity of extreme sports, mental health services may be put under more pressure.

With the rise in popularity of extreme sports, health services may be put under more pressure.

With the rise in popularity of extreme sports, there will be long term health implications for later life athletes

With the rise in popularity of extreme sports among children and young adults, there may be an decrease in academic scores for there athletes

There is no major infrastructure for treating athletes with CTE

There is no major infrastructure for detecting athletes with CTE

There is no major infrastructure for detecting athletes with CTE

There is no obvious imediate way of recognising someone with concussion like there is with other injuries

Increase in violent outbursts after suffering from concussions.

Increase in irrational decission making after suffering from concussions.

Decrease in metabolic action of the neurons

Athletes are extremely vulnerable for the 30min post concussion

Stuctural abmormalities within the brain due to concussions

Secondary impact syndrom can cause death within seconds of the second impact

## Category

## Stakeholders

Health

Health

Health

Health

Health

Health

Health

Health

Health

Health

Health

Health

Health

Health

Health

Health

Health

Health

Health

Health

Health

Health

Health

Health

Health

Health

Health

Education

Education

Health

Education

Health

Detection

Detection

Detection

Health

Health

Health

Health

Health

Health

Athlete, family, doctor, friends

Athlete, family, doctor, friends

Athlete, family, doctor, friends

Athlete, family, doctor, friends

Athlete, doctor

Athlete, doctor

Health care service, doctors, nurses, therapists, family, friends

Health care service, doctors, nurses, family

Health care service, doctors, nurses, family

Health care service, educators, therapists, family, friends

Health care service, doctors, nurses, therapists, family, friends

Athlete, doctor, paramedics

Athlete, doctor, paramedics

Athlete, doctor, paramedics

Health care service, doctors, nurses, therapists, family, friends

Health care service, doctors, nurses, therapists, family, friends

Athlete, doctor

Athlete, friends, family, paramedics

Athlete, doctor

Athlete, friends, family, paramedics, device manufacturers

# Observations

## Observations

Athlete may return to baseline after 48hrs if there are no further disturbances

Current clinical methods of cognitive detection take excessive amounts of time to complete

Current clinical methods of detection don't take into account the situation action sports concussions take place

Current clinical methods of detection often rely on multiple other personel to verify

Current clinical methods of detection can still be "cheated"

Current clinical methods can be influnced by outside factors such as fatigue or stress  
Current product based detection methods mainly indicate the force of an impact but not a concussion

Current product based detection methods can be influenced by outdside factors such as fatigue or stress  
Current product based detection methods work in labs but don't always account for adrenalin or stress responce in the body  
Current product based detection methods are bulky and not portable

Current product based detection methods are not always adminesterable by the athlete

Current product based detection methods can not detect a concussion on their own, merely the symptoms of a concussion  
Current product based protection methods increase the feeling of safety and increase risk taking behavior by the athlete

Current product based protection methods only marginally reduce the likelihood of concussions form angular accelerations  
Current product based protection methods are sometimes not based on actual science and primarily based on marketing and funded research  
Current product based protection methods don't indicate to the user that they may have sustained a concussion

Current product based protection methods do not decrease the severity of concussions and there is little evidence that they prevent them entirely  
Detection methods are unreliable if only used in isolation  
Paramedics are woefully unprepared for head injuries

Athletes can be fine and the have a rapid deterioration after a few minuites

Each paramedic has their own method of handover to ER

Each paramedic learns more on the job than from their guidelines

Memory recall test is used to diagnose concussions

Many athletes will continue to engage in an activity if they don't feel too bad,

Athletes are far more confident when they have protective gear on, even if it doesn't protect against concussion  
Many athletes don't know the dangers of concussions  
Athletes would rather "not waste the day/trip" and will continue to exercise  
Many athletes have a disconnect between what they say and what they do with regards to concussion

There needs to be a drastic change in education and/or behavior towards concussions  
No one test can detect a concussion  
Bio markers need to be used in conjunction with a system of emotional and cognitive tests to properly evaluate the athlete  
Someone can get a concussion in any sport  
Many athletes continue on with their activities after a concussion

## Category

Education

Detection

Detection

Detection

Detection

Detection  
Detection

Detection  
Detection  
Detection

Detection

Detection  
Detection

Detection  
Detection  
Detection

Detection  
Detection  
Health/Education

Health

Health

Education

Detection

Poor understanding

Poor understanding  
Poor understanding  
Poor understanding  
Education

Education  
Detection  
Detection  
Education  
Poor understanding

## Stakeholders

Athlete, doctor  
Athlete, friends, family, paramedics, device manufacturers

Athlete, friends, family, paramedics, device manufacturers

Athlete, friends, family, paramedics, device manufacturers

Athlete, friends, family, paramedics, device manufacturers

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Athlete, friends, family, paramedics, device manufacturers

Athlete, friends, family, paramedics, device manufacturers  
Athlete, friends, family, paramedics, device manufacturers  
Athlete, doctor, paramedics, Educators/policy setters

Athlete, friends, family, paramedics

Paramedics, doctors, nurses, policy setters

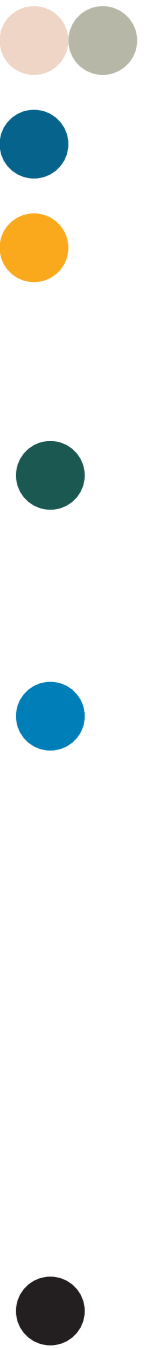
Paramedics, policy setters

Athlete, friends, family, paramedics

Athlete, friends, family, educators

Athlete, friends, family, educators  
Athlete, friends, family, educators  
Athlete, friends, family, educators  
Athlete, friends, family, educators

Athlete, friends, family, educators



# Observations

## Observations

Many athletes don't ask for a lift and try and get home independantly  
Athletes may drive home after a concussion  
Athletes may not know they are concussed  
There is a lack of awareness of concussions amongst medical staff  
There is no concensus on how to treat a concussion  
34% of all participants would be classified as depressed  
54% of all participants would be classified as high risk of depression  
Many athletes did not feel they received adequate advice  
Many athletes did not feel they received relevant advice

## Category

Poor understanding  
Poor understanding  
Detection  
Education  
Health  
Health  
Health  
Education  
Education

## Stakeholders

Athlete, friends, family, educators  
Athlete, friends, family, educators  
Athlete, friends, family, paramedics, device manufacturers  
Paramedics, doctors, nurses, policy setters, educators  
Athlete, doctor, paramedics, Educators/policy setters  
Health care service, doctors, nurses, therapists, family, friends  
Health care service, doctors, nurses, therapists, family, friends  
Athletes, paramedics, doctors, nurses, policy setters, educators  
Athletes, paramedics, doctors, nurses, policy setters, educators

# Observations

Health Related

21

Education Related

10

Detection Related

24

Poor understanding Related

7

# Problems

## Problems

Physical conditions have to be managed for a time after the initial injury  
 Causes the athlete discomfort for the duration of the effects  
 Reduces the athletes quality of life  
 Causes distress for the athlete  
 Relationship become strained  
 Puts stress on mental health services  
 Causes distress for the athlete  
 Relationship become strained  
 Reduces the athletes quality of life  
 Puts stain on the health services  
 Reduced ability to work or do daily tasks  
 Reduced academic ability  
 Reduced ability to repair neurons post concussion  
 Greater increase in demand for metabolic action  
 Greater load on the bodies systems  
 Bodies resources become depleted  
 Greater load on the bodies systems  
 Reduced neurological capacity during hyperglycolytic phase  
 Mental health system is not prepared for a large influx of ex-athlete in a number of years  
 Greater strain on the already overloaded mental health services in ireland  
 Greater increase in demand for mental health services  
 Public heath care systems may not be prepared for the influx of athlete  
 Higher levels of concussions and emergency room visits  
 Increased demand for ambulance services  
 Increased medical needs for an ageing population  
 greater dependency on medication to cope with symptoms  
 increased need for specialist in retirement homes  
 Decrease in academic scores for young athletes  
 Difficulty for athletes to get into colleges  
 greater increase in mental health issues for younger athletes  
 Increased pressures for younger athletes  
 Athletes have nowhere to get treated for their symptoms  
 No information outlets for athletes who may have CTE

No instant recognition that the person is injured  
 People don't accept that the person may be injured because it hidden  
 The injury is hidden  
 can lead to relationship issues  
 causes a stigma around sufferers of concussion  
 increases demand for therapists  
 can lead to relationship issues  
 causes a stigma around sufferers of concussion  
 increases demand for therapists  
 Reduced ability to repair neurons post concussion  
 Greater increase in demand for metabolic action  
 Greater load on the bodies systems  
 may take longer to get to refuge  
 Athletes may not be aware of their vulnerability  
 Large window of opportunity for increased damage

Sudden death may have adverse emotional effect on people around them  
 Athletes may not be aware of their vulnerability

## Category

## Stakeholders

Health	Athlete, family, doctor, friends
Health	
Health	
Health	Athlete, family, doctor, friends
Health	
Health	
Health	Athlete, family, doctor, friends
Health	
Health	Athlete, family, doctor, friends
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Health	Athlete, doctor
Health	
Health	Athlete, doctor
Health	
Health	Health care service, doctors, nurses, therapists, family, friends
Health	
Health	Health care service, doctors, nurses, family
Health	
Health	Health care service, doctors, nurses, family
Health	
Health	Health care service, doctors, nurses, family
Health	
Health	Health care service, educators, therapists, family, friends
Education	
Education	
Health	
Education	
Health	Health care service, doctors, nurses, therapists, family, friends
Detection	
Detection	Athlete, doctor, paramedics
Detection	Athlete, doctor, paramedics
	Athlete, doctor, paramedics
Health	Health care service, doctors, nurses, therapists, family, friends
Health	
Health	Health care service, doctors, nurses, therapists, family, friends
Health	
Health	Athlete, doctor
Health	
Health	Athlete, friends, family, paramedics
Health	
Health	Athlete, doctor
Health	Athlete, friends, family, paramedics, device manufacturers



## Problems

People may be cognitively impaired and thus not have the high level of skill and motor function to take part in activities safely  
As athletes can rapidly deteriorate after a concussion, they may begin to deteriorate while driving putting other road users at risk  
As athletes can rapidly deteriorate after a concussion, they may begin to deteriorate while driving putting other road users at risk  
People may be cognitively impaired and thus not have the high level of skill and motor function to take part in activities safely  
An athlete may not receive the medical advice they need  
There may be misconceptions as to how to deal with the immediate symptoms of a concussion but not get any for long term or visa versa  
Action sports athletes may be predisposed to depressive symptoms which are only compounded by the emotional impacts of concussions  
Action sports athletes may be predisposed to depressive symptoms which are only compounded by the emotional impacts of concussions  
Athletes may be reluctant to seek medical help for their next concussion  
Athletes may be reluctant to seek medical help for their next concussion

## Category

Poor understanding  
Poor understanding  
Detection  
Education  
Health  
Health  
Health  
Education  
Education

## Stakeholders

Athlete, friends, family, educators  
Athlete, friends, family, educators  
Athlete, friends, family, paramedics, device manufacturers  
Paramedics, doctors, nurses, policy setters, educators  
Athlete, doctor, paramedics, Educators/policy setters  
Health care service, doctors, nurses, therapists, family, friends  
Health care service, doctors, nurses, therapists, family, friends  
Athletes, paramedics, doctors, nurses, policy setters, educators  
Athletes, paramedics, doctors, nurses, policy setters, educators

## Needs Initial

A system to support athletes in the post concussion symptom stages  
 A system to alleviate the symptoms of concussions

a system to support athletes emotionally with the emotional degradation caused by concussions  
 improve the understanding of the potential emotional implications of suffering a concussion  
 a system of support measure to alleviate the added load to the already stressed mental health services in ireland  
 Encourage the education of the effects of concussions so athletes understand it may just be symptoms and not them  
 Encourage the education of the effects of concussions so athletes contacts understand it may just be symptoms and not them  
 A system to reduce the exceptions of an athlete in the period in which they suffer negative cognitive effects

A system that allows athletes to recover without the pressures of academic expectations or grades  
 A device that increases metabolic action within neurons after suffering from a concussion  
 A device that promotes the natural metabolic and repair cycle of neuron  
 a system or device that reduces the stresses on other aspects of the body to allow greater energy resources to be diverted to neurological repair

Increase the metabolic capacity of axons and neurons so that concussions have less of an effect on the function of the cells  
 Improvements the network of concussion aware therapists and GPs to reduce influx into mental health services

A system to manage the increased in both concussions and other extreme sport related injuries  
 A device which athletes can self assess and heal without the need for a visit to the ER  
 A system that athletes can use that limits their dependency on ambulances for minor incidents  
 A system to support aging athletes who may suffer long term issues due to concussions  
 A way to encourage healthier and natural recovery methods for symptoms of concussions  
 Improve the understanding of concussions effects on athletes in the long term to better prepare both the athlete and their contacts as to what may arise in the future  
 A system to reduce the exceptions of an athlete in the period in which they suffer negative cognitive effects  
 Encourage educational institutes to make accommodations for athletes who may be temporarily cognitively impaired during exams  
 Increase mental health understanding and education for younger athletes

A way to diagnose, treat and increase awareness of CTE and its dangers

A way for people to recognise that an athlete is injured despite it being a hidden injury  
 to increase the understanding of the risks of concussions, its effects and to accept it as an injury like any other

A device that can reduce the tendencies for violent or other wise less desirable outbursts  
 increase the understanding concussion and their potential effects on a persons behaviour

A system that reduces the likelihood of an athlete making irrational decisions after a concussion

A Device that make the athlete aware of the length of time form their concussion, reducing their movement for that time and decreasing the chances of SSE

A way to reduce the activities of an athlete in the 30 min post concussion

## Category

## Stakeholders

Health	Athlete, family, doctor, friends
Health	
Health	
Health	Athlete, family, doctor, friends
Health	
Health	Athlete, family, doctor, friends
Health	
Health	Athlete, family, doctor, friends
Health	
Health	
Health	Athlete, doctor
Health	
Health	Athlete, doctor
Health	
Health	Health care service, doctors, nurses, therapists, family, friends
Health	
Health	Health care service, doctors, nurses, family
Health	
Health	Health care service, doctors, nurses, family
Health	
Health	Health care service, educators, therapists, family, friends
Health	
Health	Health care service, doctors, nurses, therapists, family, friends
Detection	Athlete, doctor, paramedics
Detection	Athlete, doctor, paramedics
Detection	Athlete, doctor, paramedics
Health	Health care service, doctors, nurses, therapists, family, friends
Health	Health care service, doctors, nurses, therapists, family, friends
Health	Athlete, doctor
Health	Athlete, friends, family, paramedics
Health	
Health	Athlete, doctor
Health	Athlete, friends, family, paramedics, device manufacturers



# Needs

## Needs Initial

- A way to reduce the likelihood of an athlete suffering from a repeat concussion
- A system or device that can assess an athlete within the 30min vulnerability window
- A way for athletes to rest properly for 48hrs post concussion without stigma around the hidden injury
- A way to reduce the likelihood of athlete participating in activities soon after a concussion
- For a fast implementation assessment tool that doesn't take an athlete out of competition for an unnecessary amount of time if negative
- A way to encourage athletes to take concussion tests when suspected
- A device or system that can detect concussions in athletes in non clinical situations
- A device or system that can be implemented remotely to assess an athletes potential concussion
- A device or system that can be self administered and recommend actions to potentially concussed athletes
- A device or system that cannot be cheated or exploited so that athletes can return to activities whilst compromised
- A device or system that can take into consideration the stress levels an extreme sports athlete and accurately assess athletes concussion status
- A device or system that takes into considering the environment in which its being measured
- A device or system that take a number of biomarker and cognitive metrics and tests to assess concussions in an athlete
- A device or system that is portable enough to assess athletes in remote areas
- A system or device that take a multifaceted approach to concussion assessment rather than singular symptom testing
- Educate athletes to the dangers of concussions, even whilst wearing protective equipment
- A non-invasive device that can mitigate concussions in humans
- A system that shows devices which have the potential to reduce the risk of concussions
- A device or system that informs the athlete that they have or may have suffered from a concussion
- A device or system that can reduce the severity of concussions for athletes
- A system or educational method of informing medical staff of the effects of concussions and how to detect them
- A system in which concussions cannot be overlooked whilst medical checks are being performed
- A system or device which informs users that they are potentially concussed and should not continue with activities
- A system where paramedics and triage staff can communicate the details of the patients condition without error or oversights
- A system or device that aids in the training of paramedics
- A system or device that is easily used that can detect concussions accurately
- A system of device that can automatically detect concussions for the user without the need for their inputs
- A way to reduce the likelihood of an athlete continuing to participate in activities whilst possibly compromised
- to better educate athlete and the general population to the modes of a concussion
- To reduce the likelihood an athlete will choose continuing on with activities whilst compromised

## Category

## Stakeholders

- Education  
Athlete, doctor  
Athlete, friends, family, paramedics, device manufacturers
- Detection  
Athlete, friends, family, paramedics, device manufacturers
- Detection  
Athlete, friends, family, paramedics, device manufacturers
- Detection  
Athlete, friends, family, paramedics, device manufacturers
- Detection  
Athlete, friends, family, paramedics, device manufacturers
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- Detection  
Athlete, friends, family, paramedics, device manufacturers
- Detection  
Athlete, friends, family, paramedics, device manufacturers
- Health  
Athlete, friends, family, paramedics, device manufacturers  
Athlete, doctor, paramedics, Educators/policy setters
- Health  
Athlete, friends, family, paramedics, device manufacturers
- Education  
Athlete, friends, family, paramedics
- Detection  
Paramedics, doctors, nurses, policy setters
- Poor understanding  
Paramedics, policy setters
- Poor understanding  
Athlete, friends, family, paramedics
- Poor understanding  
Athlete, friends, family, educators
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Athlete, friends, family, educators
- Poor understanding  
Athlete, friends, family, educators
- Poor understanding  
Athlete, friends, family, educators
- Poor understanding  
Athlete, friends, family, educators



## Needs Initial

To reduce the likelihood an athlete will continue to progress with risky activities after suffering from a concussion  
A system in which an athlete can return safely home after suffering from a concussion

A system or device that can aid in returning athletes to a safe location to be assessed

A system of support specifically for extreme sports athletes and their specific needs

A way for athletes to receive the care they need and turn trust in the medical evaluations performed by medical staff

## Category

Poor understanding  
Poor understanding  
Detection  
Education  
Health  
Health  
Health  
Education  
Education

## Stakeholders

Athlete, friends, family, educators  
Athlete, friends, family, educators  
Athlete, friends, family, paramedics, device manufacturers  
Paramedics, doctors, nurses, policy setters, educators  
Athlete, doctor, paramedics, Educators/policy setters  
Health care service, doctors, nurses, therapists, family, friends  
Health care service, doctors, nurses, therapists, family, friends  
Athletes, paramedics, doctors, nurses, policy setters, educators  
Athletes, paramedics, doctors, nurses, policy setters, educators

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Observations

Problems

66

Needs

111

# Filtering Criteria

66 - 20

Round 1

Patient Impact

Based on the perceived impact on the patient from solving this need

Scored 1-5

Technical/Safety Risk

Based on the perceived impact on the provider from solving this need

Scored 5-1

Personal Choice

Based on my own interest or prior experience in the area or on the matter

Scored 1-5

# Filtering Criteria

## Patient Impact

### Why it was chosen

In order to determine the criteria that has the greatest impact on the patient or the user.

### How it was Measured

Measured on a 1-5 scale, rated based off personal experience, the research conducted prior and in consultation with numerous action sports athletes.

## Technical/Safety Risk

### Why it was chosen

In order to determine the criteria that has the lowest technical or safety risk for the patient or the user

### How it was Measured

Measured on a reverse 1-5 scale, rated based off personal experience, the research conducted prior and in consultation with a GP and numerous action sports athletes.

## Personal Choice

### Why it was chosen

In order to determine projects that would be of personal interest, to help keep motivation and focus throughout the project

### How it was Measured

Measured on a 1-5 scale, rated based off personal experience, the research conducted prior.

# Filtered Needs

## Needs Initial

A way to encourage athletes to take concussion tests when suspected

A device or system that can detect concussions in athletes in non clinical situations

A device or system that can be self administered and recommend actions to potentially concussed athletes

A device or system that take a number of biomarker and cognitive metrics and tests to assess concussions in an athlete

A device or system that is portable enough to assess athletes in remote areas

A non-invasive device that can mitigate concussions in humans

A device or system that can reduce the severity of concussions for athletes

A system or device that is easily used that can detect concussions accurately

A system to support aging athletes who may suffer long term issues due to concussions

A way for people to recognise that an athlete is injured despite it being a hidden injury

A Device that make the athlete aware of the length of time form their concussion, reducing their movement for that time and decreasing the chances of SIS

A device or system that can be implemented remotely to assess an athletes potential concussion

A system or device that take a multifaceted approach to concussion assessment rather than singular symptom testing

A system in which concussions cannot be overlooked whilst medical checks are being performed

A system of device that can automatically detect concussions for the user without the need for their inputs

A system of support specifically for extreme sports athletes and their specific needs

A way for athletes to receive the care they need and turn trust in the medical evaluations performed by medical staff

For a fast implementation assessment tool that doesn't take an athlete out of competition for an unnecessary amount of time if negative

A system where paramedics and triage staff can communicate the details of the patients condition without error or oversights

A device or system that cannot be cheated or exploited so that athletes can return to activities whilst compromised

## Category

Detection 

Detection

Detection 

Detection 

Detection

Detection

Detection

Detection

Health

Detection 

Health

Detection

Detection 

Health

Detection 

Health

Education

Detection 

Health 

Detection 

## 20 - 10

### Round 2

Treatment  
Landscape

The Number of  
Solutions and/  
or the number of  
users effected by  
this need

Scored 1-5

Feasibility

Manufacturability  
or ease of  
integration of a new  
solution

Scored 1-5

Market Size

The scalability of a  
potential solution /  
How many people  
would use/buy

Scored 1-5

Competition  
Level

The number of  
alternatives on the  
market already

Scored 5-1

# Filtering Criteria

## Treatment Landscape

Why it was chosen

In order to determine the scope and room for development in the area of concussions

How it was Measured

Measured on a 1-5 scale, rated based off the research conducted prior and further market analysis

## Feasibility

Why it was chosen

In order to determine the ease of implementation or manufacturability of the idea

How it was Measured

Measured on a 1-5 scale, rated based off similar ideas/concepts available on the market and how they are produced &/or implemented

## Market Size

Why it was chosen

In order to determine the size of the potential market that each idea would be entering

How it was Measured

Measured on a 1-5 scale, rated based off market analysis for each of the ideas

## Competition Level

Why it was chosen

In order to determine the levels of competition already on the market that solve similar needs

How it was Measured

Measured on a 1-5 scale, rated based off market analysis for each of the ideas



# Top 10

- 1 A device or system that cannot be cheated or exploited so that athletes can return to activities whilst compromised 

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- 2 A system where paramedics and triage staff can communicate the details of the patients condition without error or oversights 

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- 3 A way to encourage athletes to take concussion tests when suspected 

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- 4 A device or system that can be self administered and recommend actions to potentially concussed athletes 


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- 5 A device or system that take a number of biomarker and cognitive metrics and tests to assess concussions in an athlete 

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- 6 For a fast implementation assessment tool that doesn't take an athlete out of competition for an unnecessary amount of time if negative 

---

- 7 A way for people to recognise that an athlete is injured despite it being a hidden injury 

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- 8 A system or device that take a multifaceted approach to concussion assessment rather than singular symptom testing 

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- 9 A system or device that can automatically detect concussions for the user without the need for their inputs 

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- 10 A device or system that can be implemented remotely to assess an athletes potential concussion

## A device or system that

- 1 \_\_\_\_\_ Cannot be cheated or otherwise exploited to return to activities whilst compromised
- 2 \_\_\_\_\_ Takes a multifaceted approach to detection using multiple detection methods
- 3 \_\_\_\_\_ Automatically detect concussions for the user without the need for their inputs
- 4 \_\_\_\_\_ Uses a combination of biomarkers and cognitive testing to detect concussions
- 5 \_\_\_\_\_ Be rapidly implementable
- 6 \_\_\_\_\_ Can be self administered if the athlete is in isolation
- 7 \_\_\_\_\_ Can recommend actions for athlete that is isolated
- 8 \_\_\_\_\_ Encourages concussion testing among the extreme/action sports population
- 9 \_\_\_\_\_ Informs medical staff of the athletes concussion
- 10 \_\_\_\_\_ Can be implemented in remote areas
- 11 \_\_\_\_\_ Is non invasive
- 12 \_\_\_\_\_ Usable by people of all capabilities

## Must Haves

The ability to diagnose concussion

Cannot be cheated or otherwise exploited to return to activities whilst compromised

Takes a multifaceted approach to detection using multiple detection methods

Uses a combination of biomarkers and cognitive testing to detect concussions

Can be self administered if the athlete is in isolation

Can be implemented in remote areas

Is non-invasive

Non-reliant on the athletes perception

## Nice to Haves

Automatically detect concussions for the user without the need for their inputs

Be rapidly implementable

Can recommend actions for athlete that is isolated

Encourages concussion testing among the extreme/ action sports population

Informs medical staff of the athletes concussion

Backup in case of electronic failure

## Design Requirements

Design guide based off both the primary and secondary research.  
Used as reference for how to apply design principles of provide a positive user experience

A better way to consistently detect concussions in extreme sports athletes that does not rely on the potentially compromised perception abilities of the athlete that is non-invasive, takes a multifaceted approach to detection and that cannot be cheated like conventional cognitive testing procedures in order to reduce the incidents of repeat concussions in action sports

# Ideation Chapter.

# Breakdown

Overview	pg 72
Prevention	pg 75
Detection	pg 79
Situational Recovery	pg 89
Recovery	pg 96
Selection Method	pg 102
Top 4 Ideas	pg 104
Idea 1	pg 105
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Idea 4	pg 110
Moving Forward	pg 111

From the needs there were 4 clear areas that could be focused on

## Prevention

To prevent concussions happening to begin with

## Detection

Detection of concussions as they happen

## Situational Recovery

Recovery from the moment of concussion

## Recovery

Long term mental and physical recovery



Although there are 4 sections, the lines between the sections are blurred

Prevention

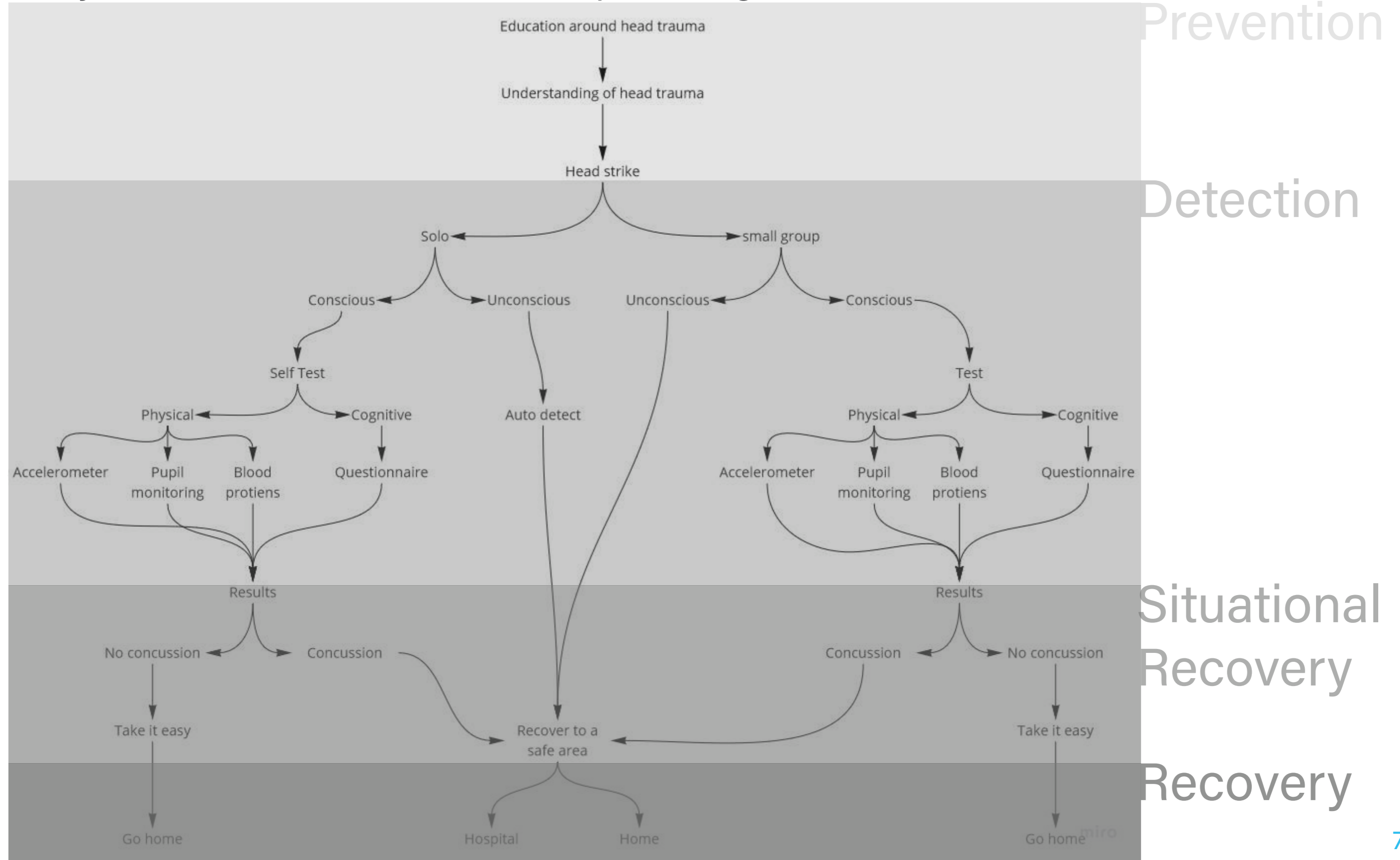
Detection

Situational Recovery

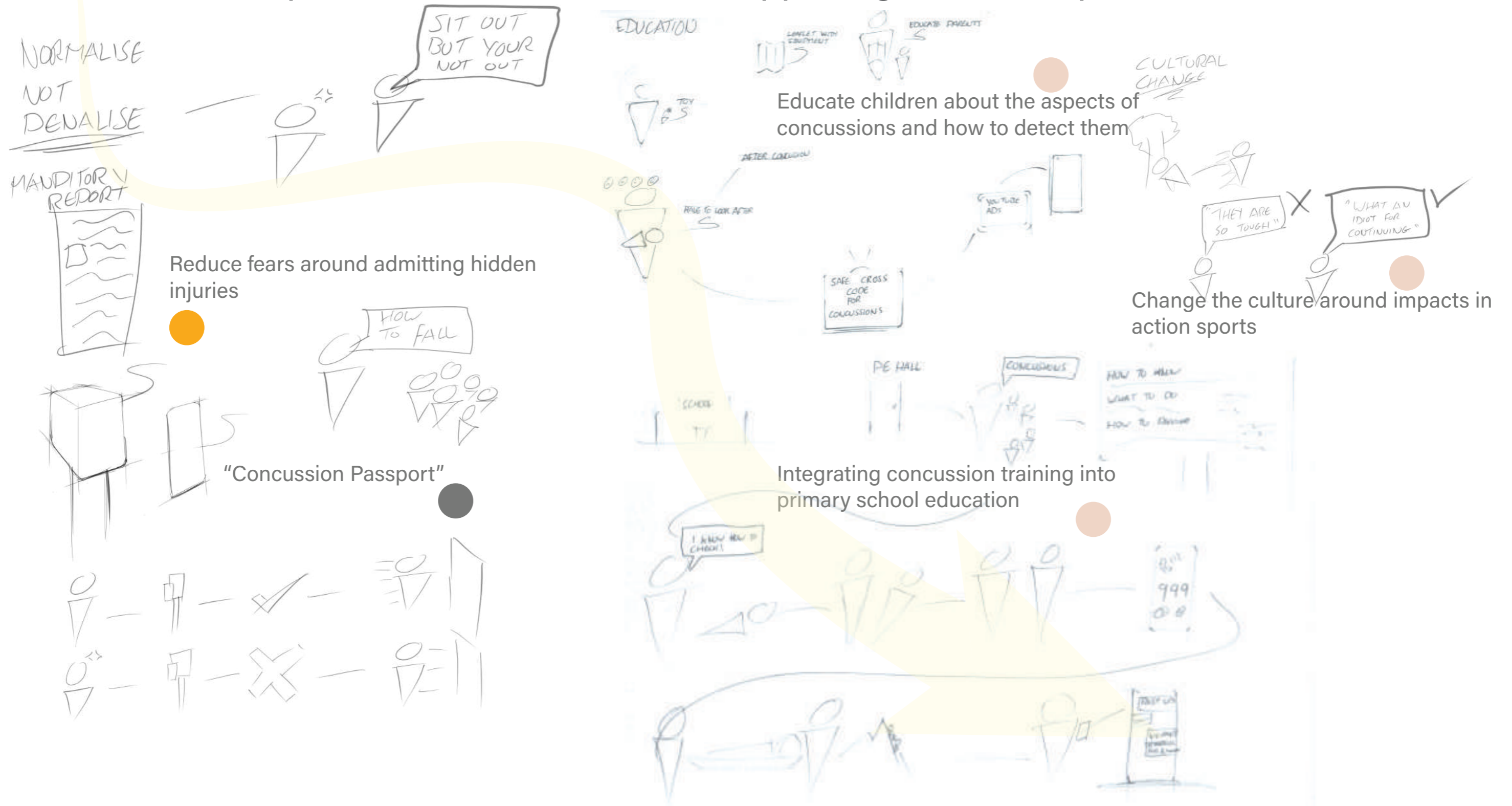
Recovery

# Overview

Many of the sections influence the superseding section



## How to prevent concussions from happening in the first place



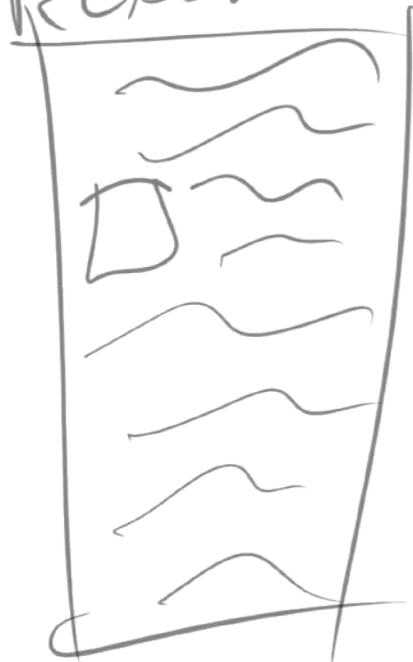
## How to prevent concussions from happening in the first place

NORMALISE

NOT

DENALISE

MANDATORY  
REPORT



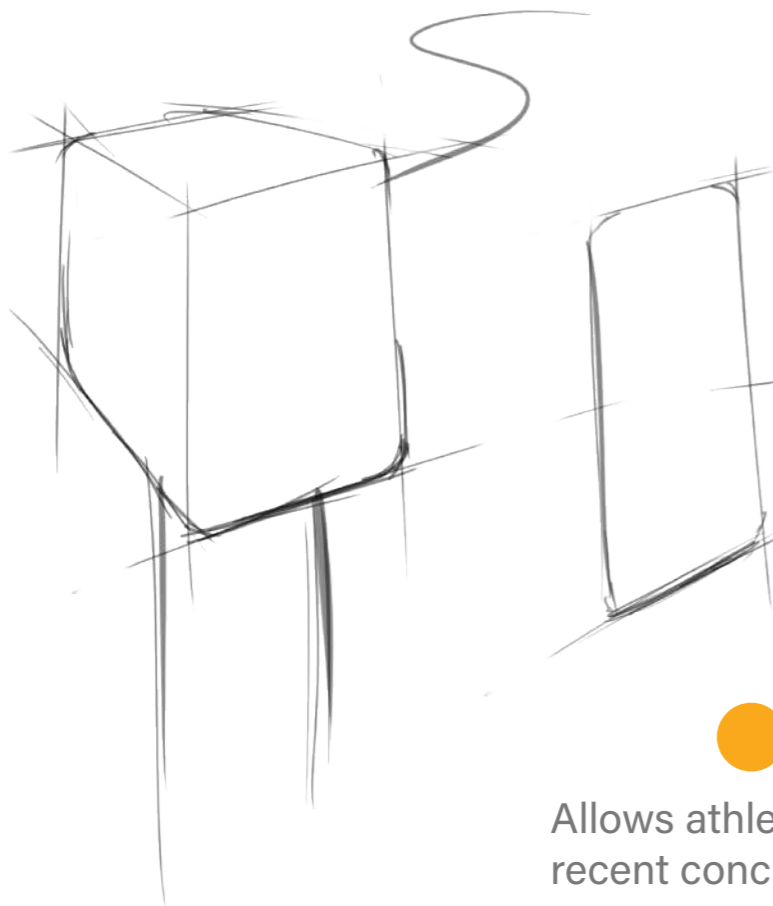
Implement mandatory reporting for all head injuries in all sports



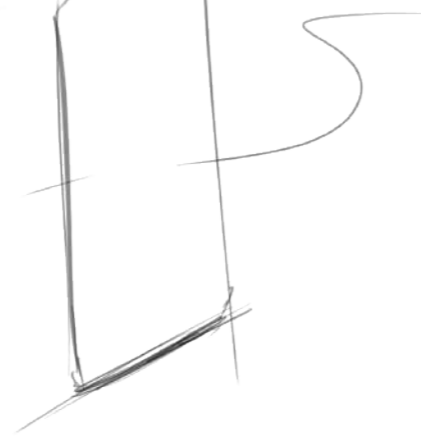
Reduce the fear of reporting injuries to coaches/officials

# Prevention

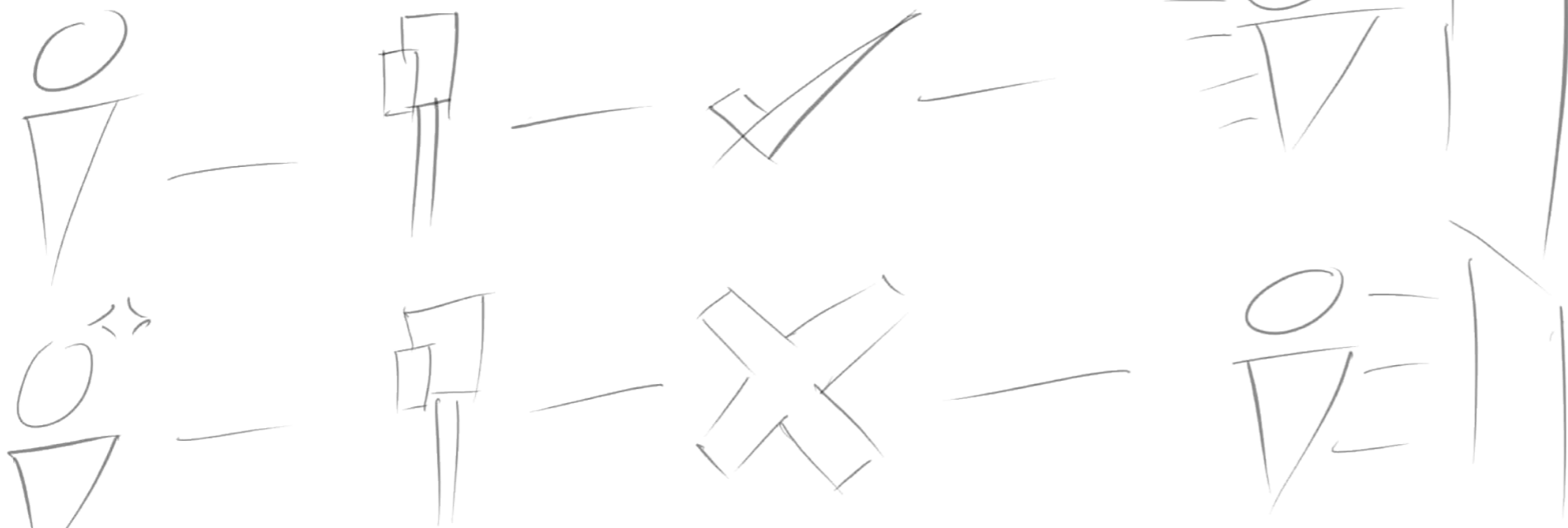
Action sport entrance gate



Concussion passport



Allows athletes who haven't had a recent concussion form continuing



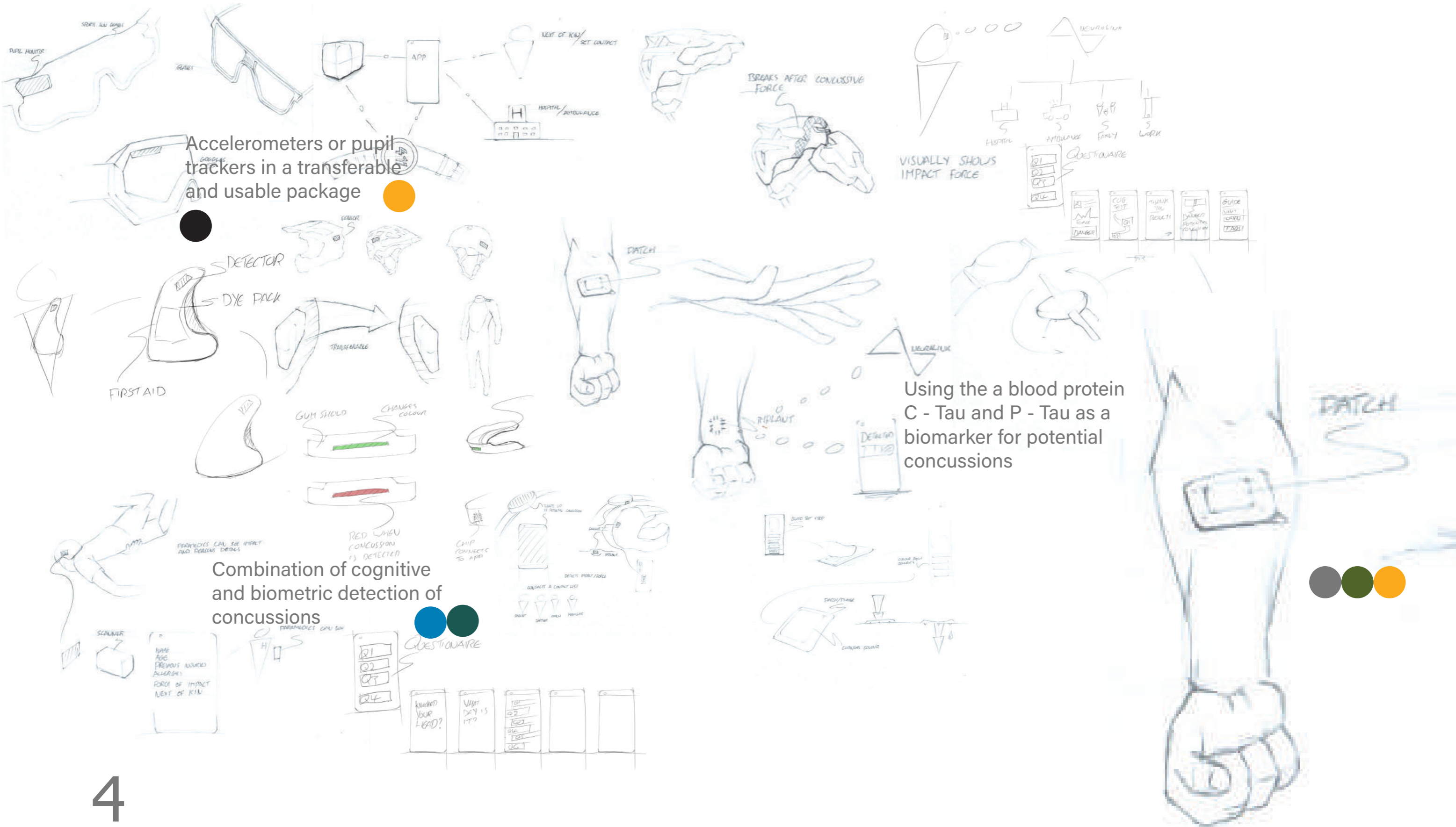
Infrastructure could be set up at marked entrances to action sports such as ski lifts, bike lift, stadium entrances and trail heads.

This would be easier implemented in alpine areas with preexisting ski lifts as they require a lift pass already.

A system of medical records and live updating of personal health would have to be implemented first to ensure the system as a whole could work

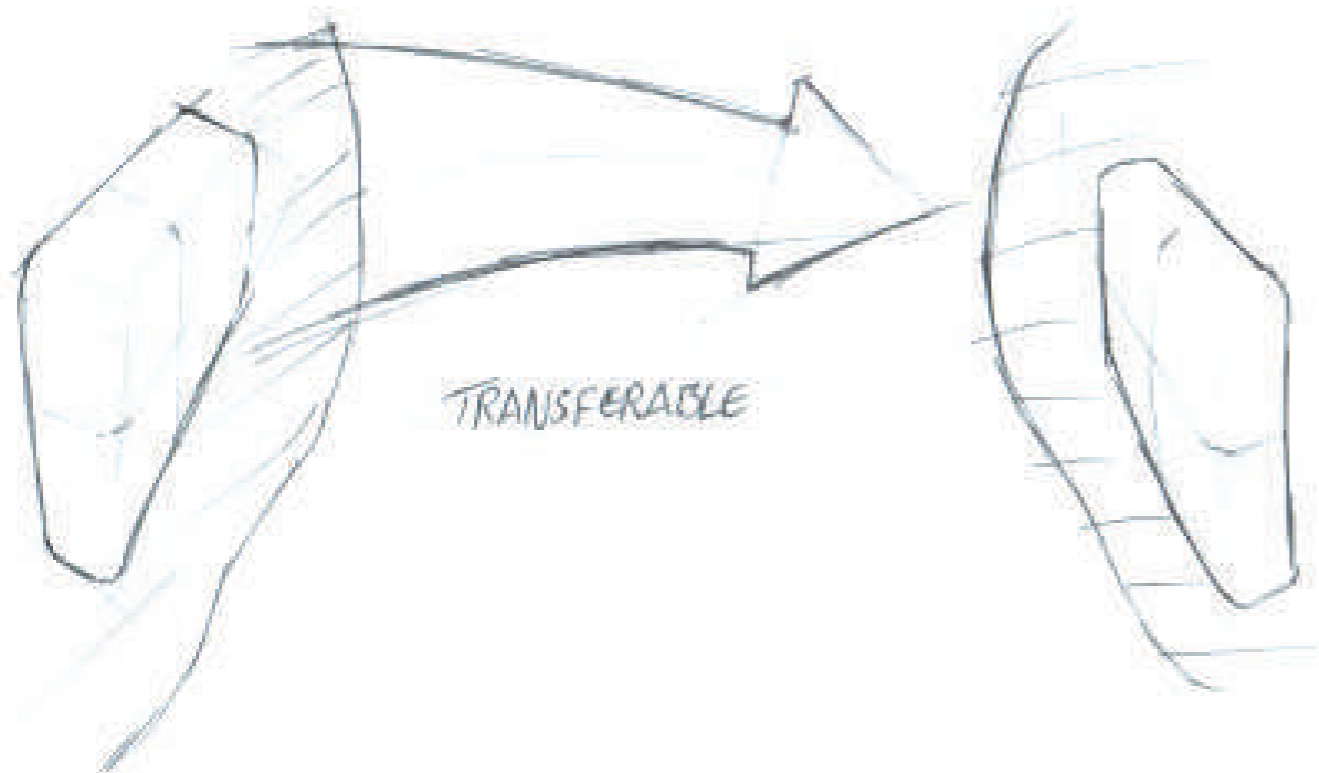
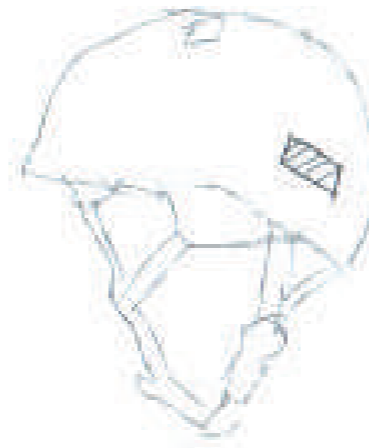


## All Detection methods



## Physical Detection

Sensor / accelerometer  
that can be transferred  
between equipment  
as many action sports  
athletes do multiple sports



Kayak



Trail Bike



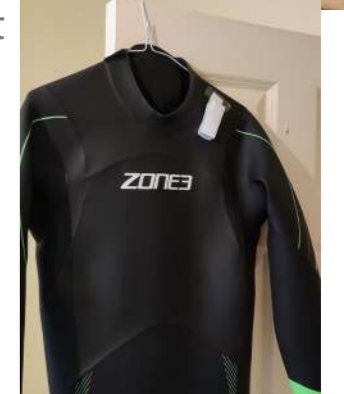
Full Face



Standard

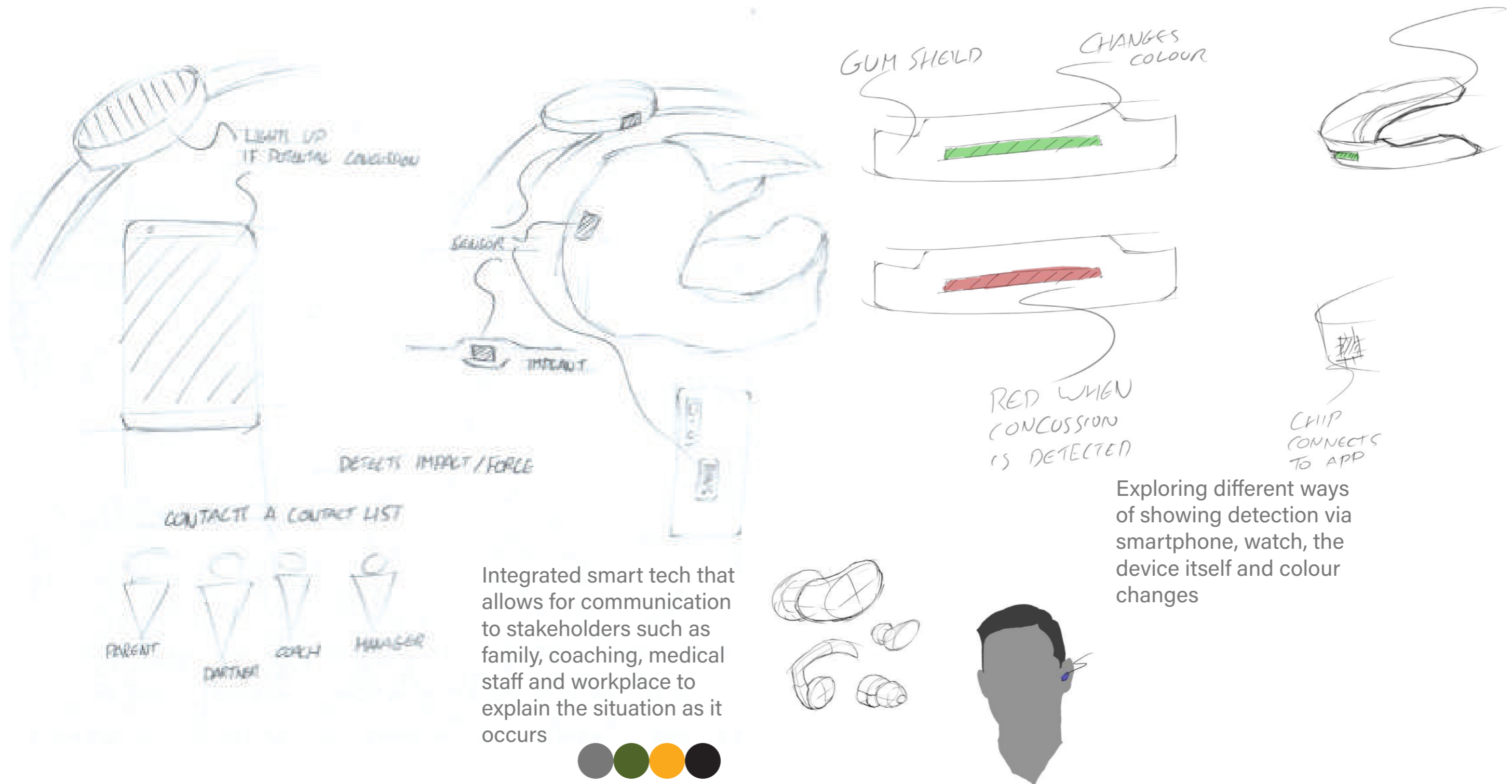


Wet-suit

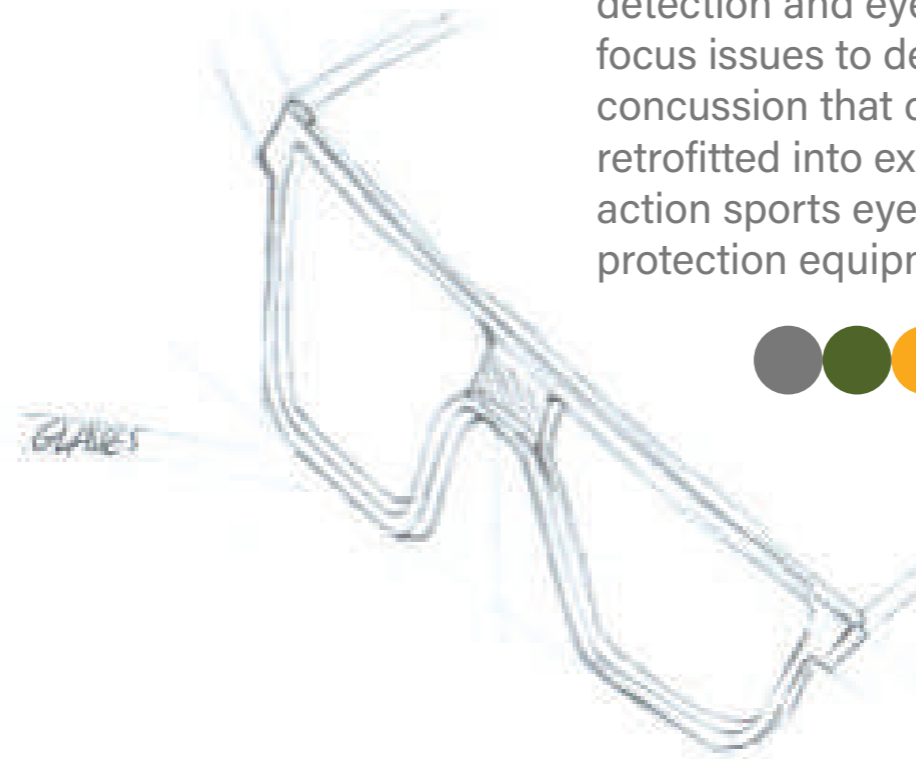
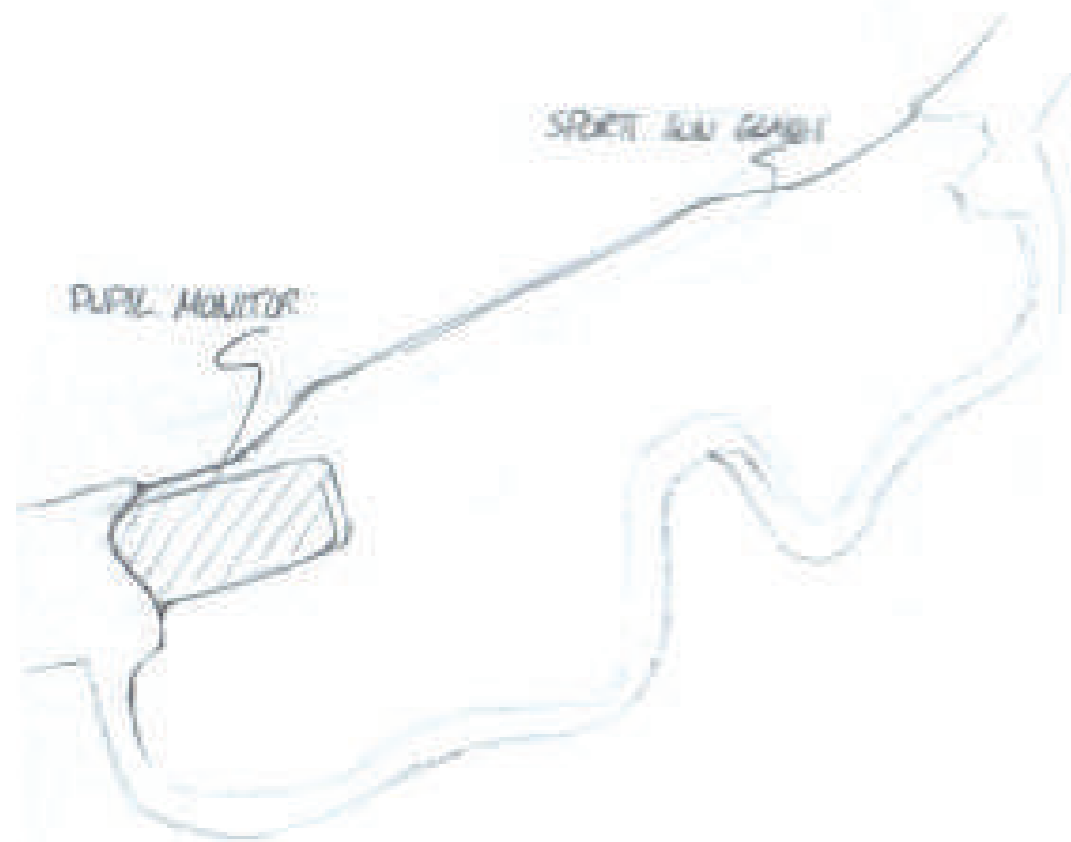




## Physical Detection



## Physical Detection



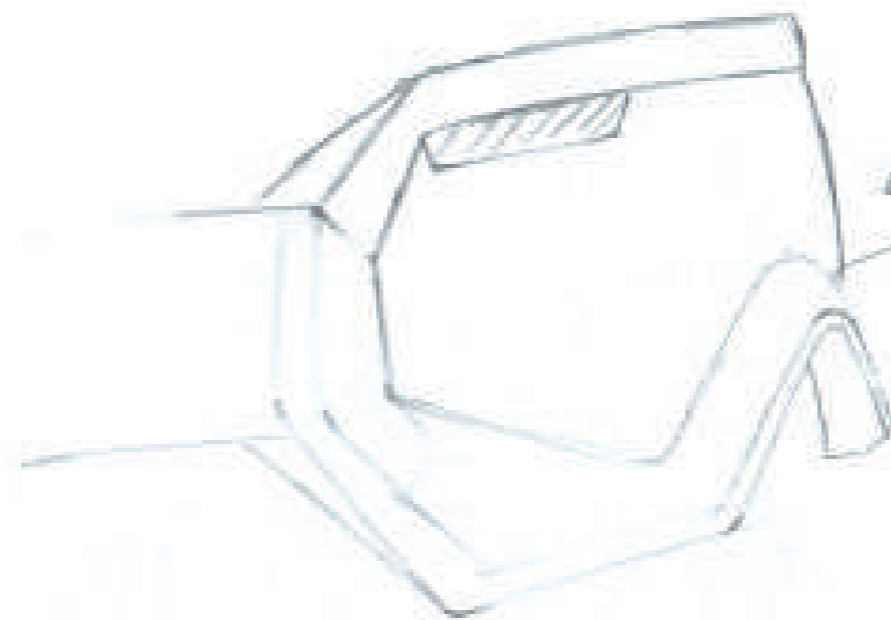
Using pupil dilation detection and eye focus issues to detect concussion that can be retrofitted into existing action sports eye protection equipment.



FPV of view blocked by device within goggles

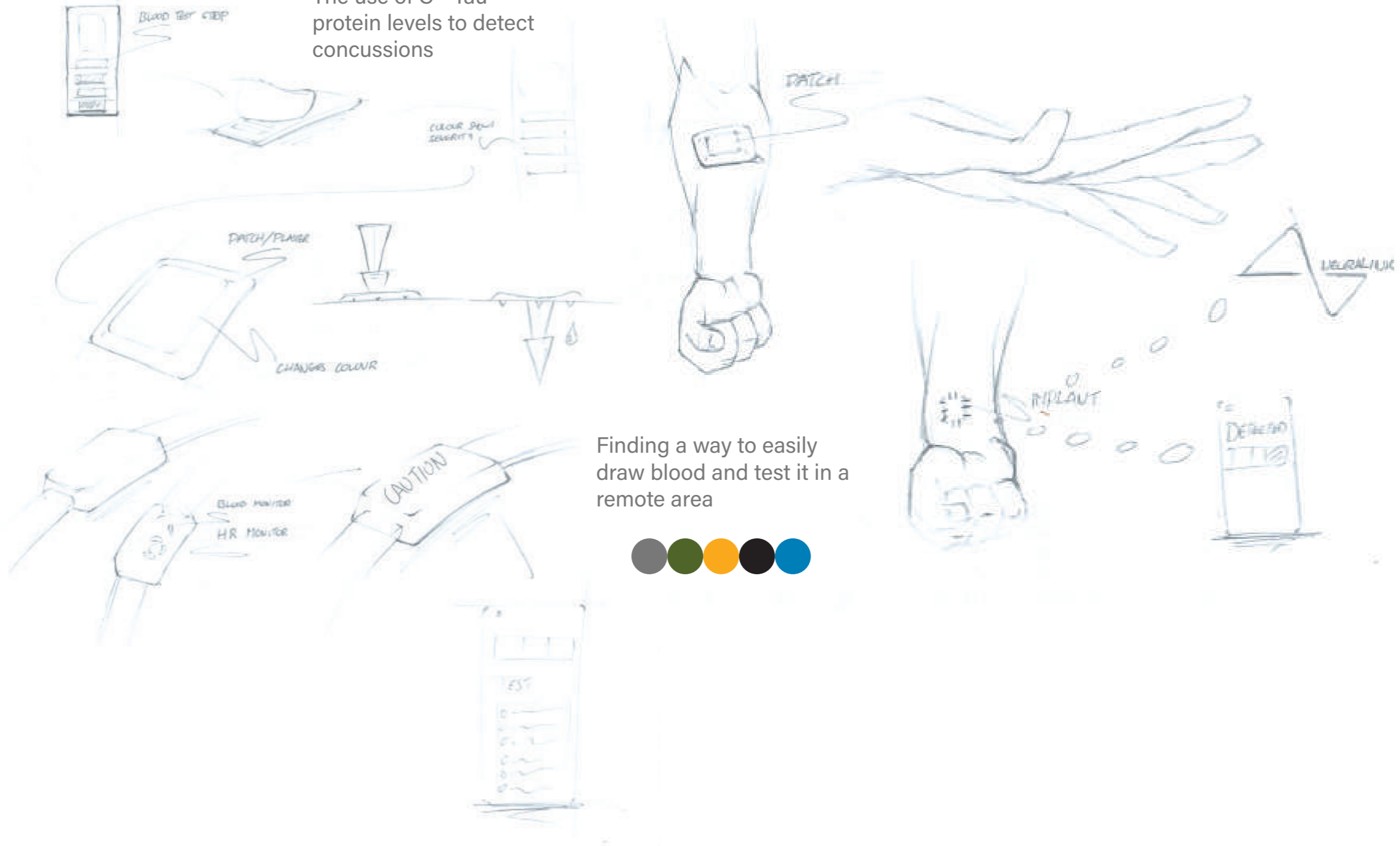


FPV of view blocked by device within glasses



## Physical Detection

The use of C - Tau protein levels to detect concussions

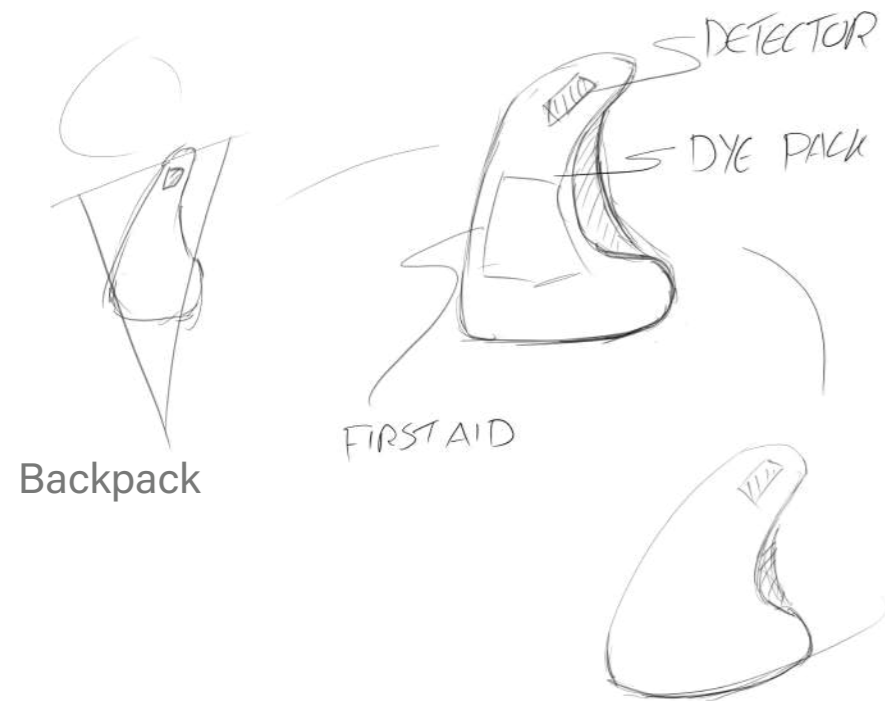


Finding a way to easily draw blood and test it in a remote area

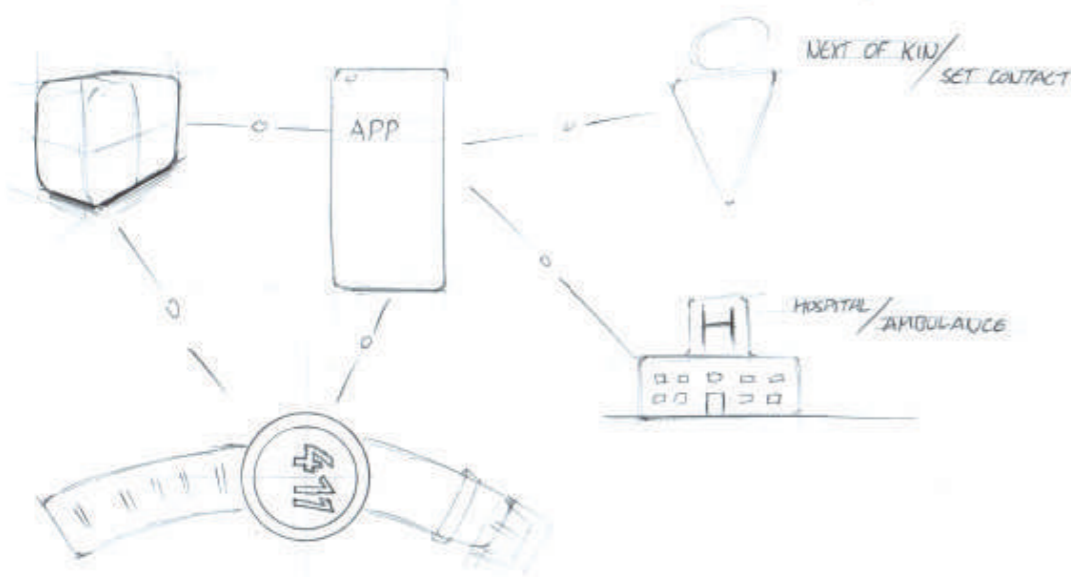


## Physical Detection

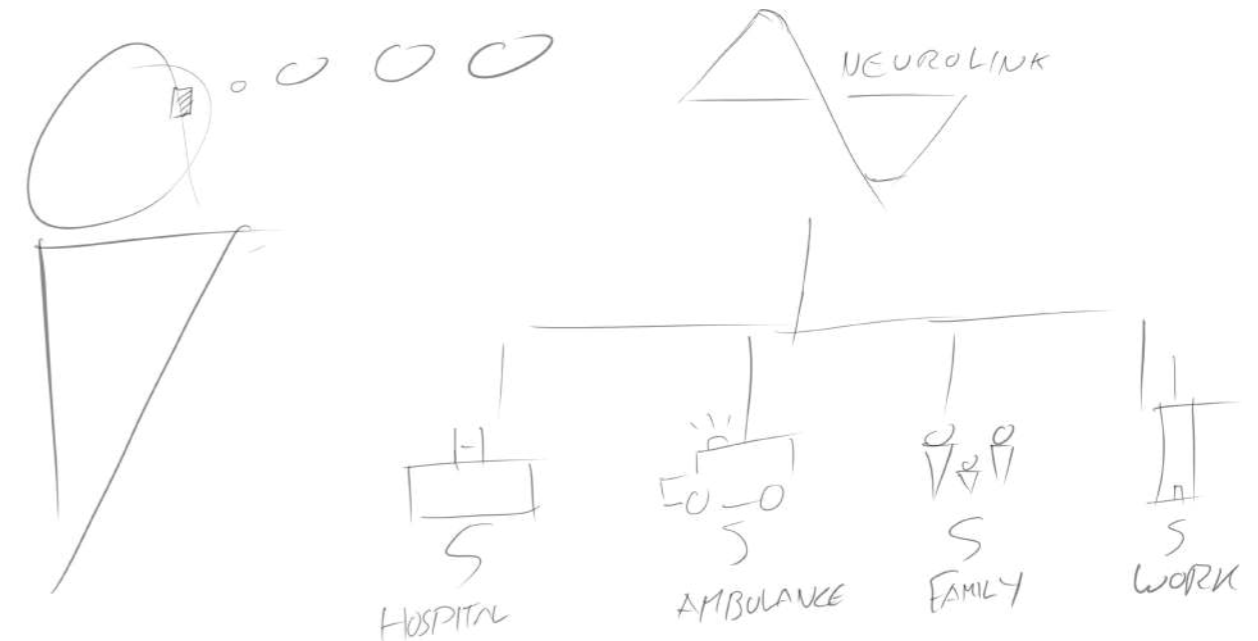
A system of first aid and detection that action sports athletes could take with them on their activities



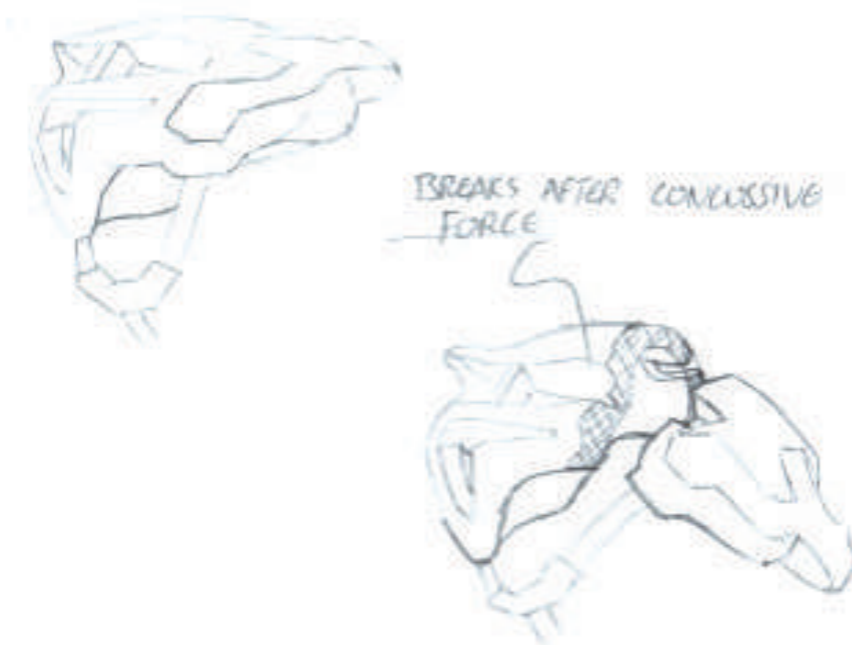
## Physical Detection



Using interconnected tech that detects and responds to concussions and alerts the athlete and emergency services



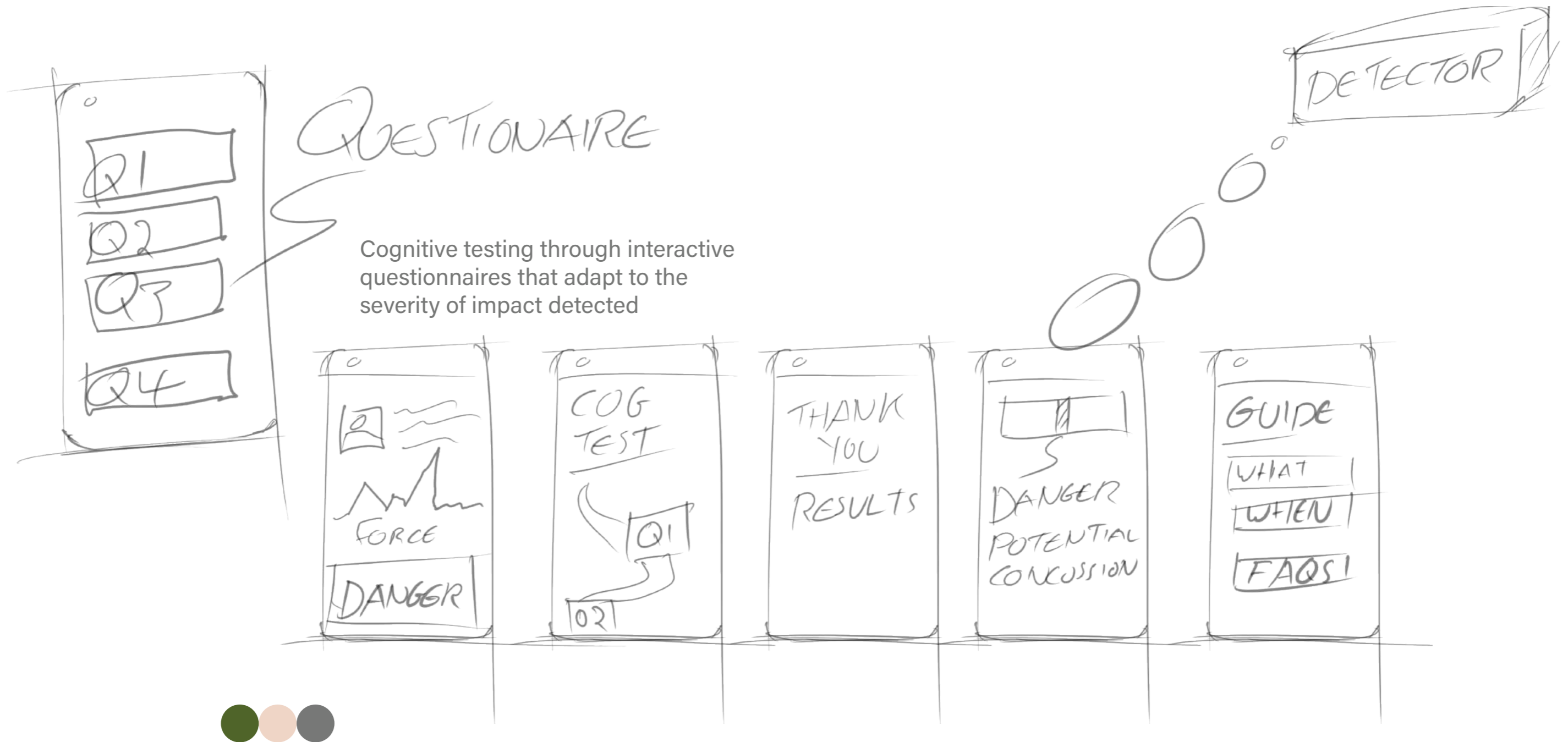
Using emergent technology such as NeuroLink to detect and transfer information about the incident to emergency services and to remind the user later on about the incident and how to recover



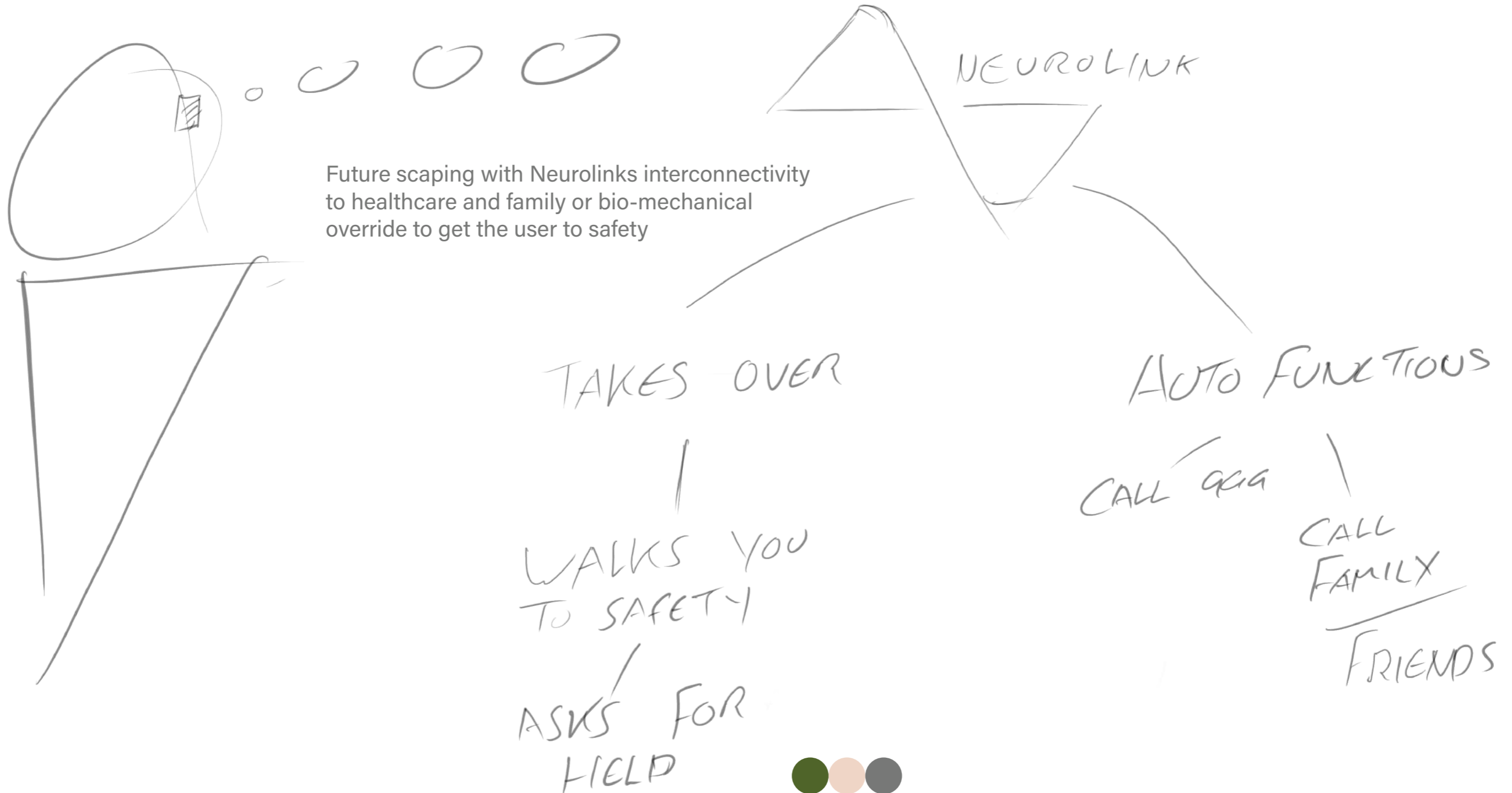
Using visual indicators of the force of an impact to show the user the extent of the potential trauma.



## Cognitive Detection



## Cognitive Detection



## Cognitive Detection



Mobile cognitive tests that relay results in real time



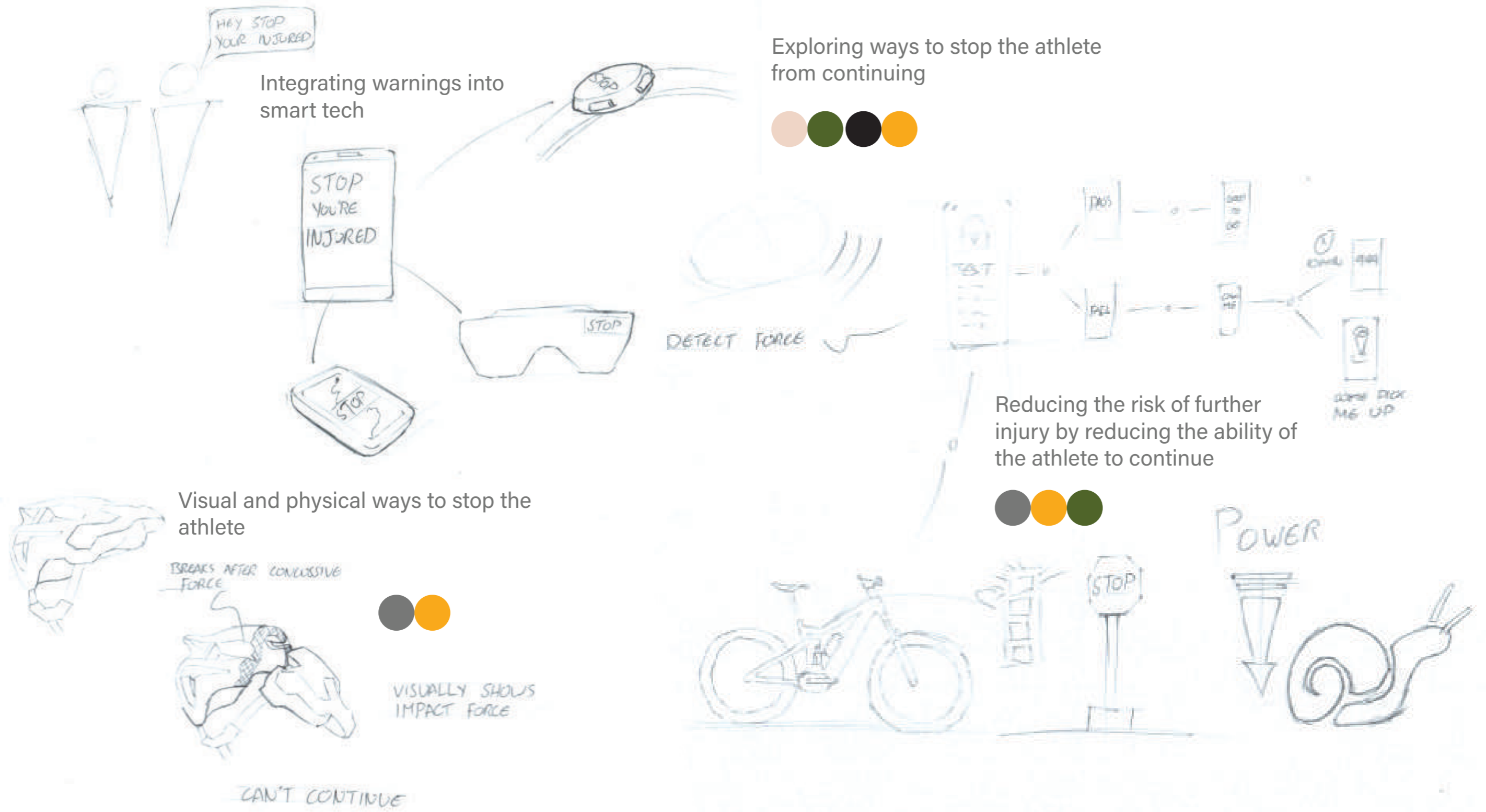
Test should be able to be carried out at any time and place and show results in real time



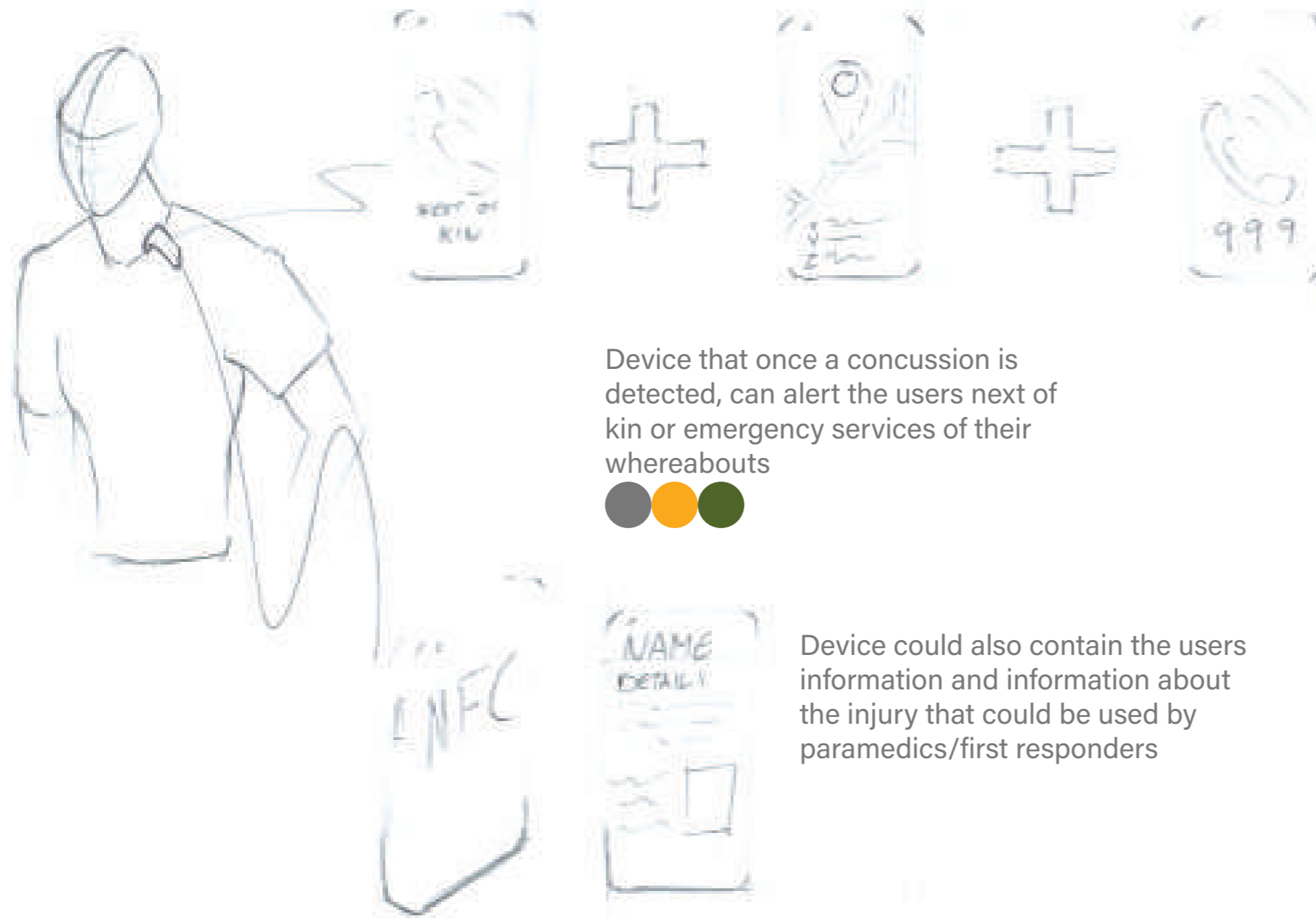


# Situational Recovery

## How to get help right after a concussion has occurred

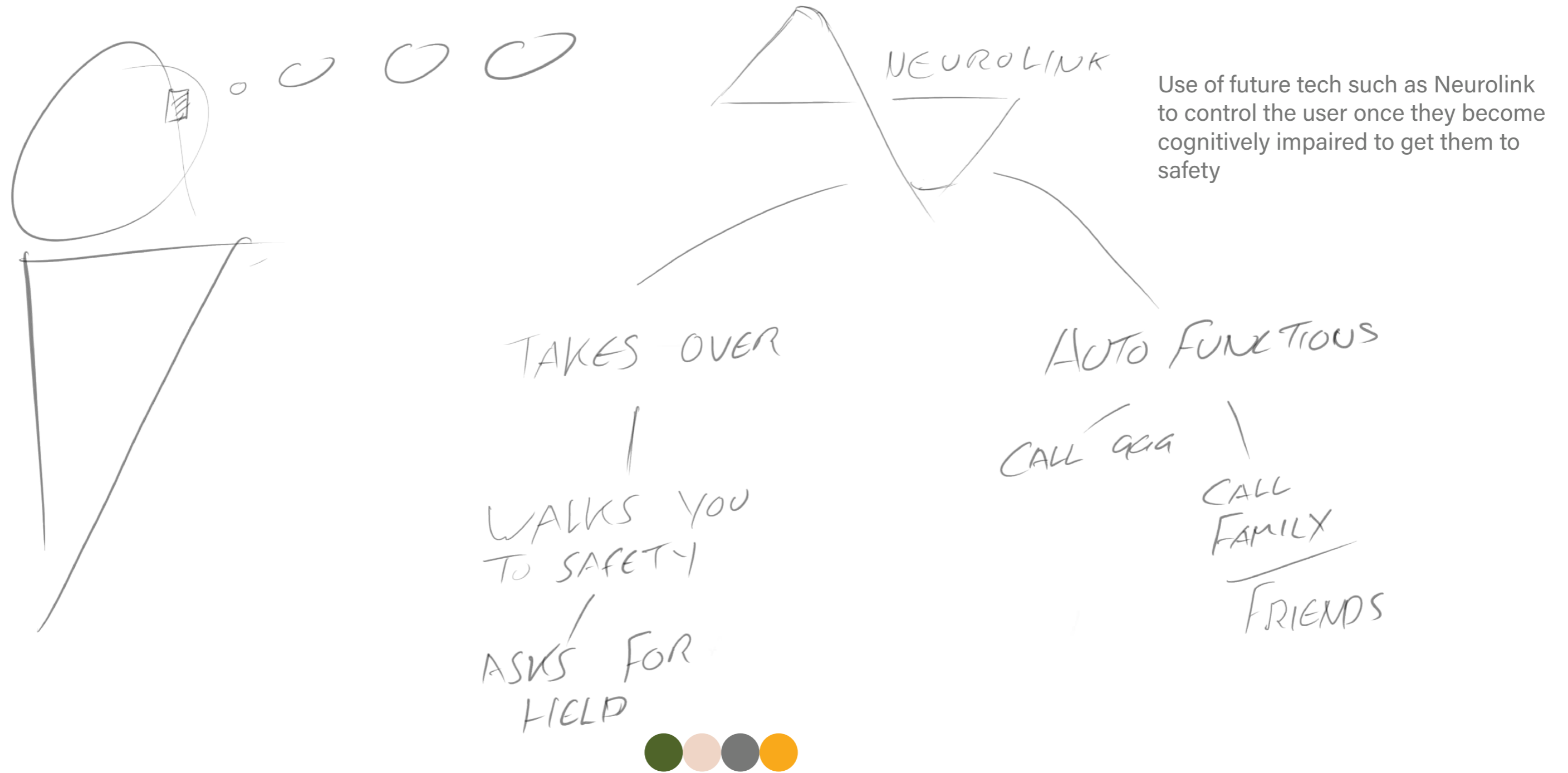


## How to get help right after a concussion has occurred



# Situational Recovery

How to get help right after a concussion has occurred



# Situational Recovery

How to get help right after a concussion has occurred



Develop a community of support around action sports to help recover athletes to their home or hospital once they suffer a concussion

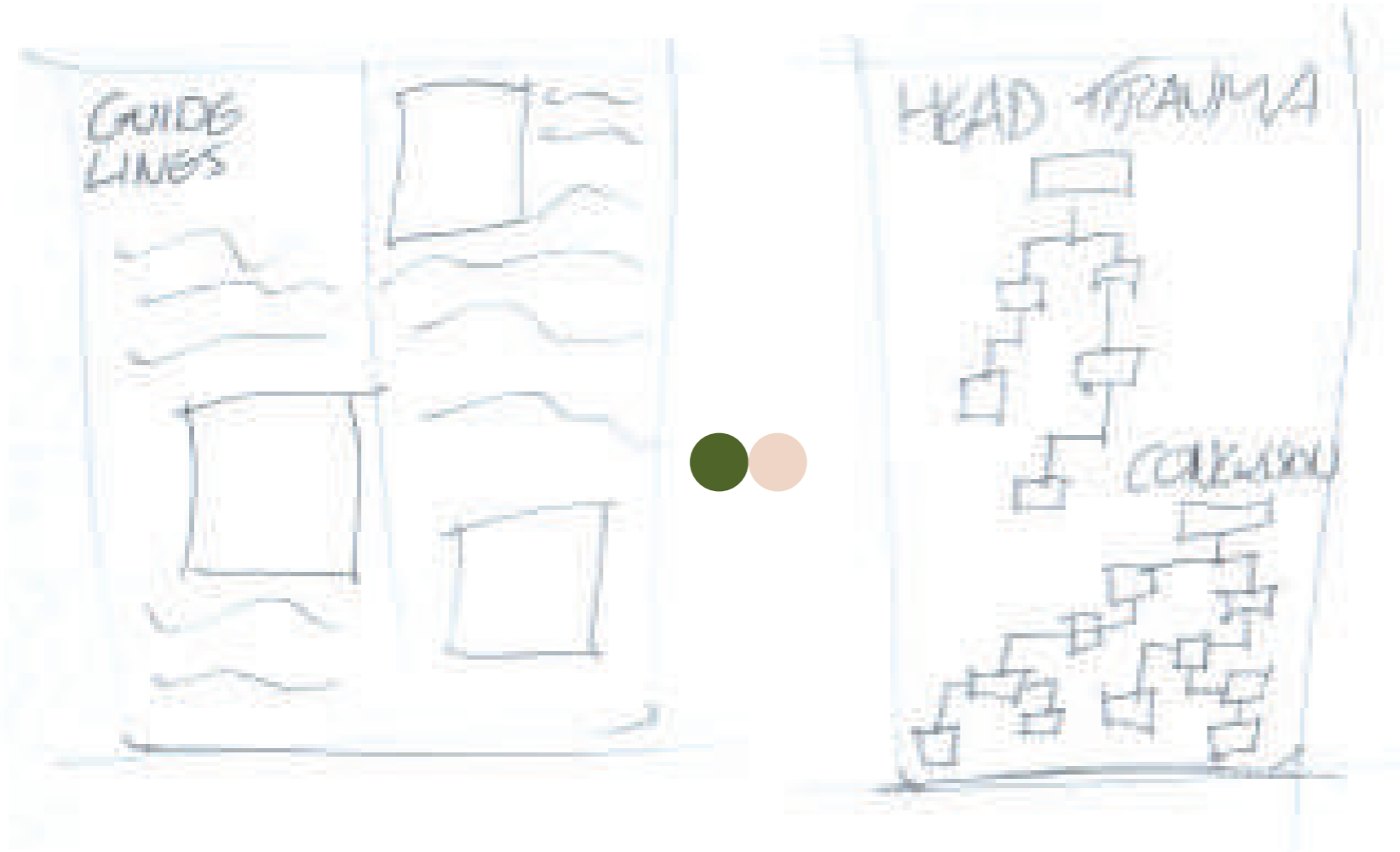


Ride share system to help athletes make it home without having to drive home impaired



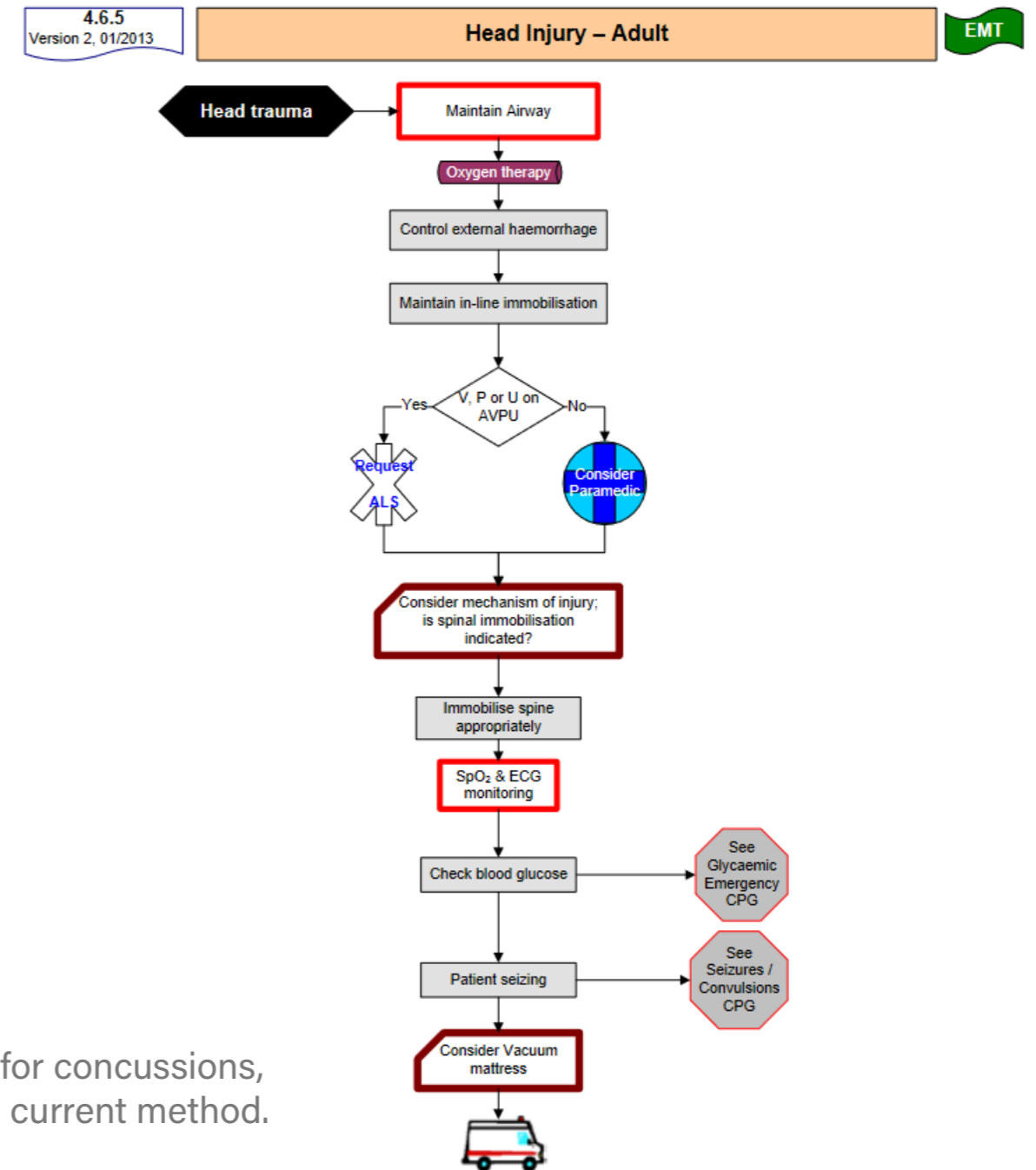
# Situational Recovery

How to get help right after a concussion has occurred



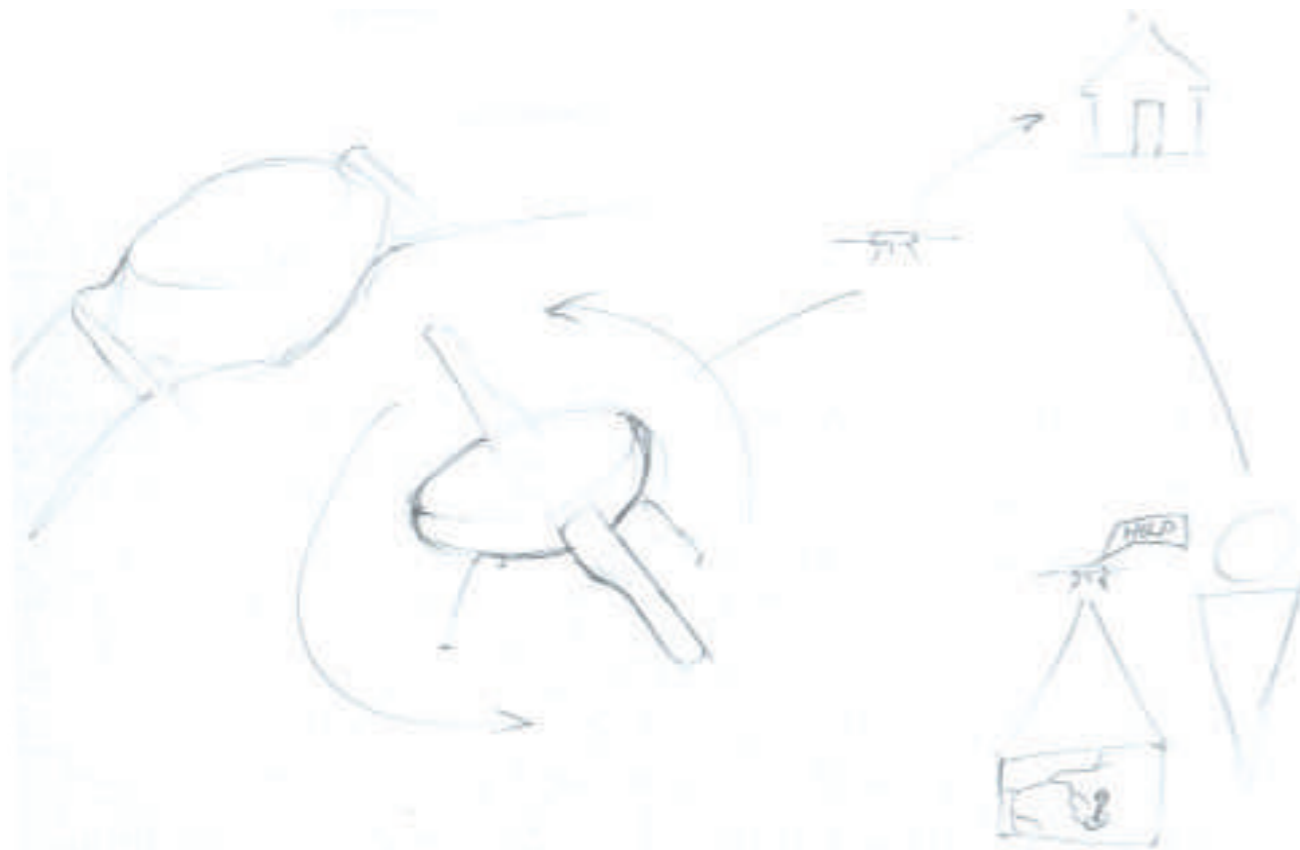
Improved guidelines for paramedics when it comes to dealing with concussions and mTBIs

One specifically for concussions, compared to the current method.

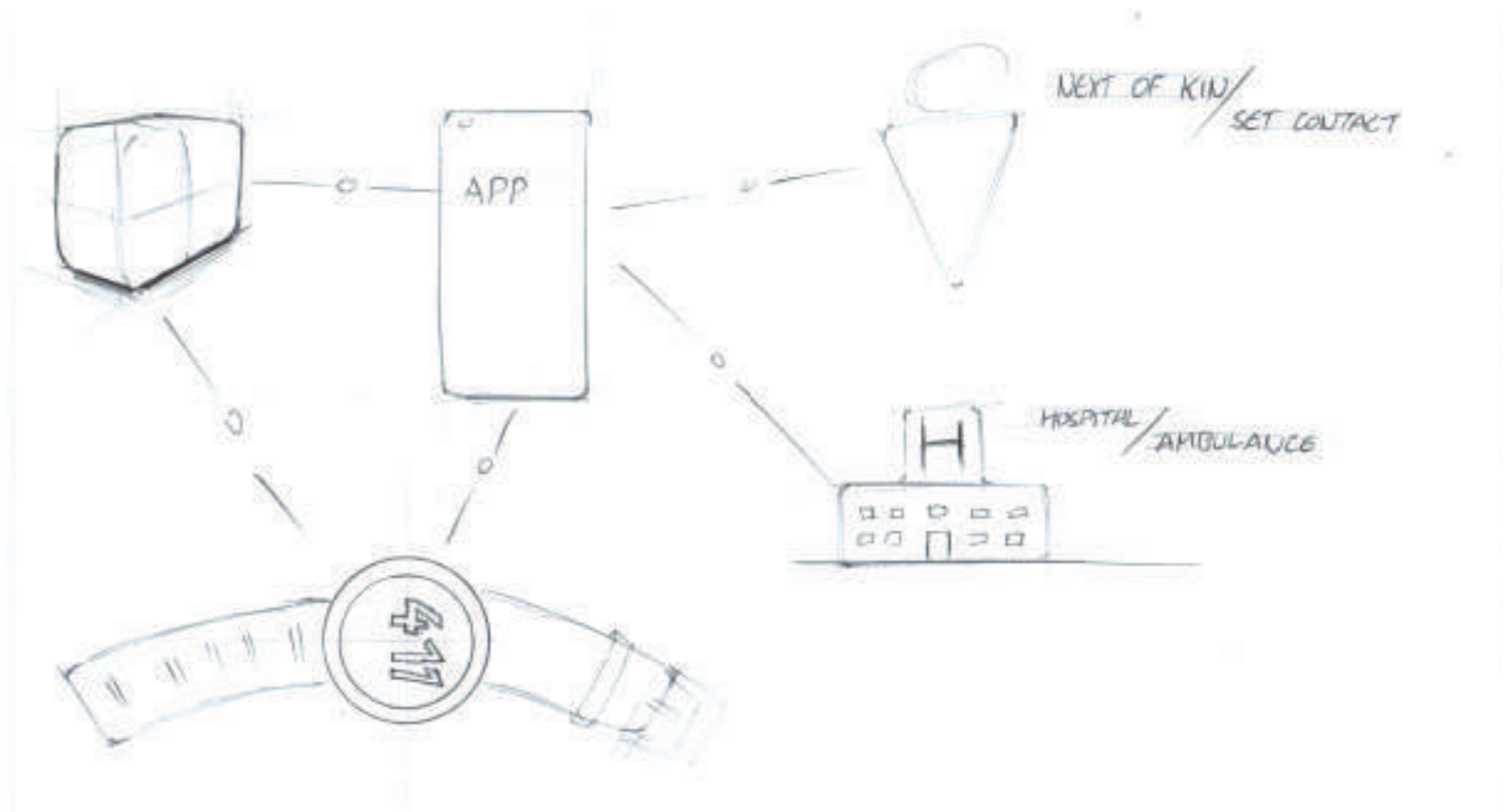


# Situational Recovery

How to get help right after a concussion has occurred



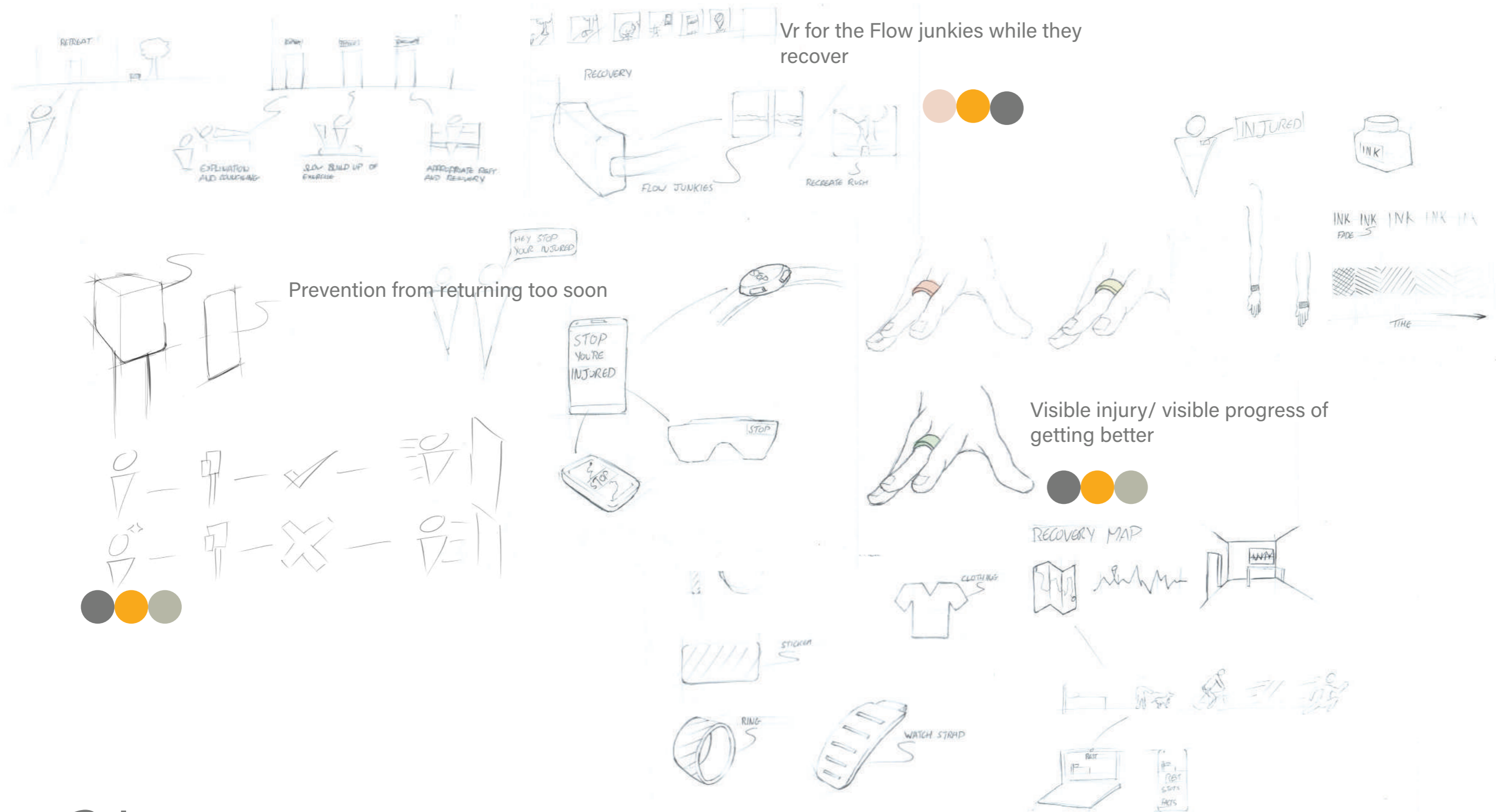
Remote recovery that auto ejects and seeks help for the user, projects a map that shows the users position and their vitals



Further interconnectivity to alert medical staff and paramedics of the users condition and location

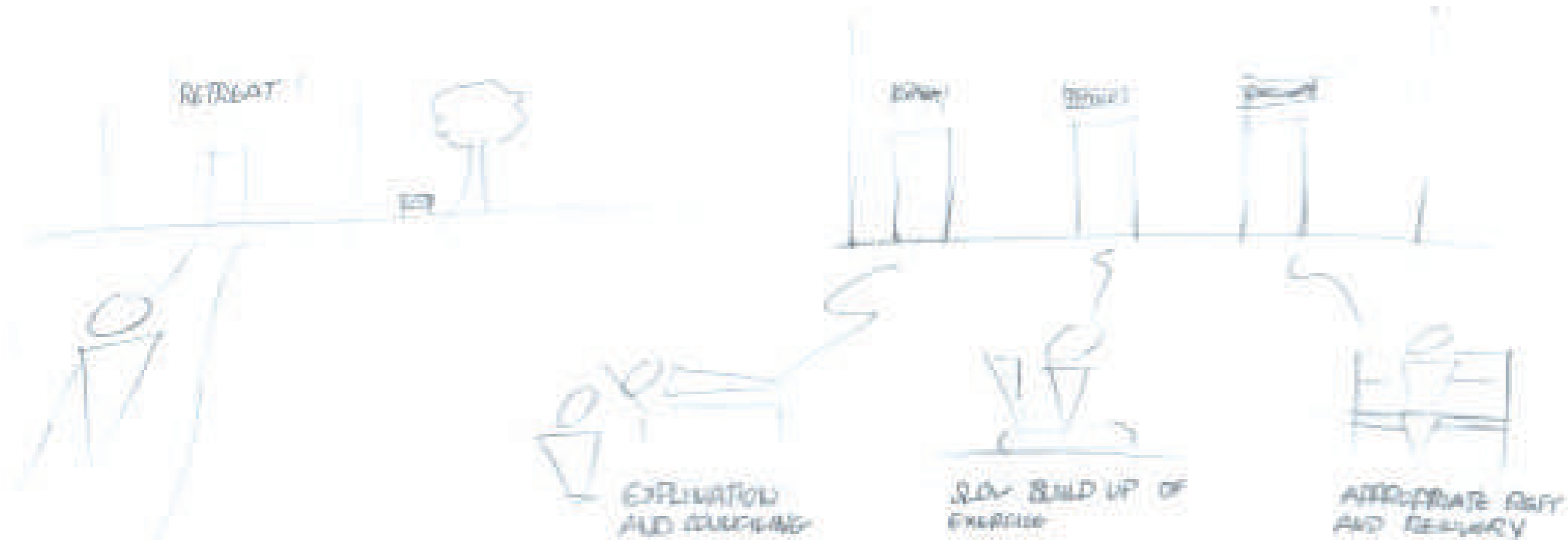


## How to aid the physical and mental recovery post concussion



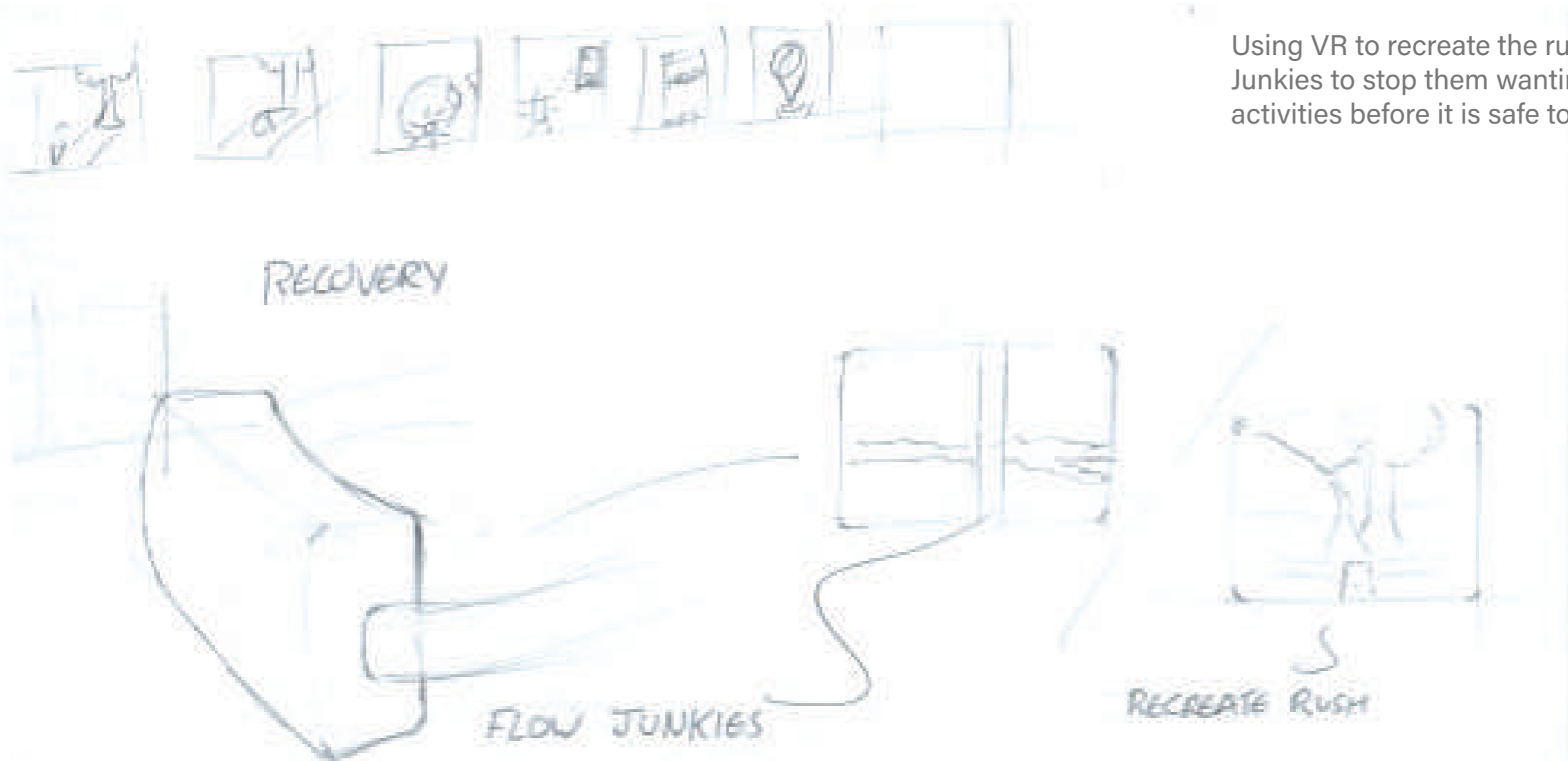


## How to aid the physical and mental recovery post concussion



Retreat centre/ system of concussion recovery that integrates education, rebuild of exercise and appropriate rest

## How to aid the physical and mental recovery post concussion

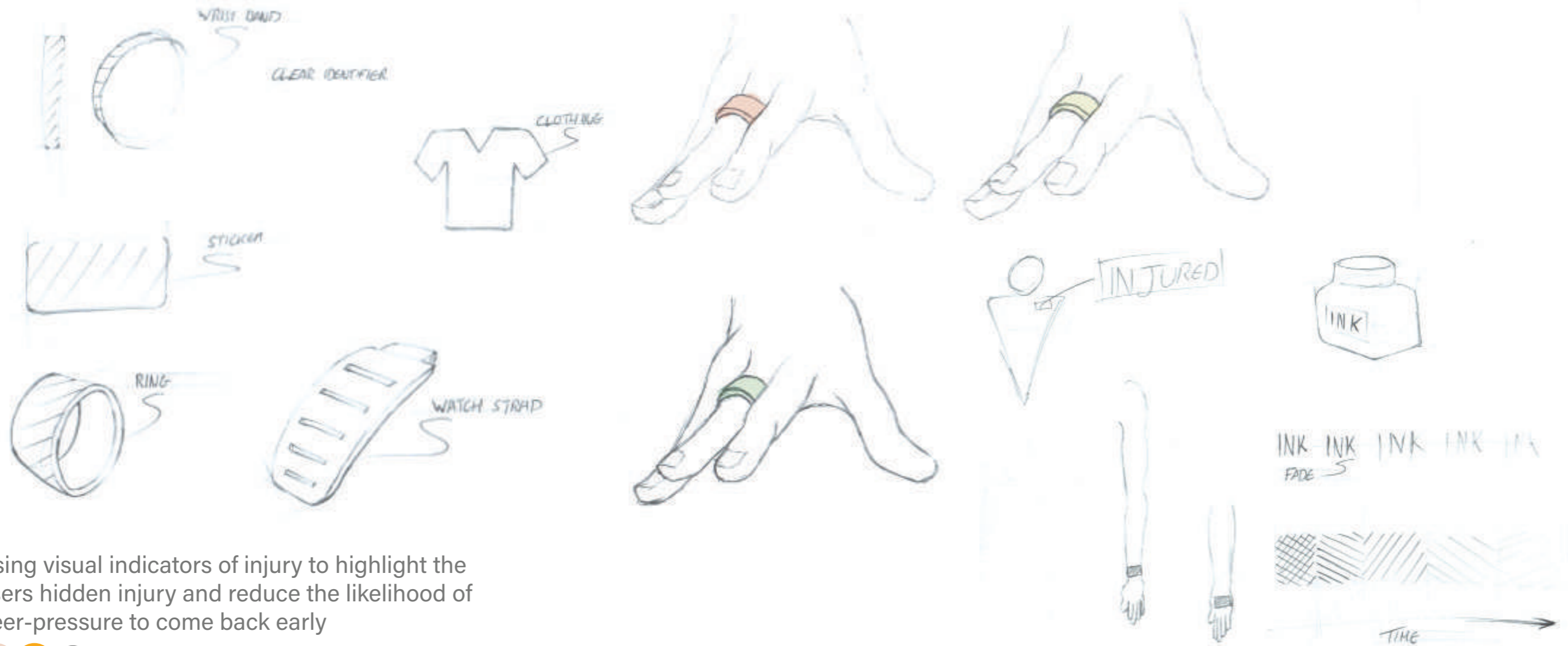


Using VR to recreate the rush for Flow Junkies to stop them wanting to do the activities before it is safe to do so

Could be used to keep skills up when he person is resting



## How to aid the physical and mental recovery post concussion



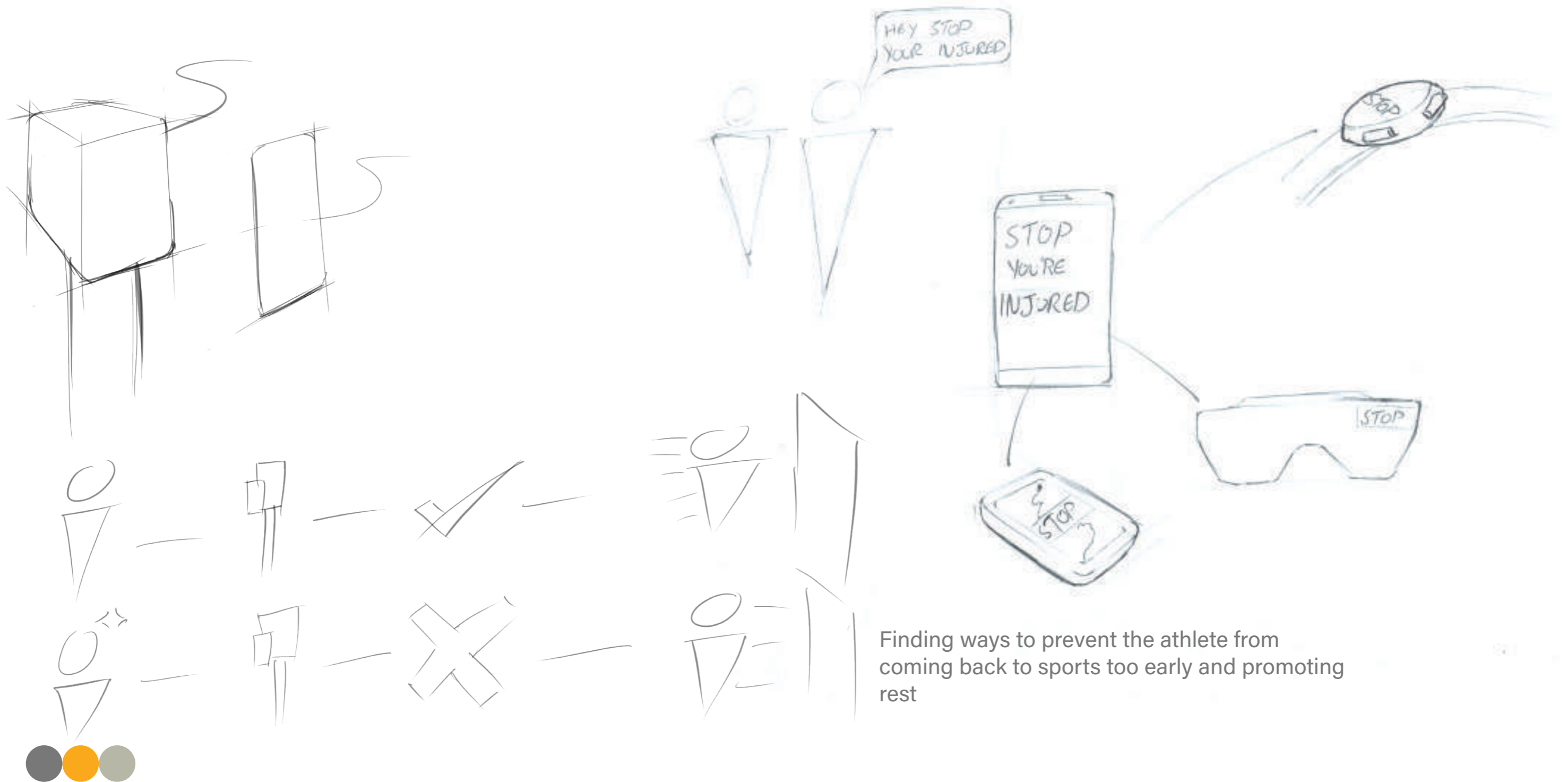
Using visual indicators of injury to highlight the users hidden injury and reduce the likelihood of peer-pressure to come back early



Indicators that last the same time as the recovery time

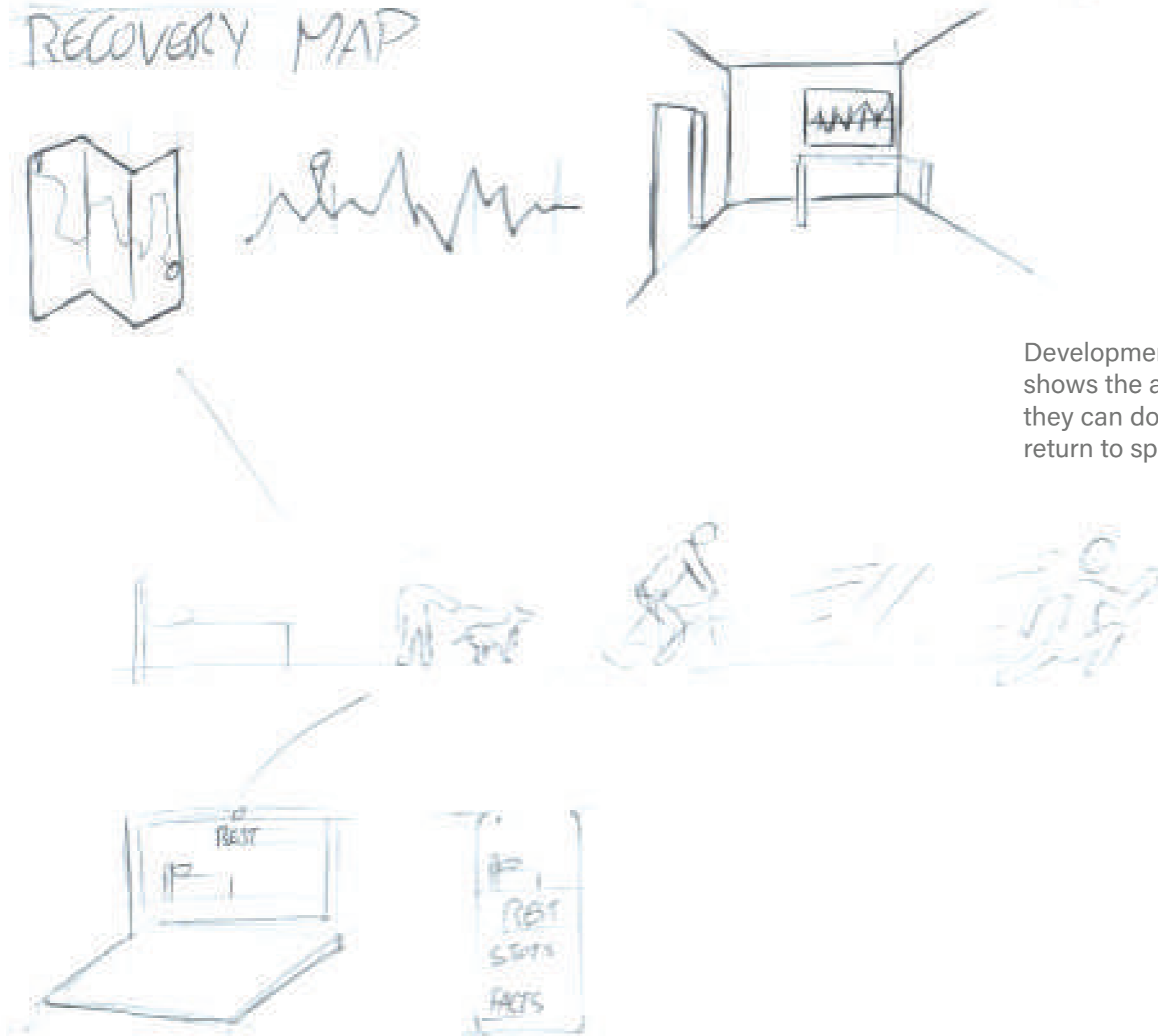


## How to aid the physical and mental recovery post concussion



Finding ways to prevent the athlete from coming back to sports too early and promoting rest

## How to aid the physical and mental recovery post concussion



Development a physical or digital roadmap that shows the athlete what stage they are at, what they can do at each stage and when they can return to sports

## Selection Method

Selection criteria for the top 4 ideas

Personal interest

Meets needs highlighted prior in accordance with the theme

Can be accomplished in the time frame

Has positive implications for the user

Scope of positive implications

# Selection Method

Theme	Description	Personal Interest	Needs Met	Time Frame	Implications	Scope	Total
Detection	Blood test	5	5	4	4	4	22
Recovery	Physical identifier for hidden injury	5	4	5	4	4	22
Situational Recovery	Uber/lift share home	5	3	5	4	4	21
Detection	First Aid addition	3	5	4	4	4	20
Situational Recovery	Neurolink taking control of your body	4	5	1	5	5	20
Detection	transferable accelerometer	3	3	5	4	4	19
Detection	Wearable accelerometer/Smartwear	3	3	5	4	4	19
Situational Recovery	Locater and recovery system for medics	5	2	5	4	3	19
Prevention	Mass education program	3	5	3	5	2	18
Situational Recovery	Help finding device	4	3	4	4	3	18
Recovery	Roadmaps for concussion sufferers	3	3	5	4	3	18
Detection	Interconnected tech	3	3	4	3	3	16
Detection	Neurolink integration	2	3	1	5	5	16
Recovery	Rehab centre	1	3	5	4	3	16
Situational Recovery	Imped the users ability to continue	2	2	3	5	3	15
Recovery	Vr Recovery	4	2	3	3	3	15
Prevention	Gate and passport system	2	2	4	3	2	13
Detection	Eye test	1	2	5	3	2	13
Situational Recovery	New paramedic procedures	1	2	5	3	2	13
Recovery	No access gates	2	2	4	3	2	13
Prevention	Mandatory reporting	1	2	5	3	1	12
Detection	Questionnaire app	2	3	3	3	1	12
Detection	Portable questionnaire	1	2	3	3	2	11

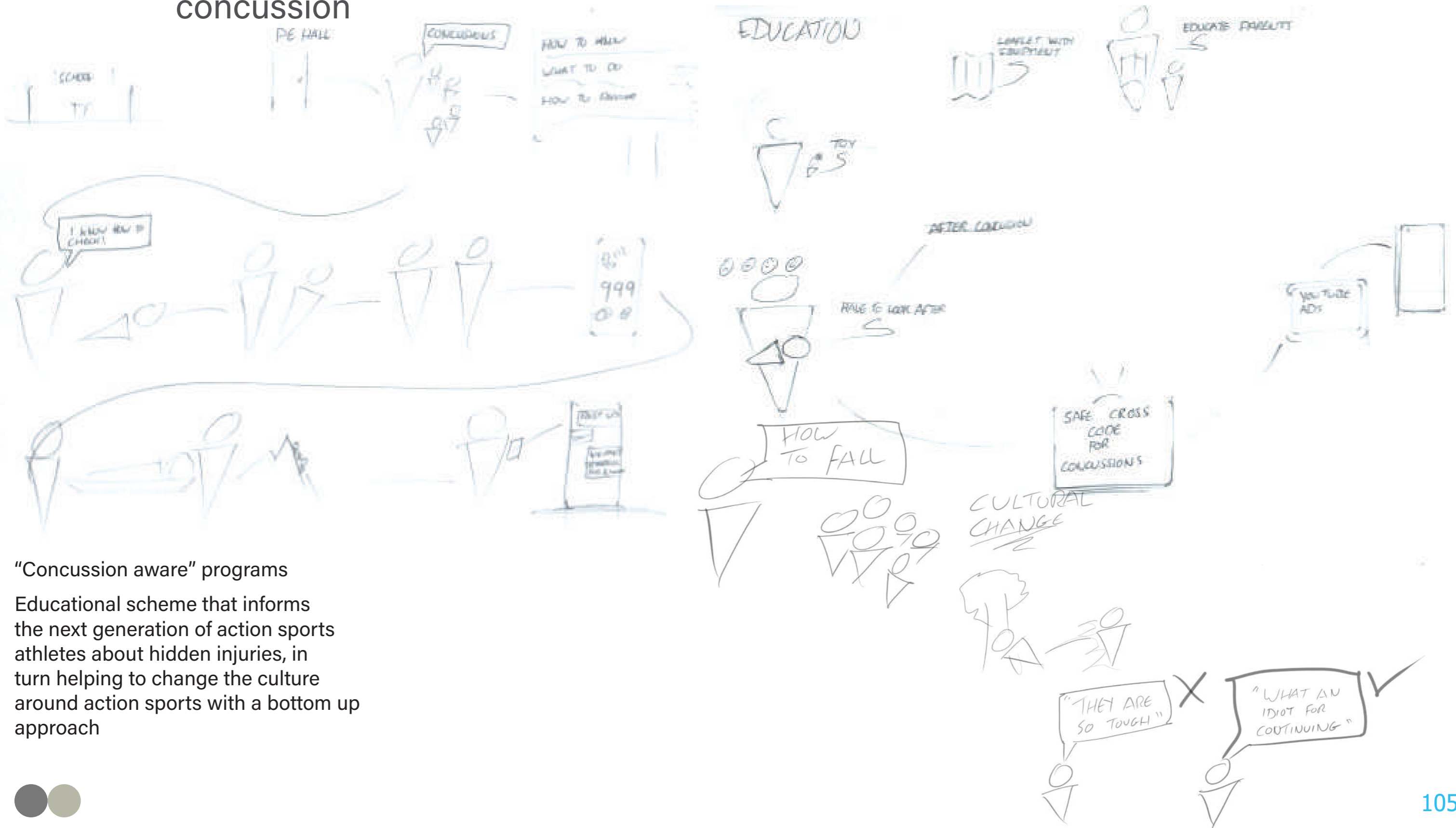
## Top 4 Ideas by Category

- |   |                      |                                       |
|---|----------------------|---------------------------------------|
| 1 | Detection            | Blood test                            |
| 2 | Recovery             | Physical identifier for hidden injury |
| 3 | Situational Recovery | Uber/lift share home                  |
| 4 | Prevention           | Mass education program                |



# Idea 1

Educational programs teaching the next generations how to deal with a concussion



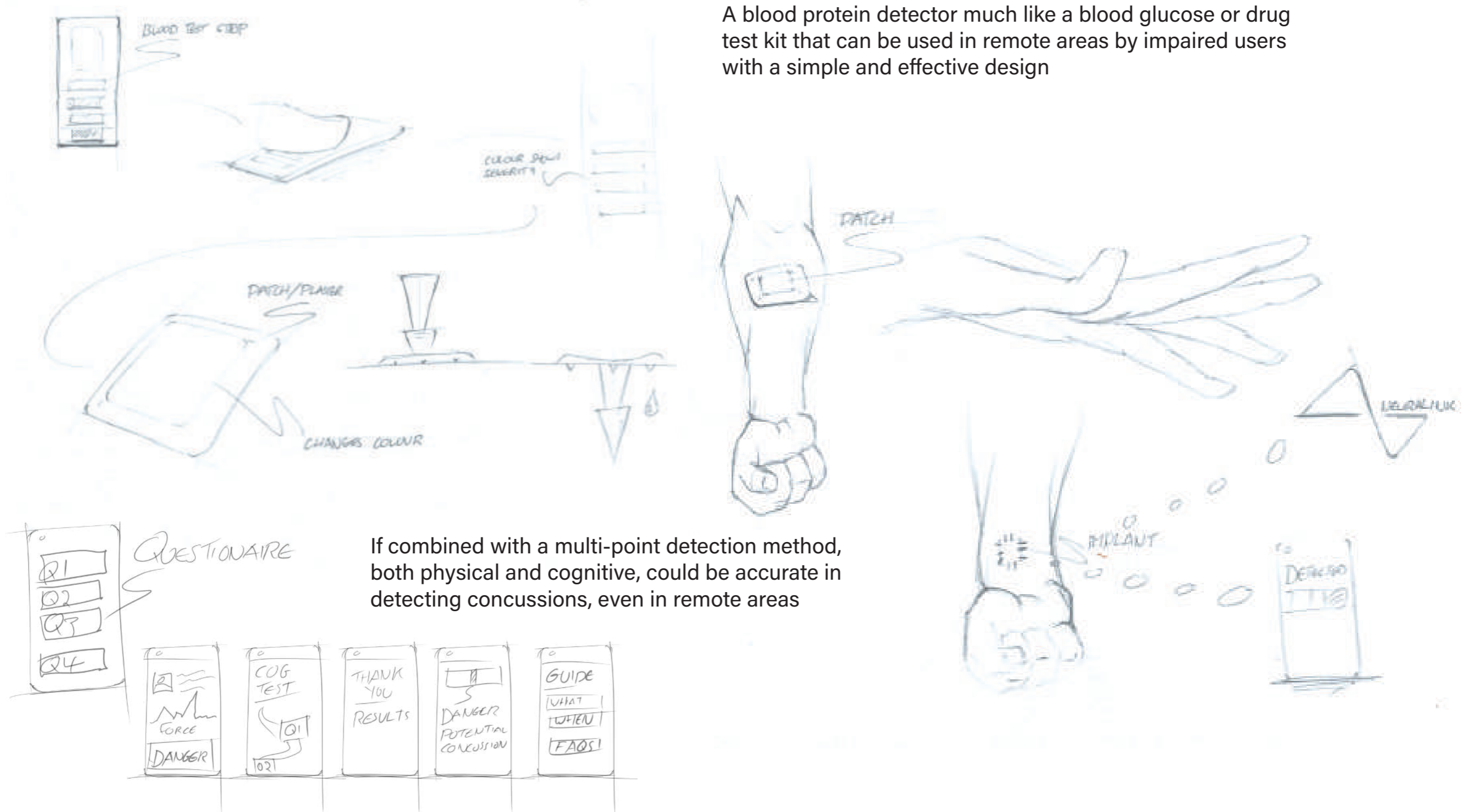
## "Concussion aware" programs

Educational scheme that informs the next generation of action sports athletes about hidden injuries, in turn helping to change the culture around action sports with a bottom up approach



## Using Blood Protein detection as a biomarker for concussions

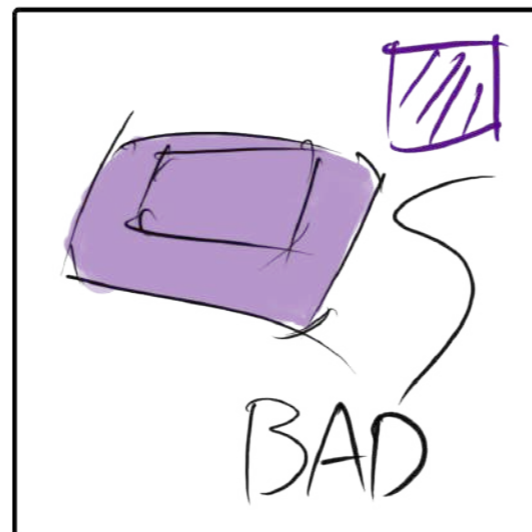
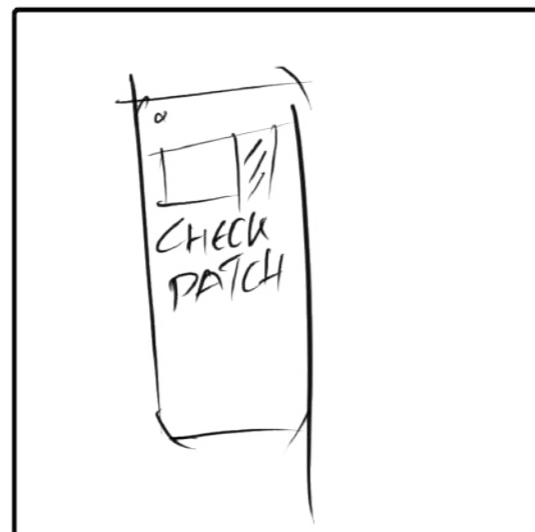
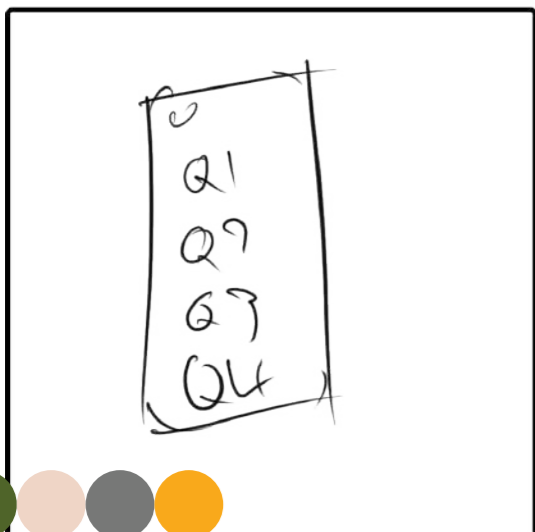
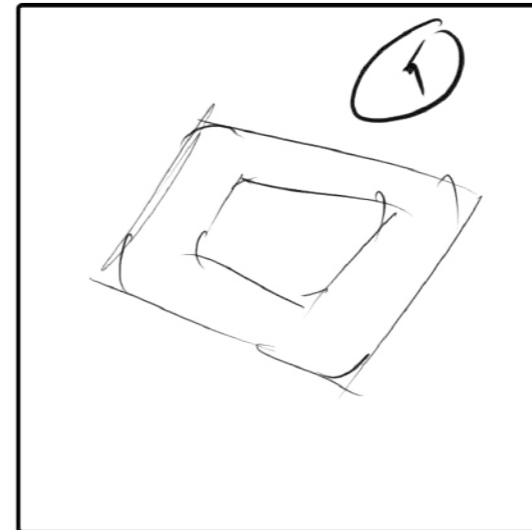
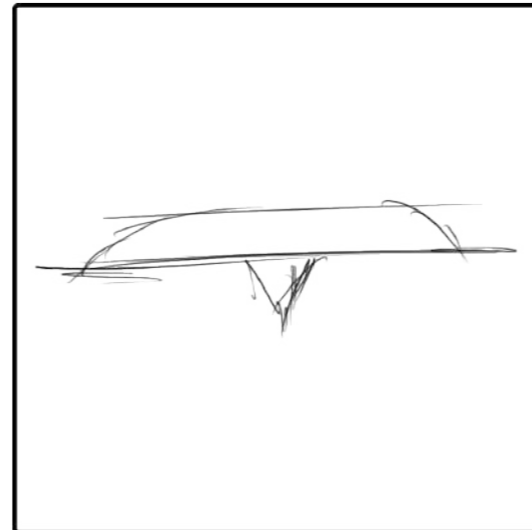
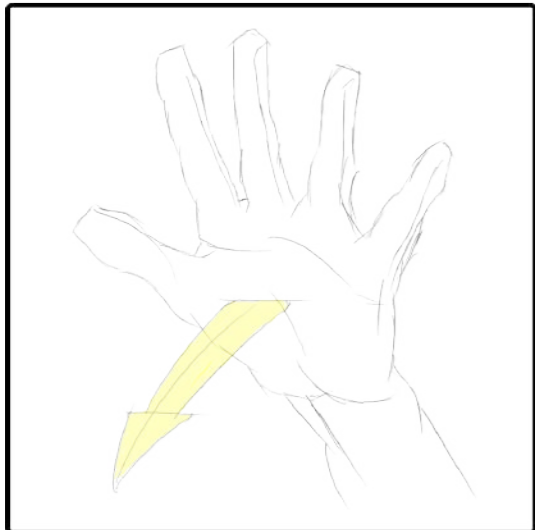
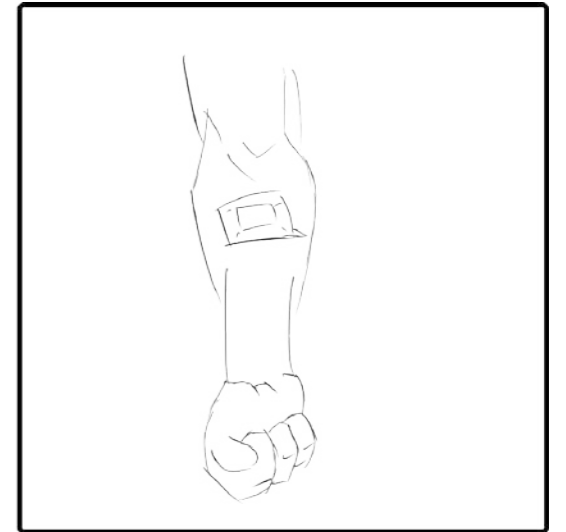
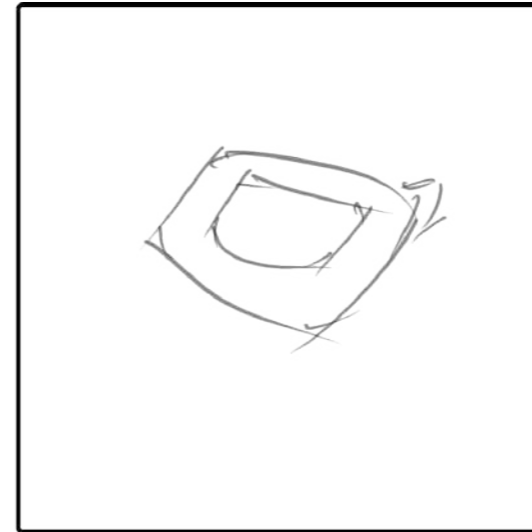
A blood protein detector much like a blood glucose or drug test kit that can be used in remote areas by impaired users with a simple and effective design



If combined with a multi-point detection method, both physical and cognitive, could be accurate in detecting concussions, even in remote areas

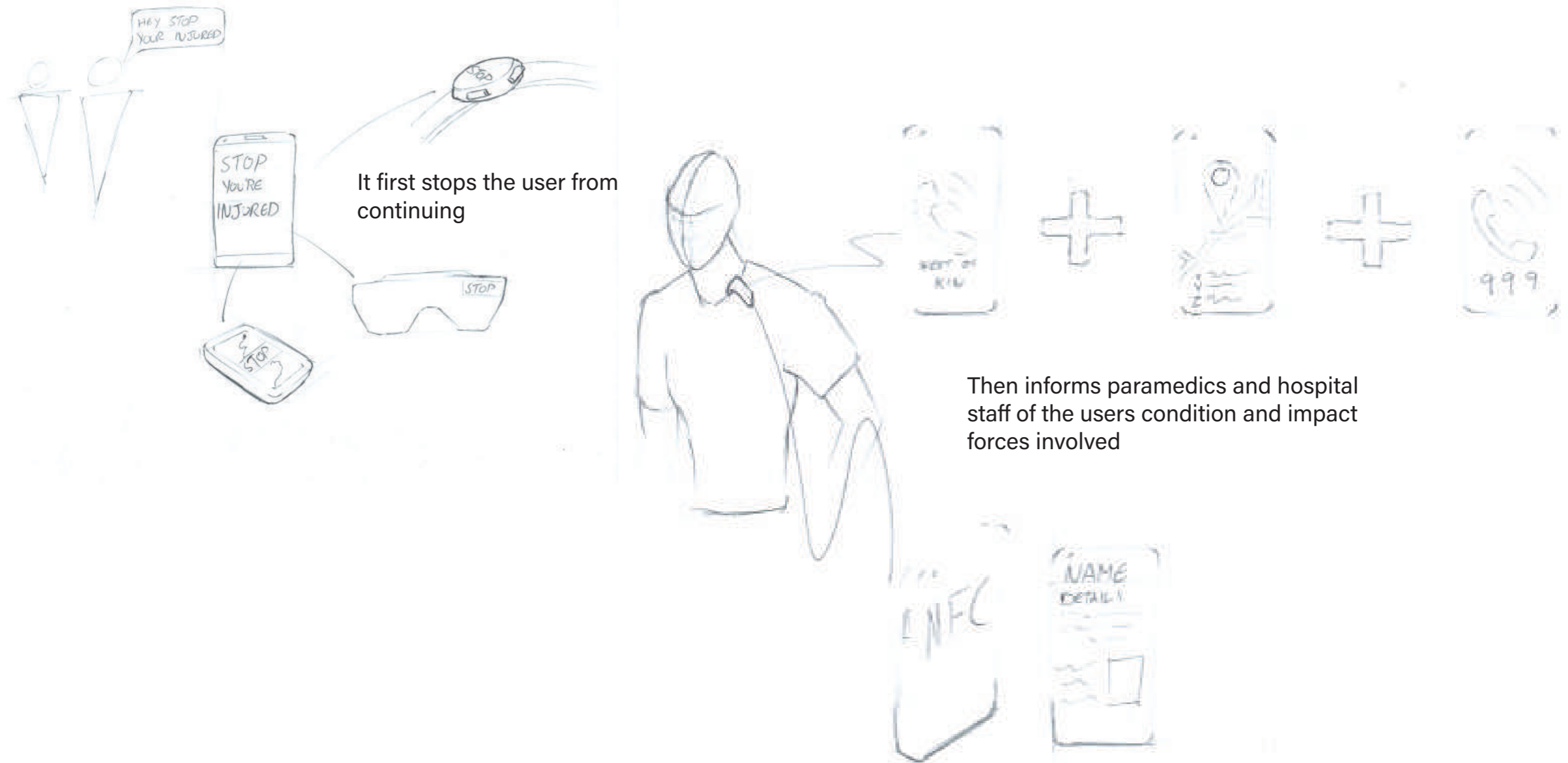
# Idea 2

How it would be used



# Idea 3

Integrated and interconnected suite of devices that relays information back to paramedics, hospitals and family members



# Idea 3

This could also tie into a recover app for stranded and impaired riders



Develop a community of support around action sports to help recover athletes to their home or hospital once they suffer a concussion



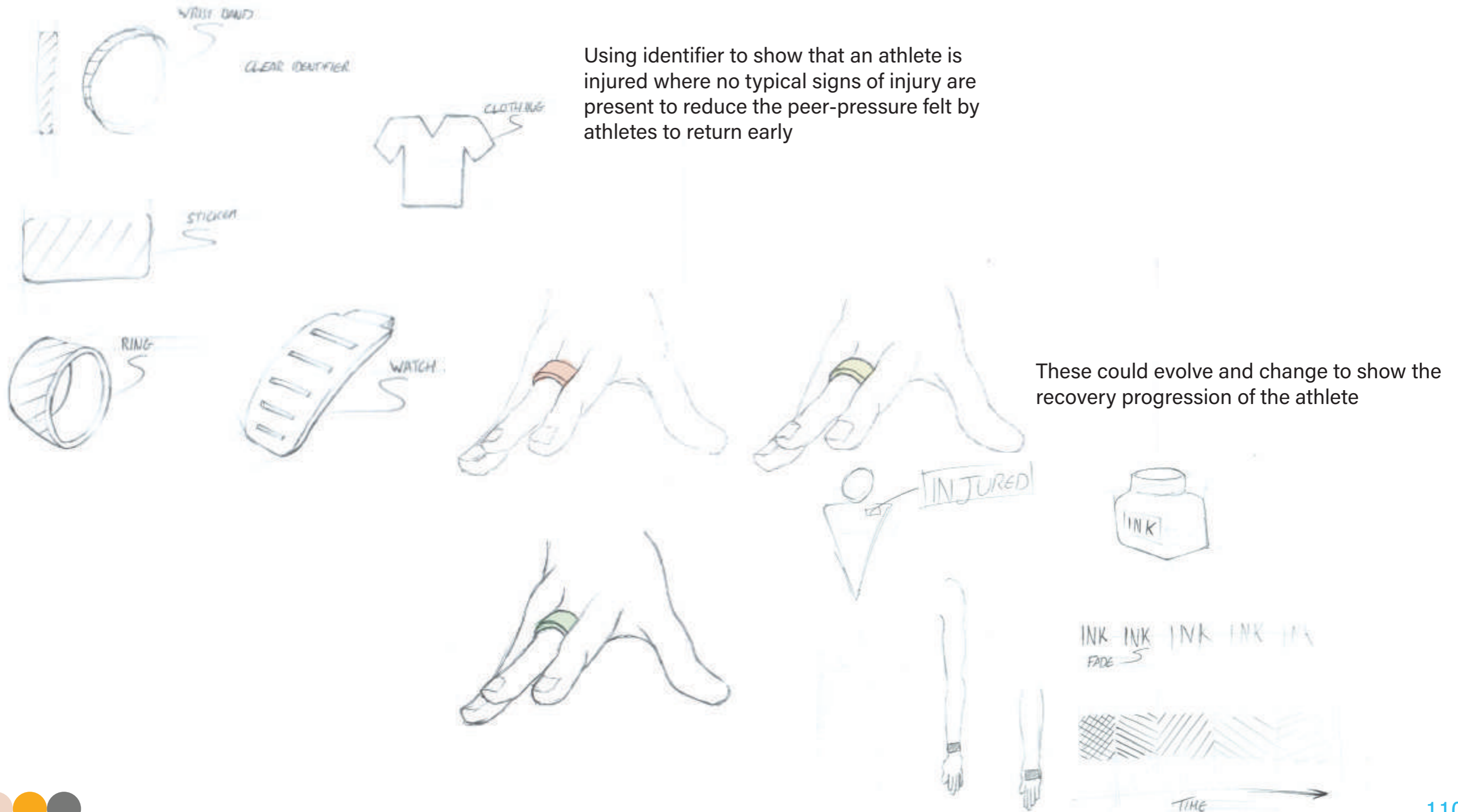
Ride share system to help athletes make it home without having to drive home impaired



# Idea 4

## Make the hidden injury seen

Using identifier to show that an athlete is injured where no typical signs of injury are present to reduce the peer-pressure felt by athletes to return early



These could evolve and change to show the recovery progression of the athlete



### Rational

Using a blood protein detection method allows for greater accuracy in detecting concussion and can be implemented post concussion incident, rather than relying on “always on” technology or monitors.

This test can also be easily integrated into a wider system of currently used medical practices such as the REC training for ease of acceptability within the action sport community.

### Needs Met

A device or system that can be self administered by a potentially concussed athletes

The ability to diagnose concussion

Can be implemented in remote areas

Is non-invasive

Uses a combination of bio-markers and cognitive testing to detect concussions

### Other

Potential regulation to be designed to.

ISO 13485: 2016

<https://www.iso.org/publication/PUB100422.html>

MDR/IVDR

### Rational

Using a social shared application allows for a multifaceted approach to concussion detection and response. The platform allows for both a cognitive test to be performed on an impaired individual but also to request help if other issues arise from nearby active users.

This allows for both the over arching themes of Detection and Situational Recovery to be addressed within one integrated system which can be implemented in parallel or individually from Concept 1

### Needs Met

A device or system that can be self administered and recommend actions to potentially concussed athletes

The ability to diagnose concussion

Can be implemented in remote areas

Is non-invasive

Uses a combination of bio-markers and cognitive testing to detect concussions

Can recommend actions for athlete that is isolated

### Other

Potential regulation to be designed to.

ISO 13485: 2016

<https://www.iso.org/publication/PUB100422.html>

MDR/IVDR



# Concept Development.

## Breakdown Overview

Current Methods	pg 115
Final Solution	pg 116
Concept 1	pg 117
What it is	pg 119
How it works	pg 120
Research	pg 121
Final Design	pg 174
Concept 2	pg 180
What it is	pg 182
How it works	pg 183
Final Design	pg 214

# Current Methods

## Physical Detection

Head Impact Detection Devices

Novel Eye Tracking Devices

X2 Patch

I-Portal Eye Movement Goggles

Pupil Screening for Pupil Dilation

CSX

## Cognitive Detection

Rivermead Post-Concussion  
Symptoms Questions (RPQ)

Modified Rivermead Post-  
Concussion Symptoms Questions  
(mRPQ)

MPAI-4 Questionnaire

SCAT 5 Questionnaire

HIA Questionnaire

## Final Solution

The final outcome from this chapter is a fully integrated detection and recovery system that allows athletes to quickly detect concussions and request help to recover to a safe and secure place.

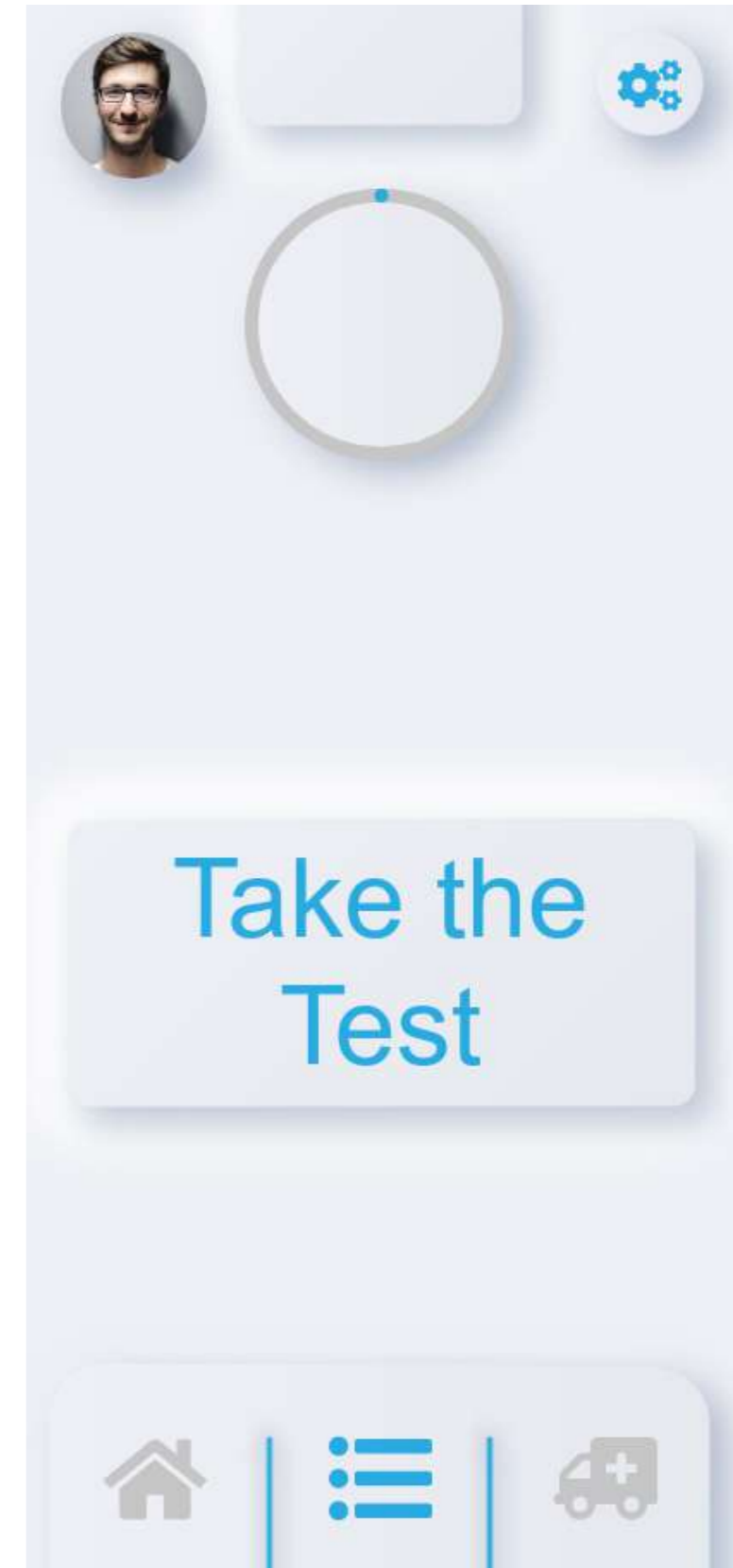
This is achieved via 2 separate and independent aspects systems. First being a physical detection device

The second is an application that contains an cognitive test and a recovery process.

Physical Detection Device



Cognitive Test App



# Concept 1.

Physical Detection

# Breakdown

What it is	pg 115
How it works	pg 116
Research	pg 117
Initial development	pg 119
Prototype 1	pg 132
Unique identifier	pg 135
New direction	pg 141
Prototype 2	pg 180
Development	pg 182
Prototype 3	pg 155
Development	pg 158
Final Design	pg 174

## What it is

Using blood protein level detection as a bio-marker for concussions

This is a device that takes a small blood sample from the effected athlete and analysis it for C-Tau and P-Tau proteins within the blood. This is to give an accurate gauge on whether or not the athlete has sustained a concussion.



The device would have to be portable, usable in remote areas, simple to use and display rapid results.

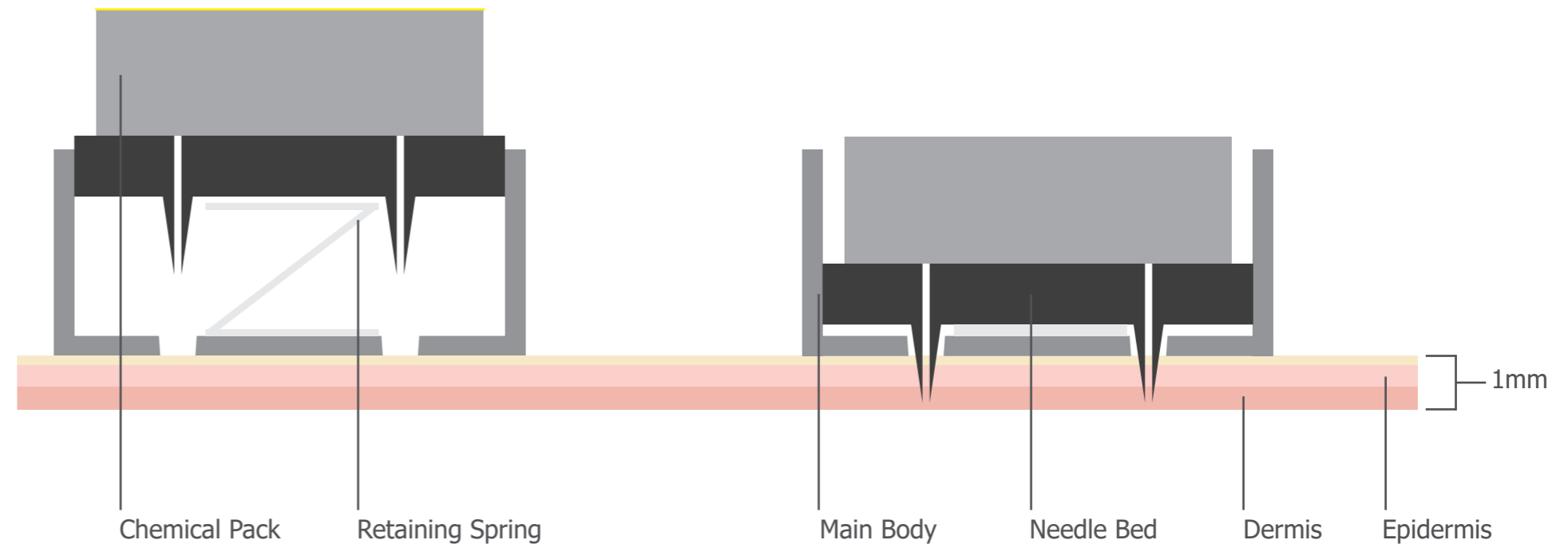
# How it Works

## Mechanics

The athlete put the device on their arm much like an arm band

The athlete then applies rapid downward pressure on the highlighted area in order to project the micro needles into the skin and draw blood

The athlete then waits for a few minutes for the chemical reaction and the results to show on the device

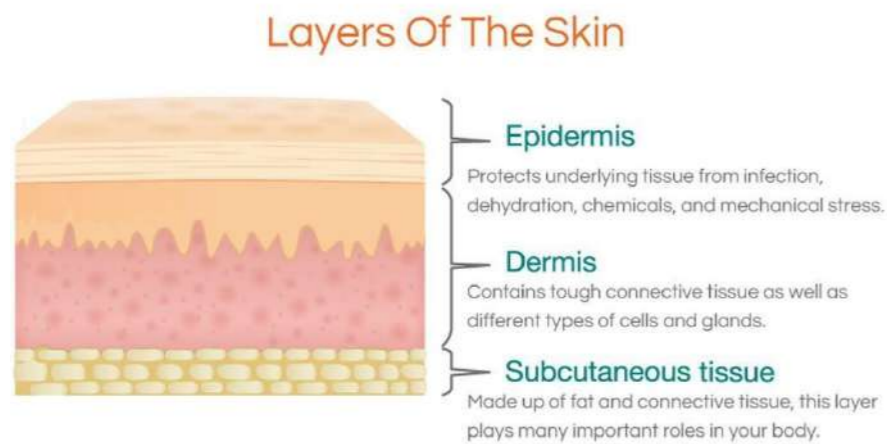


The downward pressure overcomes the spring force and protrudes the needle bed into the athlete's dermis layer of skin. This puncture site draws blood and through capillary action, draws the blood sample into the chemical pack located above the needle bed.



Further research that was required

## Skin Layers



(Mohs Skin Cancer Surgery, 2020)

## Cognitive impairment

Usability for users with cognitive impairment.

An expert in special education and training was consulted

## Needle Handling

<https://healthservice.hse.ie/staff/benefits-services/health-and-safety/safe-use-of-sharps.html>

## ISO 13485: 2016

Further exploration of medical device regulation and requirements

# Mechanism Research

## Methods of needle handling post use

### Leave exposed



Leave the needle as is without concern

### Retract the needles



Have a needle retraction system to prevent repeat penetration

### Cover the needles



Have a cover or cap that prevents repeat penetration

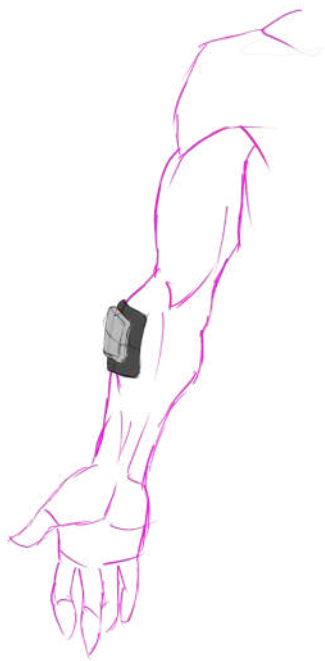
### Water soluble needles



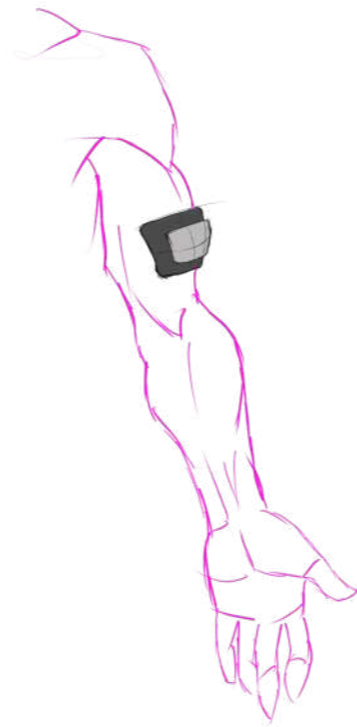
Have Soluble needles that disintegrate once activated and blood has been drawn

# Initial Development

Using a plaster type device that can be placed in a number of spots around the body



Forearm

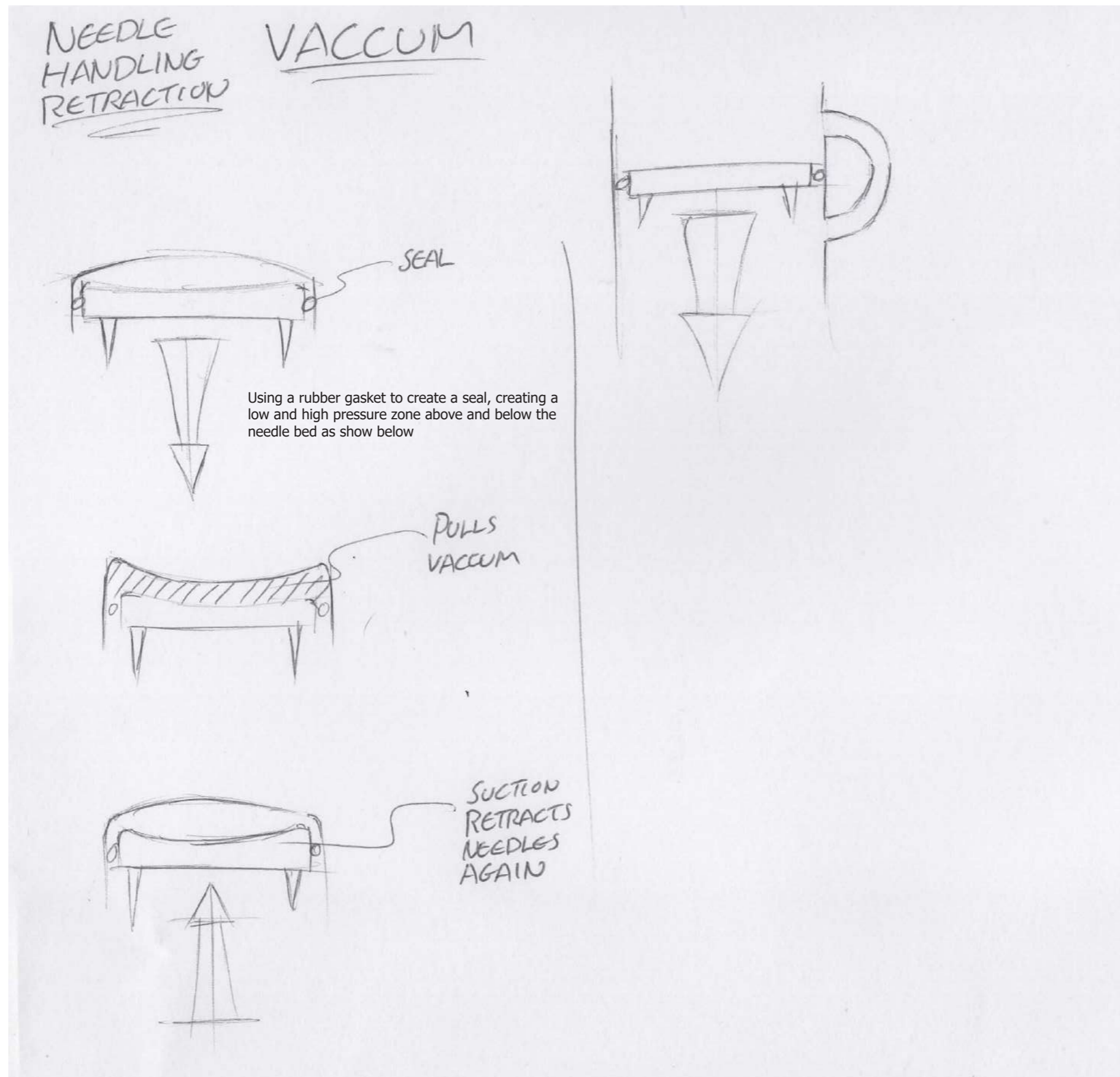


Bicep



Shoulder





## Exploring methods of needle retraction

Exploring the potential for a vacuum spring that would retract the needle using negative pressures.

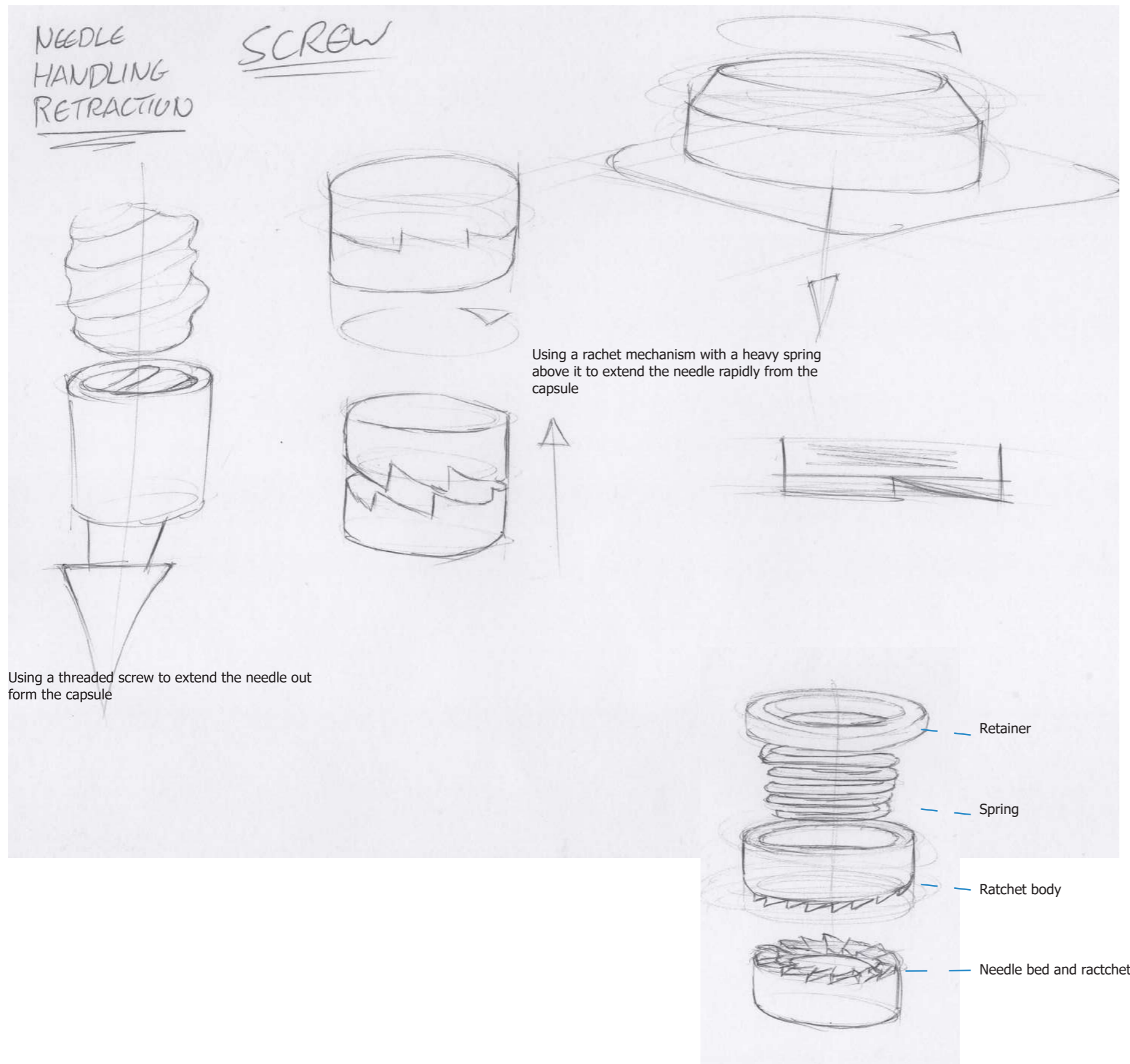
### Benefits

No mechanical failure points  
Simple in principle

### Drawbacks

This added extra complexity and difficult tolerances to be met at the scale it would be implemented  
Added manufacturing cost for a single use device

# Mechanism Development



## Exploring methods of needle retraction

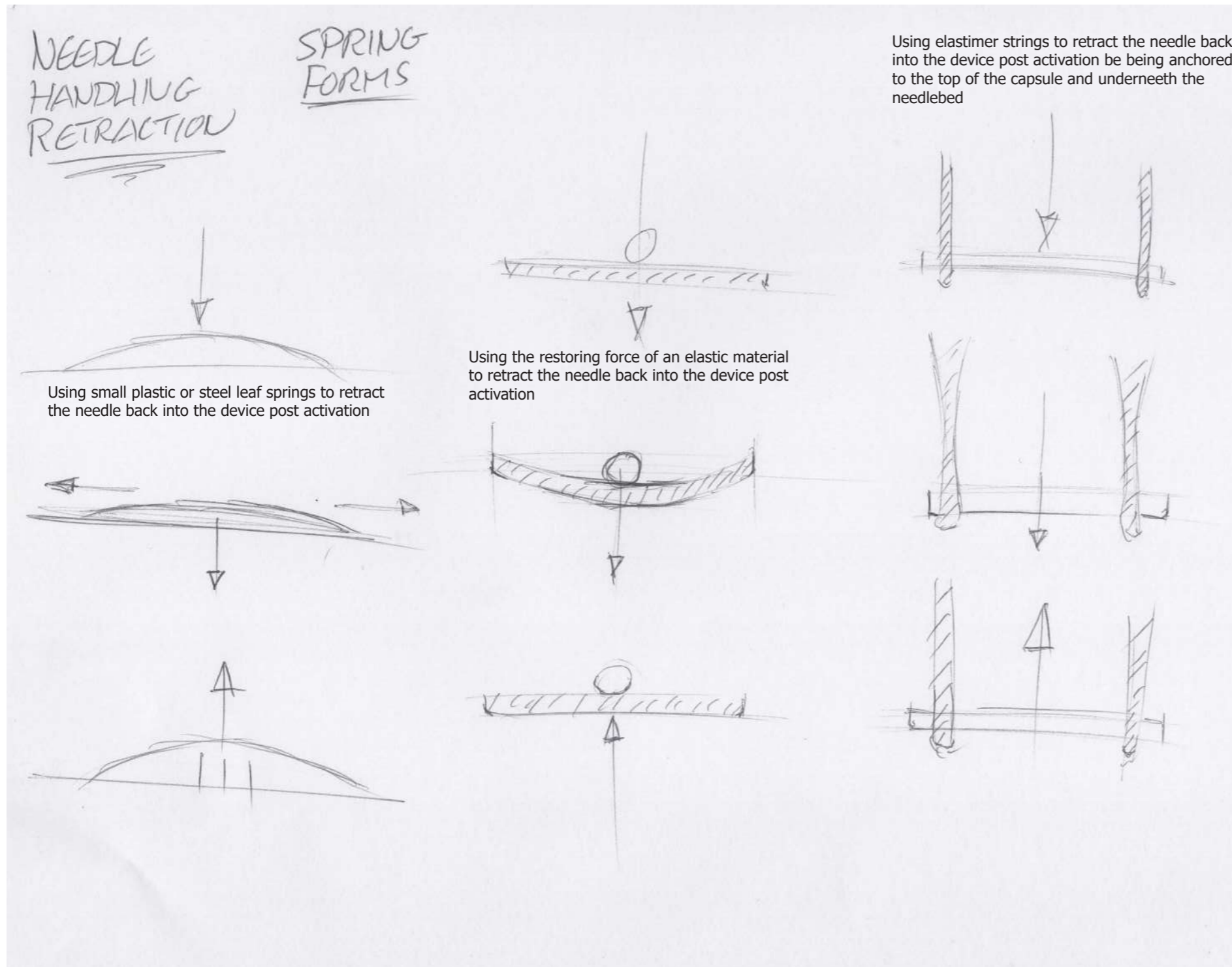
Exploring the potential for a screw mechanisms that would retract the needle using a twisting motion.

### Benefits

Simple and reliable mechanism

### Drawbacks

Adds considerable mass and bulk to the device  
Very slow activation which may unsettle users



## Exploring methods of needle retraction

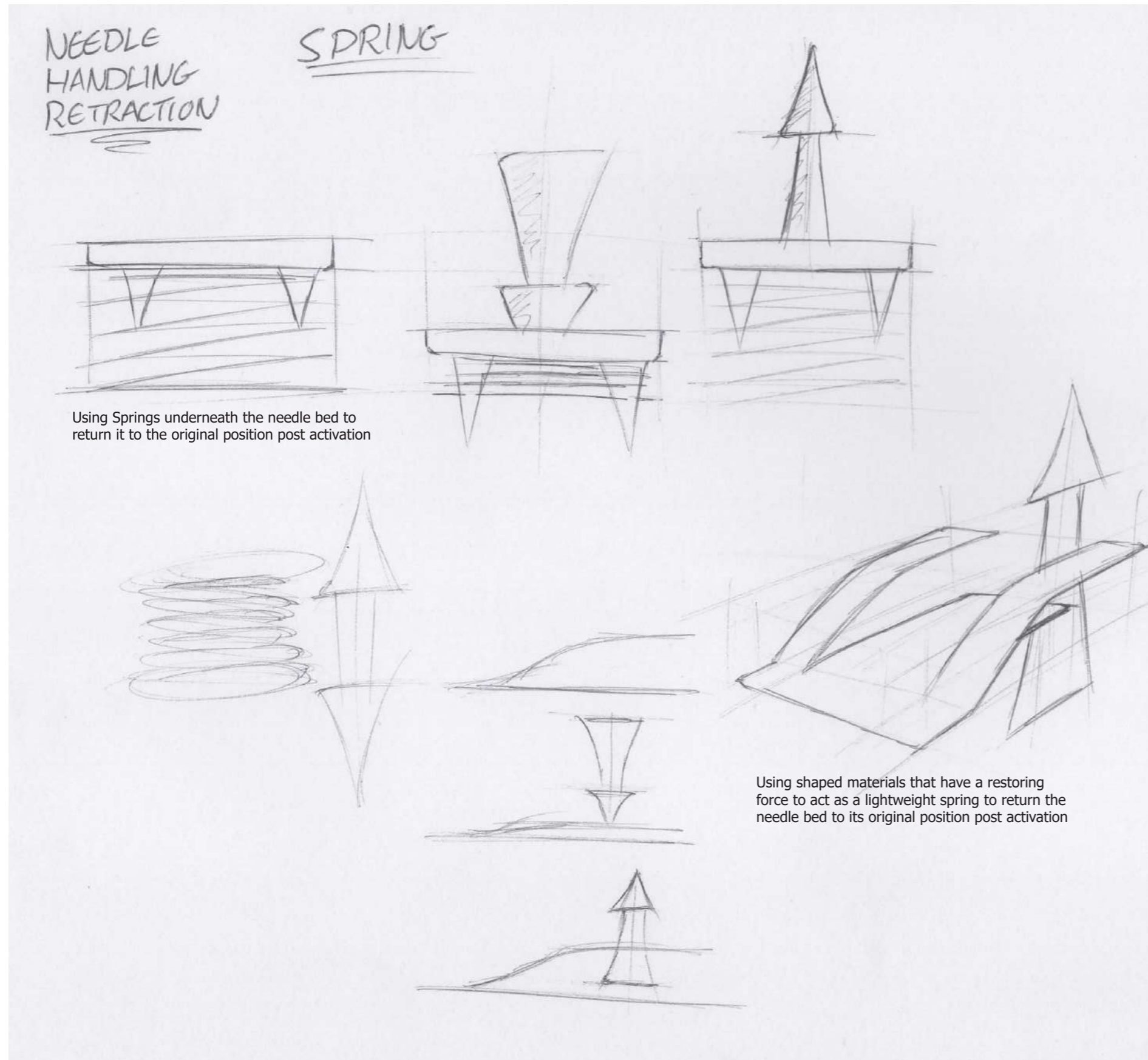
Exploring the potential for a spring mechanisms that would retract the needle using the restoring force of the spring.

### Benefits

Simple and reliable mechanism  
Easy to manage on a small scale

### Drawbacks

Spring retention fades after multiple uses



## Exploring methods of needle retraction

Further exploring the potential for a spring mechanisms that would retract the needle using the restoring force of the spring.

### Benefits

- Can be a single material
- Can be made with simple geometry

### Drawbacks

- Traditional materials may be heavy

# Mechanism Development



Creating illustrator drawings to work out the mechanics in a 2d framework.



## Exploring methods of needle retraction

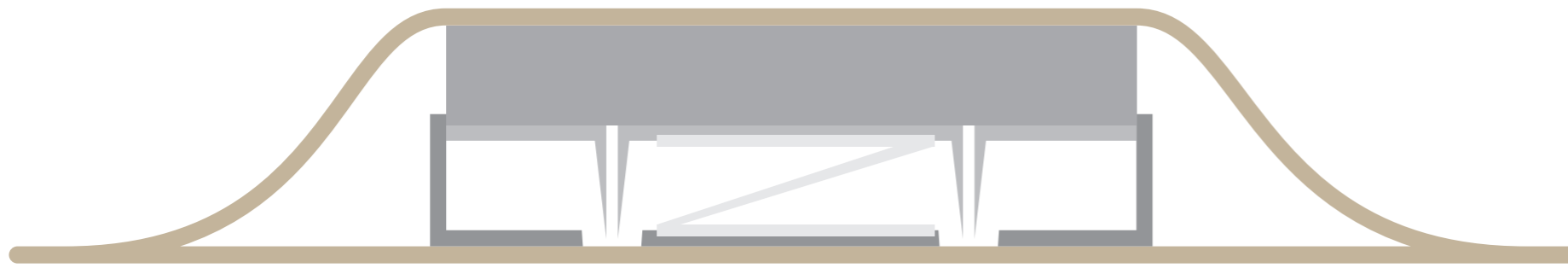
The downward pressure overcomes the spring force and protrudes the needle bed into the athletes dermis layer of skin. This puncture site draws blood and through capillary action, draws the blood sample into the chemical pack located above the needle bed.

A - 3, A - 4, A - 5



## Exploring methods of needle retraction

This can be packaged in a relatively small footprint and so has the potential to be implemented into a plaster form

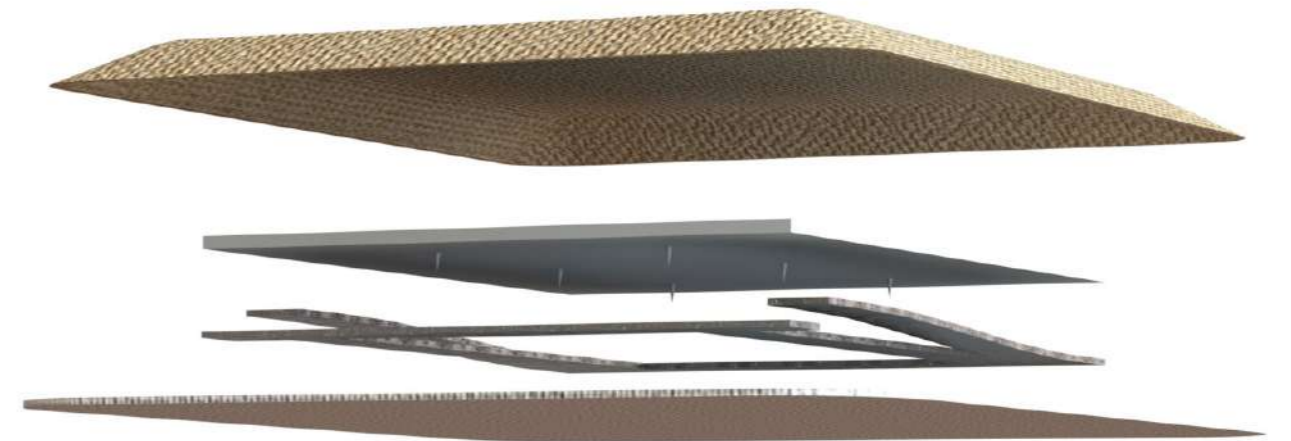


Looking at the packability of the system within a currently accepted form factor

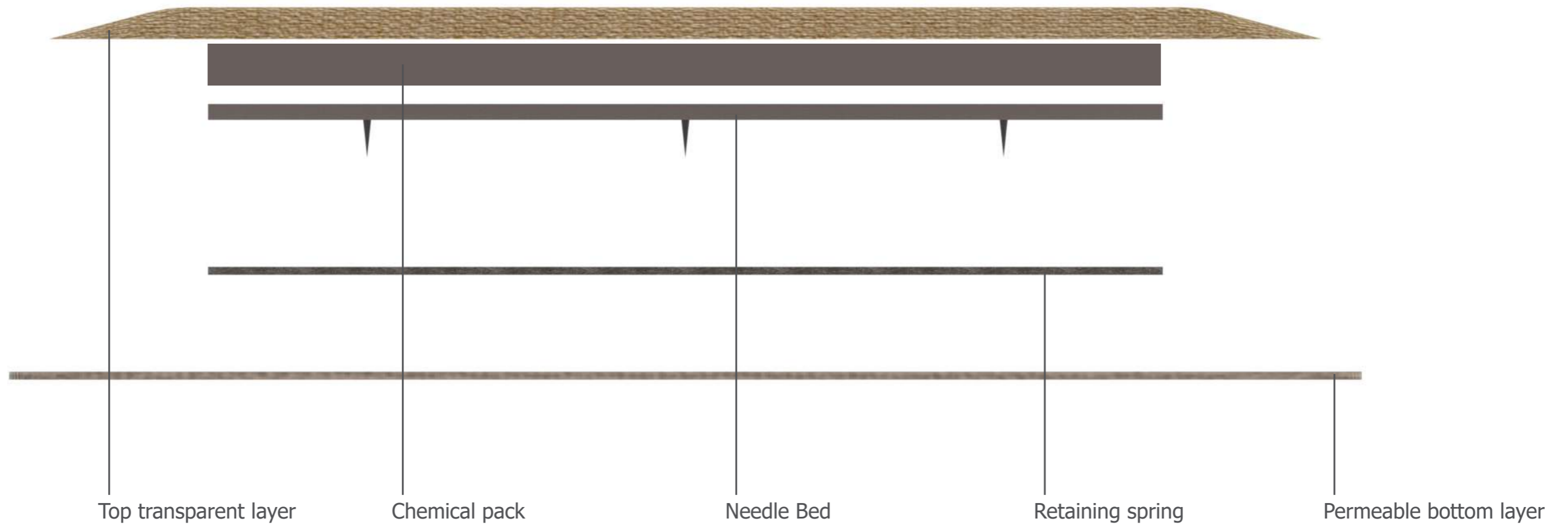


The needle bed would perforate the bottom layer of material and into the skin allowing for the blood sample to be taken

# Early Renders



# Early Renders



# Prototype 1



# Testing Methods

## How

The prototype was tested by 3 users, as there were restrictions brought on by the Covid 19 pandemic.

The process of unwrapping the plaster prototype, applying it to the skin activating it was tested.

### Tasks

- Remove plaster from the wrapping
- Apply the plaster to an area of exposed skin
- Slap the plaster in position

## What

The users were then asked a number of set questions in order to evaluate the usability of the concept and ways to improve the concept.

These questions were as followed

1. Would you feel comfortable using this device
2. How did you find the securement method
3. How did you find the dimensions of the device
4. Did you find the device comfortable
5. Did you find the device intuitive to use
6. Is there anything you would change on it?

## Why

- Would you feel comfortable using this device  
To determine acceptability of the device by the user group
- How did you find the securement method  
To determine the usability of the device and its fitment
- How did you find the dimensions of the device  
To determine the scale and shape of the device that is most favoured
- Did you find the device comfortable  
To determine the users comfort levels in both using and wearing the device
- Did you find the device intuitive to use  
To determine the devices inherent understandability

# Prototype Testing

Male  
23

Ultra-marathon Runner

"It won't stick to my arm"

"I might mistake it for a normal plaster at some stage"

Female  
20

Mountain Biker

"I'm allergic to the latex in it"

"It's too large for my arm"

"Does it have to be a plaster?"

Male  
29

Endurocross Rider

"I don't wear this the whole time do I?"

"What's stopping it going off in the first aid kit?"

[Design History File - 2. Verification - Testing Results - Prototype Test 1](#)

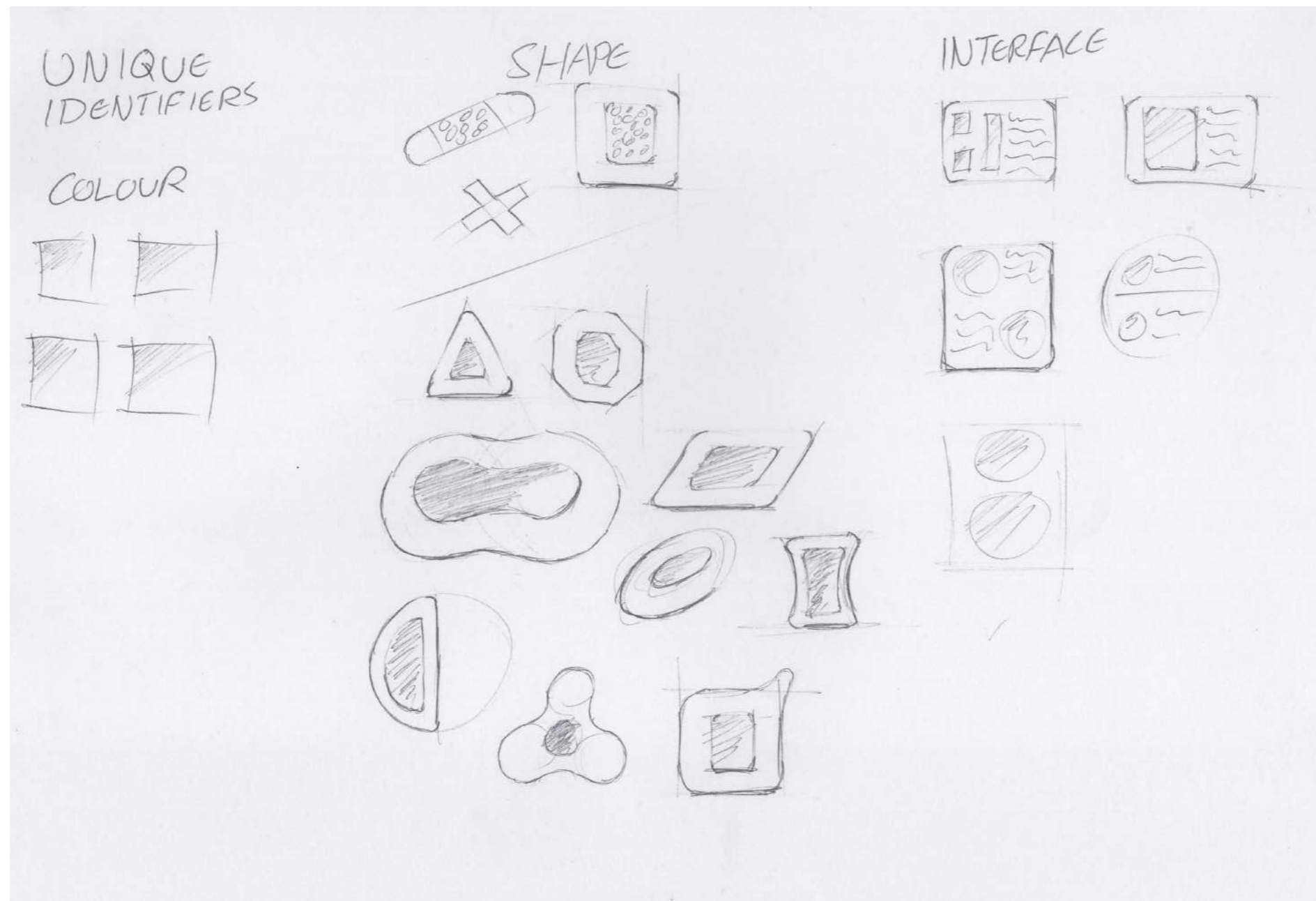
## Key changes to be made

Unique Identifier

Securement method

Accidental Discharge

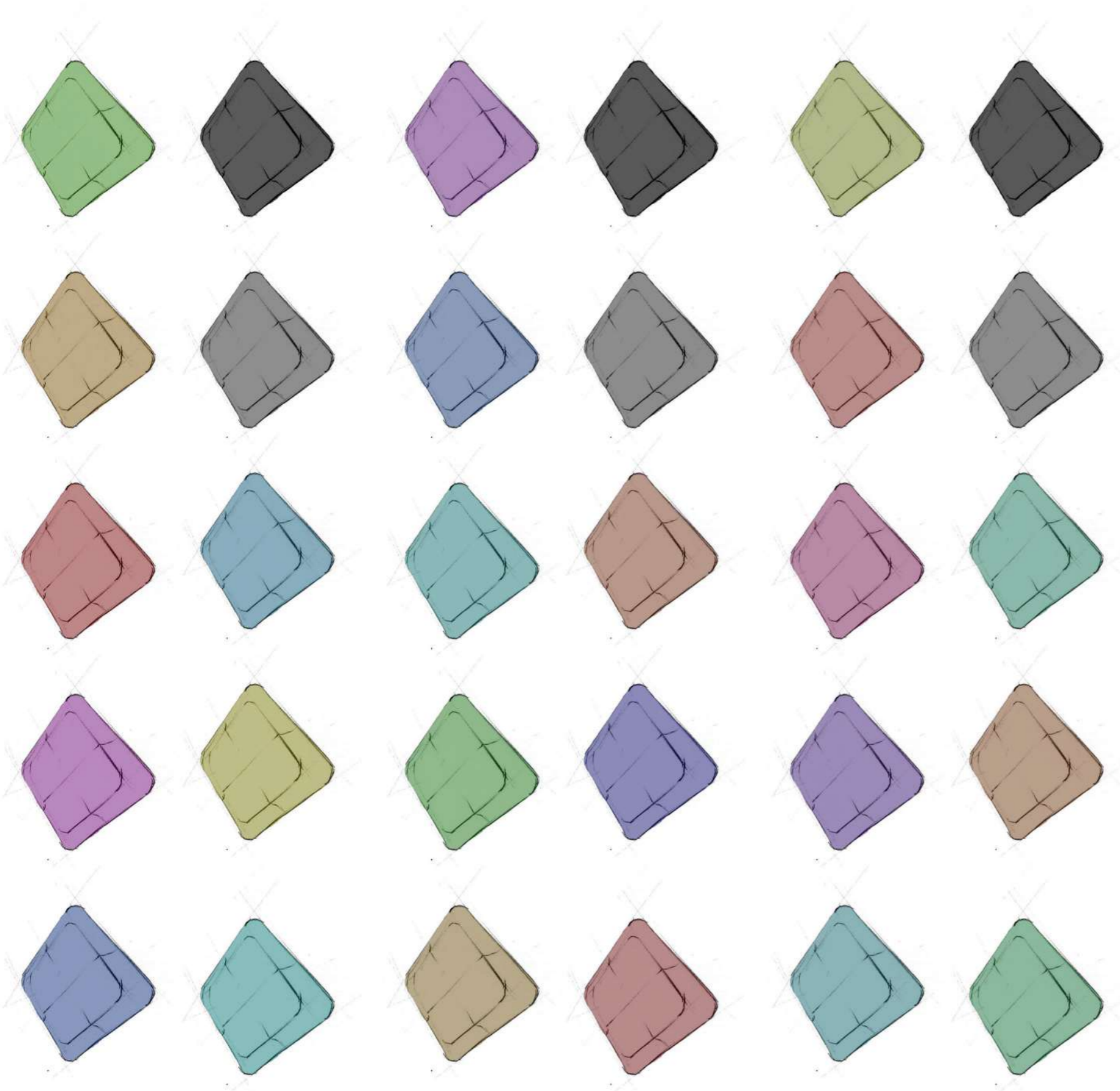
# Unique Identifiers



## Exploring unique identifiers for the plaster

Due to the prototype being based off a conventional plaster, participants noted that users may miss identify the plaster as a normal plaster or apply a normal plaster while meaning to apply a concussion test, because of this, unique identifiers were explored to separate the device from conventional plasters.

# Unique Identifiers



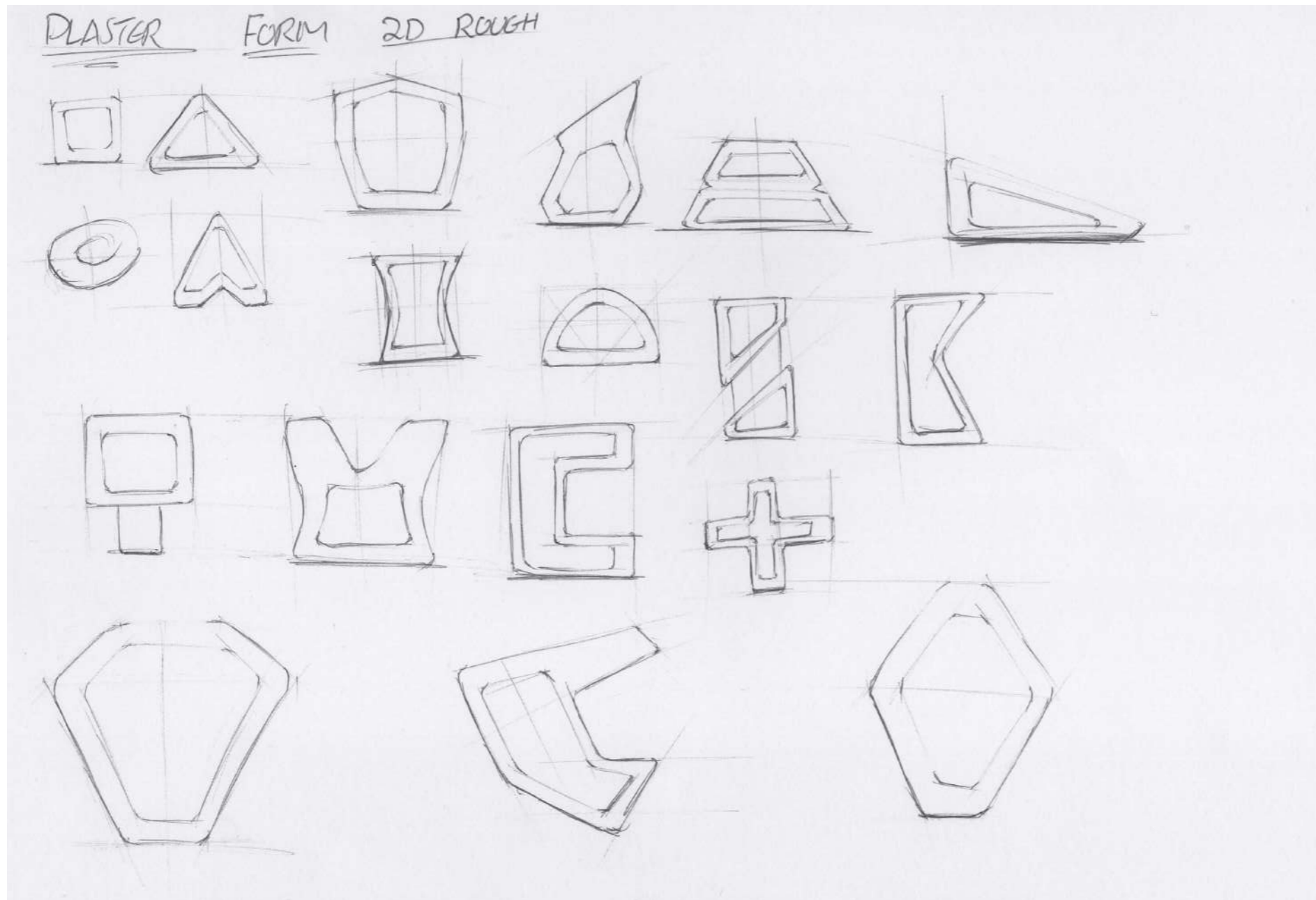
Exploring unique identifiers  
for the plaster

Colour was one of the  
first aspects explored to  
differentiate the device  
from a standard plaster.

A colour way could also be  
used to tie the device to  
the corresponding app



# Unique Identifiers

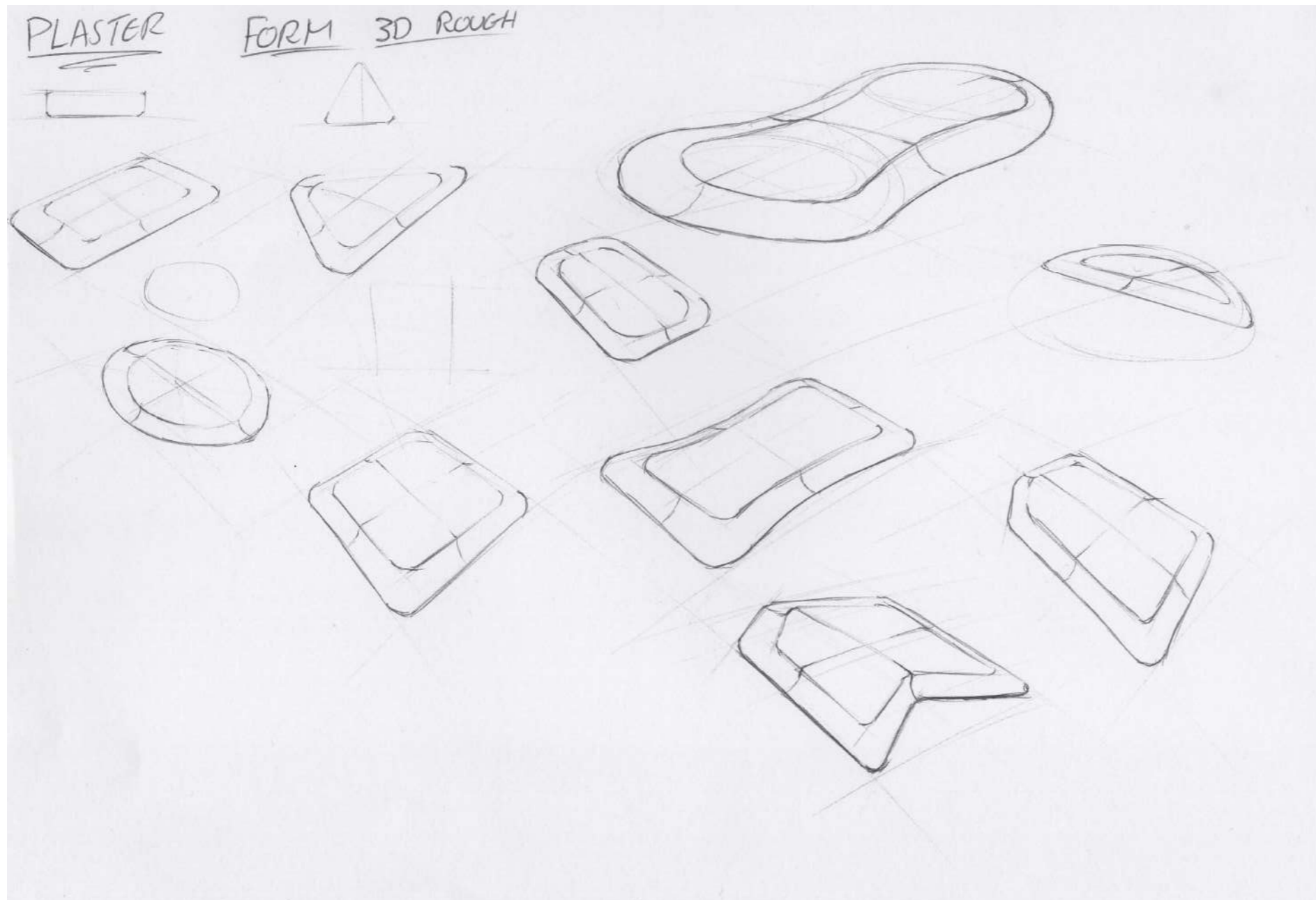


Exploring unique identifiers  
for the plaster

Form was one of the  
first aspects of creating  
a unique device that  
separated itself from a  
conventional plaster.

2D forms were explored  
prior to exploring 3D forms

# Unique Identifiers

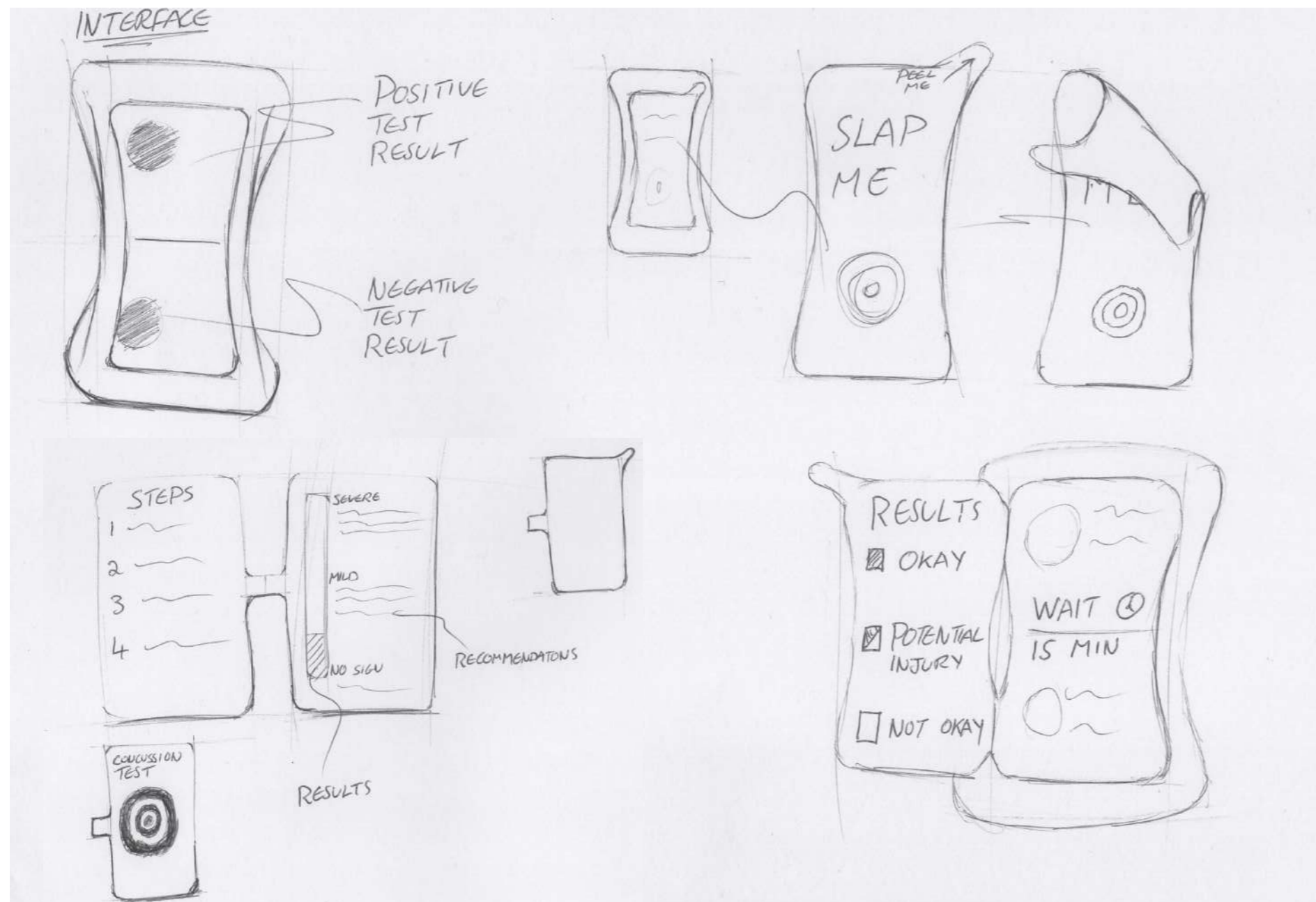


Exploring unique identifiers  
for the plaster

A number of 3D forms  
were then explored to get  
a better sense of form for  
the device and to explore  
ideas not feasible in 2D



# Features



Exploring unique identifiers for the plaster

The Interface on the app was another area explored on the device to give it a unique look.

The primary interface on the device would be the IFU and print on the device itself.

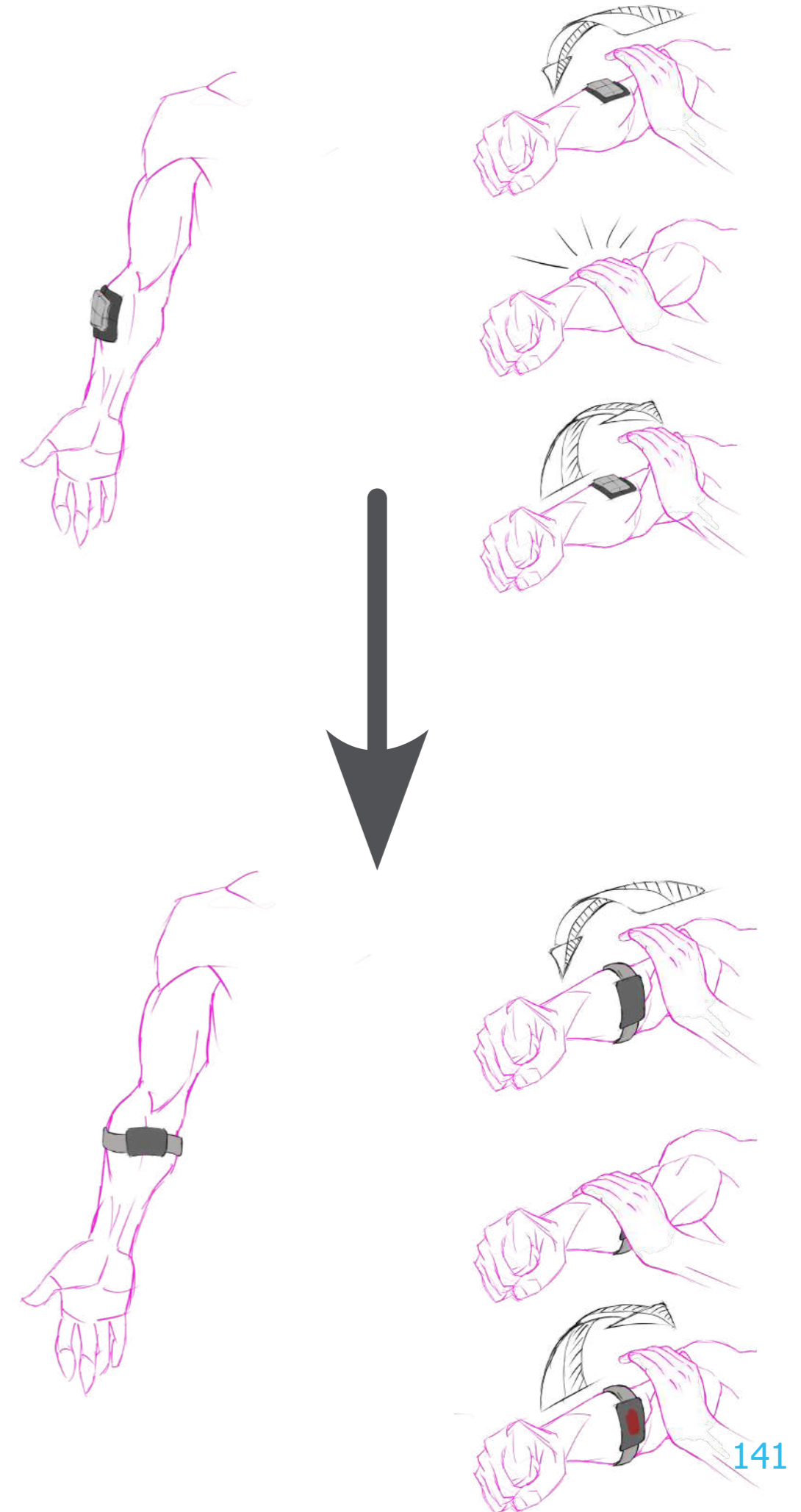
## Further Outcomes

One of the major decision paths made was the change from an adhesive based securement system to a elastomer strap based system

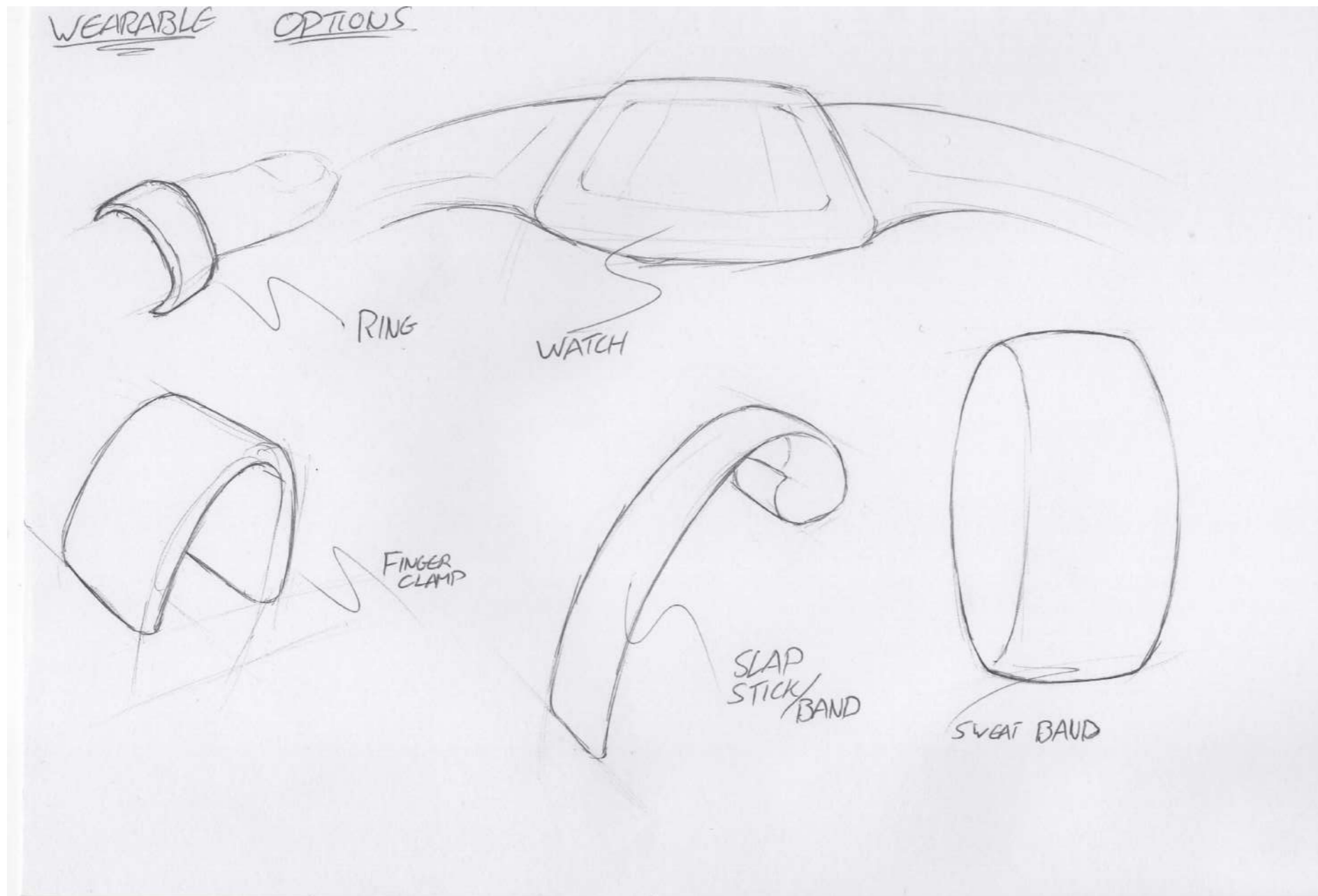
### Why?

This was due to high rates of latex and adhesive allergies which may not be initially detected and may also limit the number potential users

This also has the potential to reduce the packaging needed for the device and allows for the option to explore multi-use devices



## Further Outcomes



Ring	Watch	Finger Clamp
2	16	0

Band	Cap	Sweat Band
2	0	7

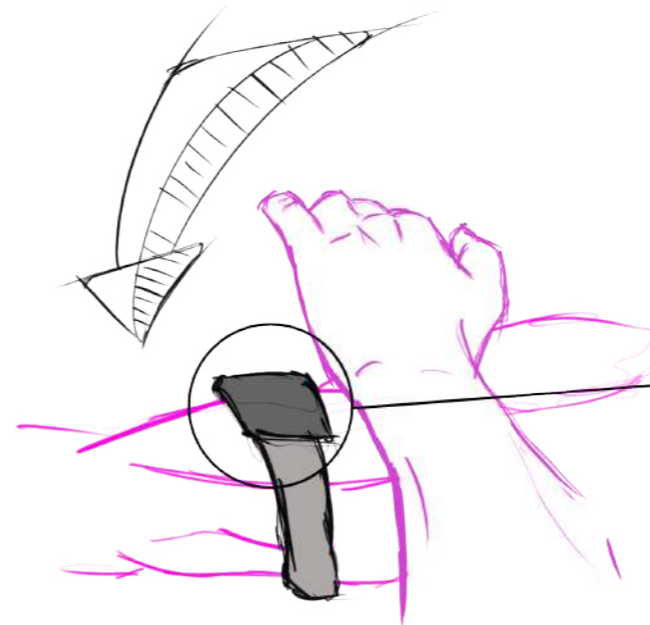
Exploring new forms for the device

Multiple types and configurations of wearable were considered but a hybrid of a sweatband and a watch type device came to the forefront when consulting action sports athlete who felt they could continually wear it during exercise or fit it into or around their first aid kits easily

## How To Draw Blood

### Step 1

Slap the device that is on your bicep



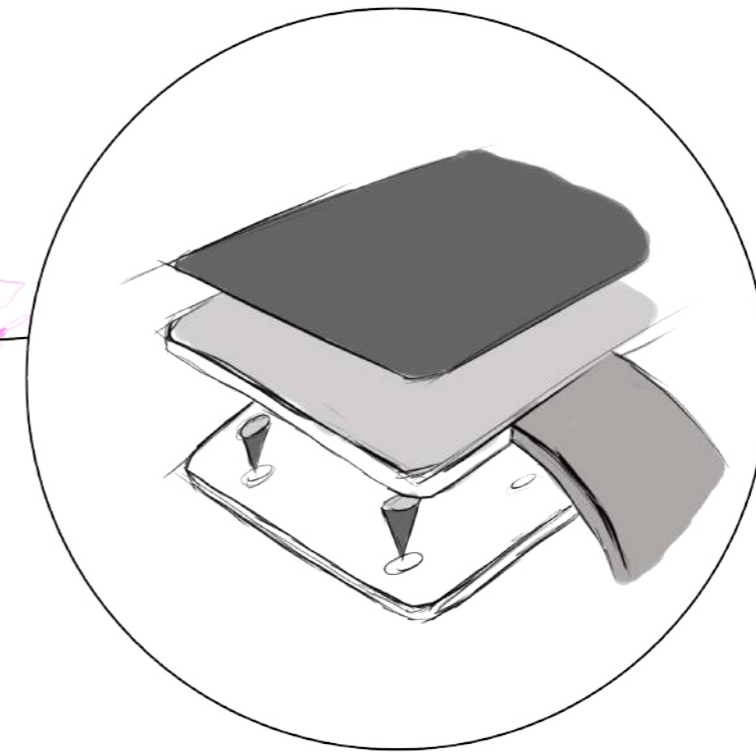
### Step 2

Press down firm

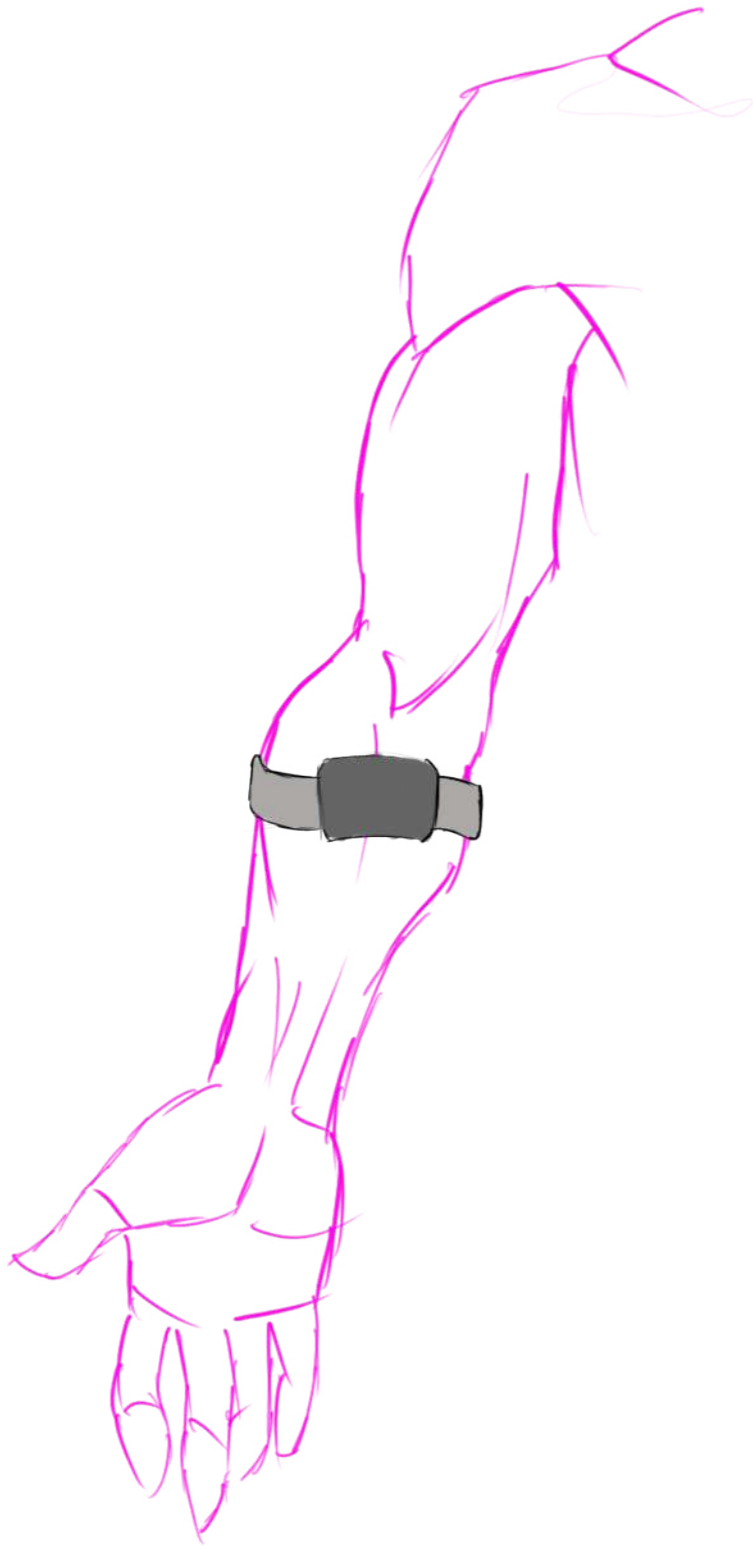


### Step 3

Pull hand away



# Further Outcomes



## Step 1

Slap the device  
that is on your  
bicep



## Step 2

Press down firm



## Step 3

Pull hand away





## Prototype 2



Concept 1

Exploring the new form factor

A monster model prototype was created to explore the usability of the device in the new configuration.

This drew a more positive response for the participants who felt it could be implemented in remote areas without the reliance on adhesives which may not function in poorer weather climates

# Testing Methods

## How

The prototype was tested by 3 users, as there due to the restrictions brought on by the Covid 19 pandemic.

The process of putting on the strap, inserting the capsule and activating it was tested.

### Tasks

- Put on the strap in a comfortable position to slap with your opposite arm
- Put in the capsule
- Slap the capsule whilst in position

## What

The users were then asked a number of set questions in order to evaluate the usability of the concept and ways to improve the concept.

These questions were as followed

1. Would you feel comfortable using this device
2. How did you find the securement method
3. How did you find the dimensions of the device
4. Did you find the device comfortable
5. Did you find the device intuitive to use
6. Is there anything you would change on it?

## Why

- Would you feel comfortable using this device  
To determine acceptability of the device by the user group
- How did you find the securement method  
To determine the usability of the device and its fitment
- How did you find the dimensions of the device  
To determine the scale and shape of the device that is most favoured
- Did you find the device comfortable  
To determine the users comfort levels in both using and wearing the device
- Did you find the device intuitive to use  
To determine the devices inherent understandability

# Prototype Testing

Male  
23

Ultra-marathon Runner

"The edges dig in when you slap it"

"It's a bit big, wouldn't fit in my kit"

Female  
20

Mountain Biker

"The strap is way to big for my arm"

"I think it's a bit big but hard to miss"

Male  
29

Endurocross Rider

"Would it puncture through my jersey?"

"Any way to tighten the strap?"

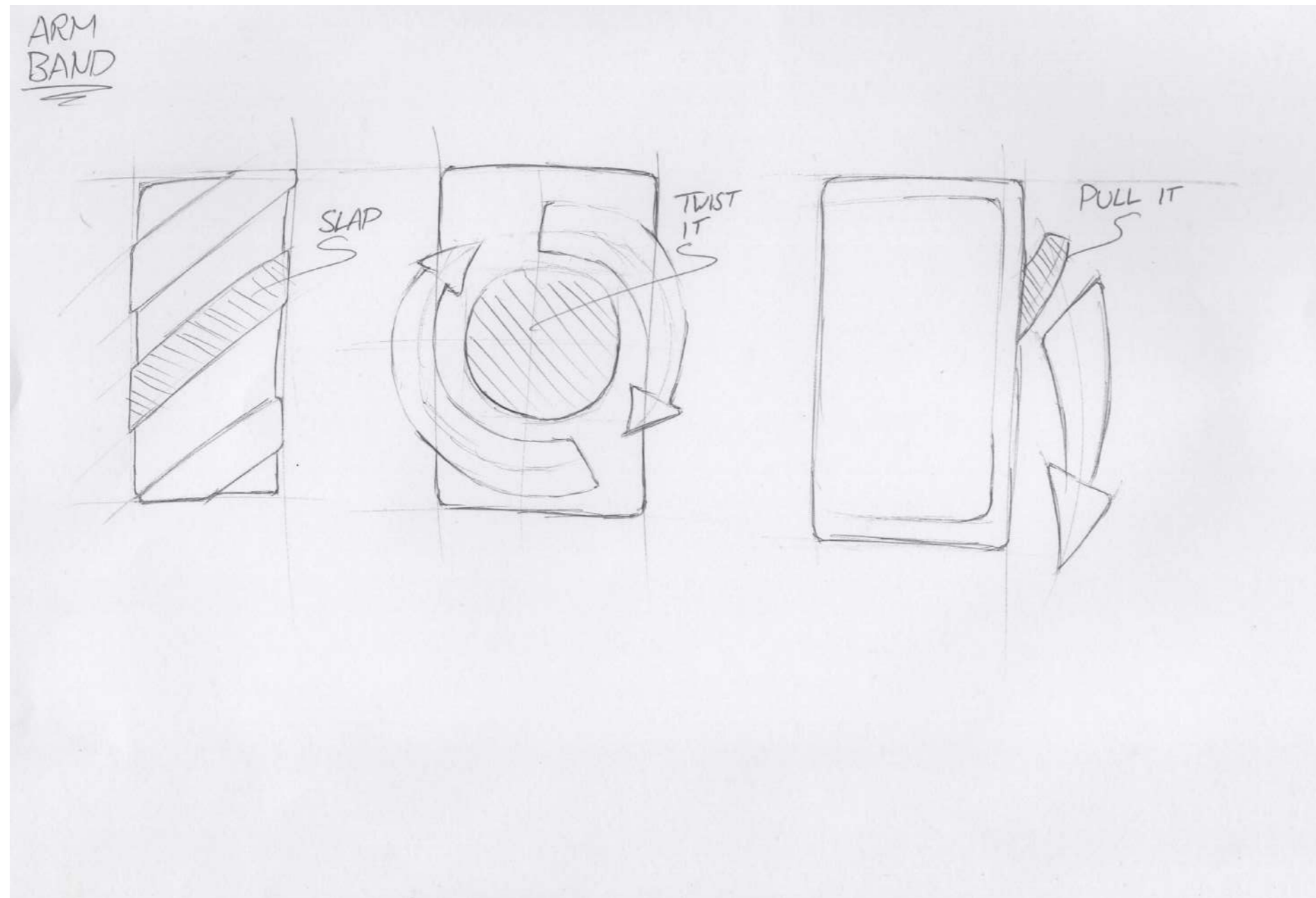
[Design History File - 2. Verification - Testing Results - Prototype Test 2](#)

## Key changes to be made

Size of the device

The shape where it meets the skin

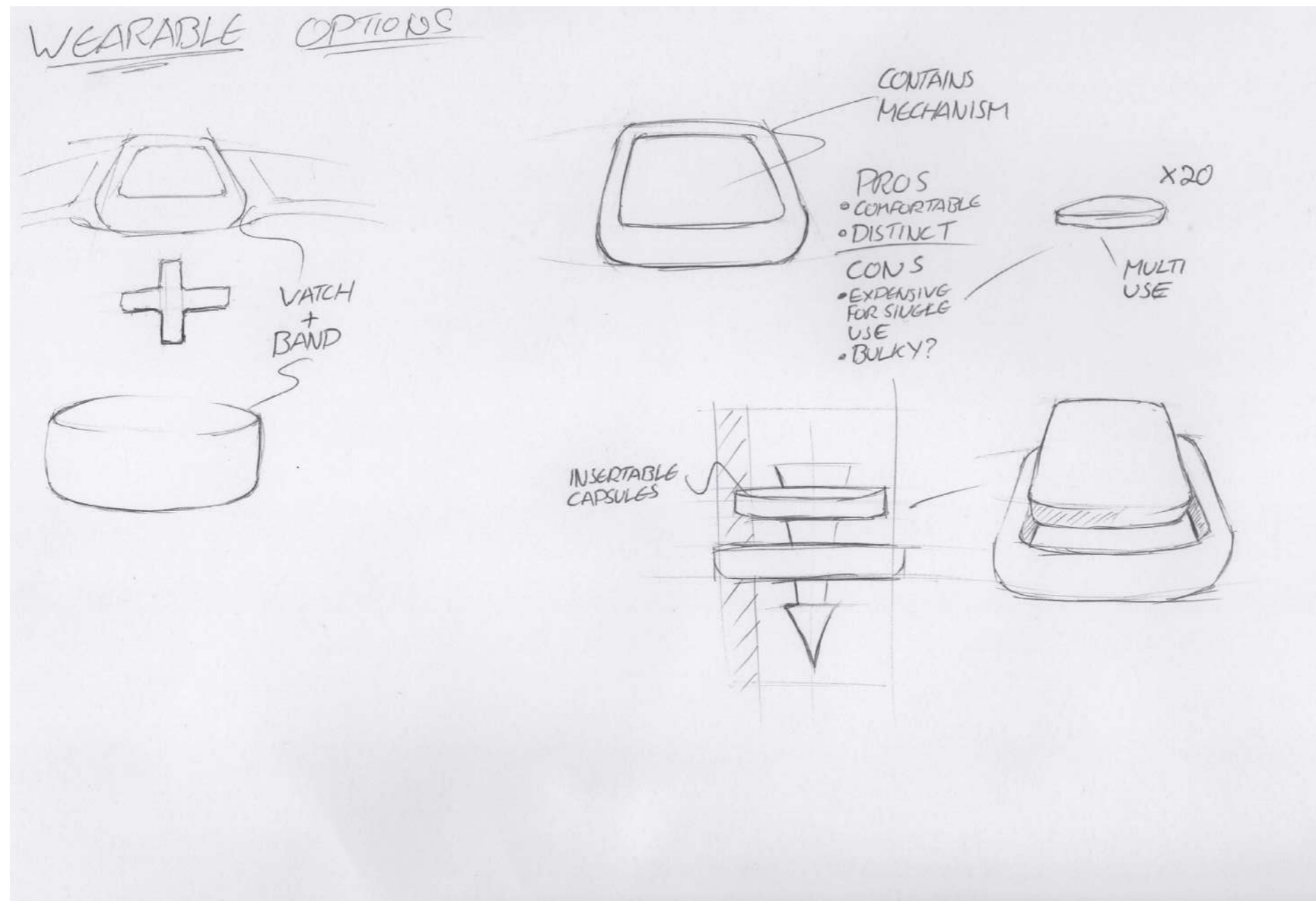
The securement and strap



Exploring new form factor  
for the device

With the new form, new  
methods of activation and  
sampling were explored to  
find what may work best  
with the form and potential  
positioning of the device

# Mechanism



Exploring the possibility of multi-use capabilities

With the new form also brought the possibility of multi-use capabilities by inserting capsules into the device which contain the blood test

This brought a new challenge of how to retain the capsule/cartridge within the device

## Mechanical

Friction  
Pressure Fit  
Tolerance  
Button  
Twist lock  
Buckle  
Spring  
Compression  
Snap Fit  
Joints  
Stretch  
Tabs  
Groves  
Shape  
Sliding pin  
Ratchet

## Magnetic

Fid Lock  
Twist to Release  
Electro Magnet  
Magnetic Lock  
Snap magnet  
Magnetic mesh  
Magnet to magnet

## Misc

Lace  
Velcro  
Rubber bands  
Elastic  
Slotted and fix  
Screwed  
Glue  
Ties  
Cable ties

# Mechanism

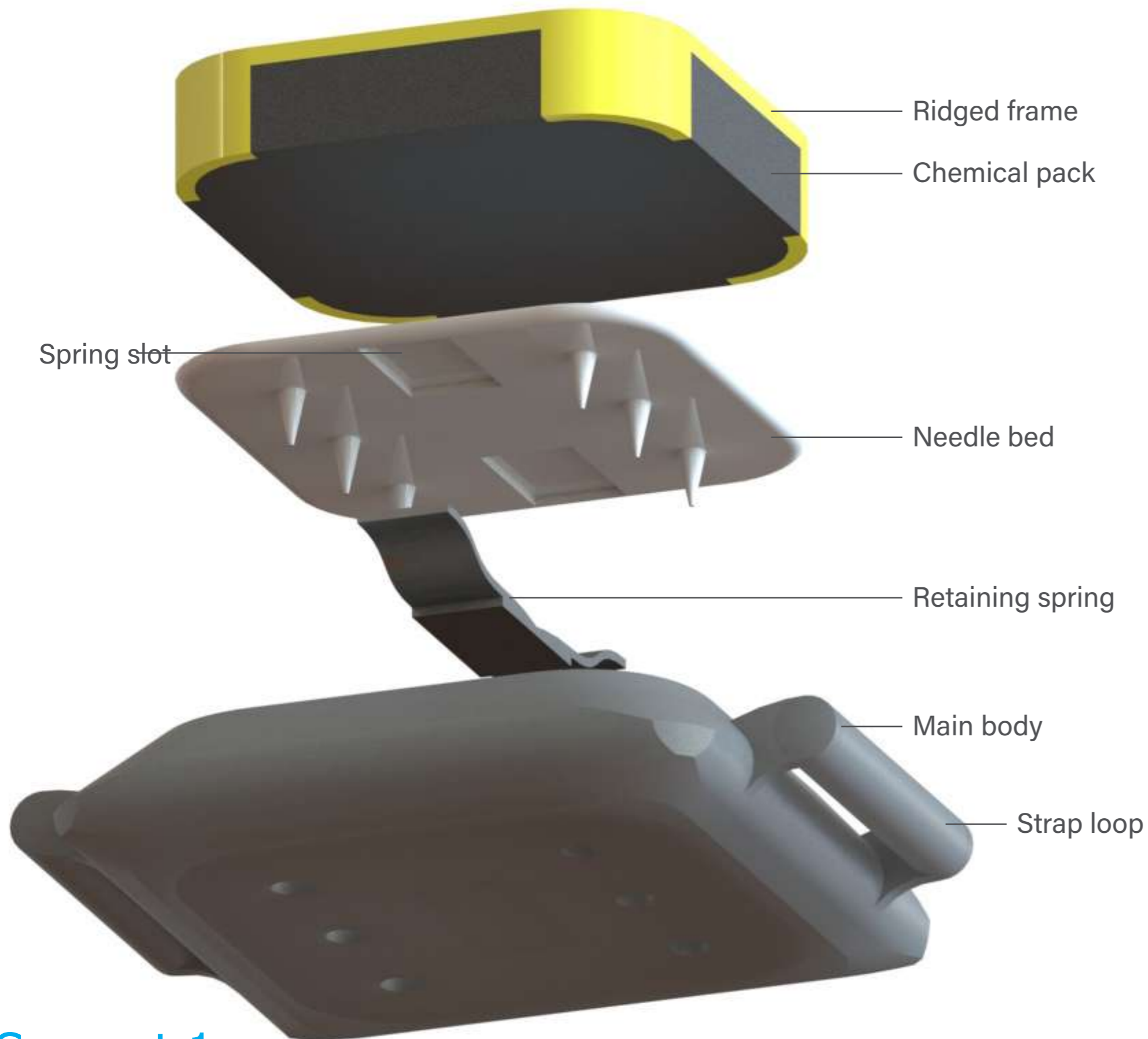


Exploring adapting the original concept

Exploring the possibility of using the existing concept of downward pressure to draw a sample



# Mechanism



Exploring adapting the original concept

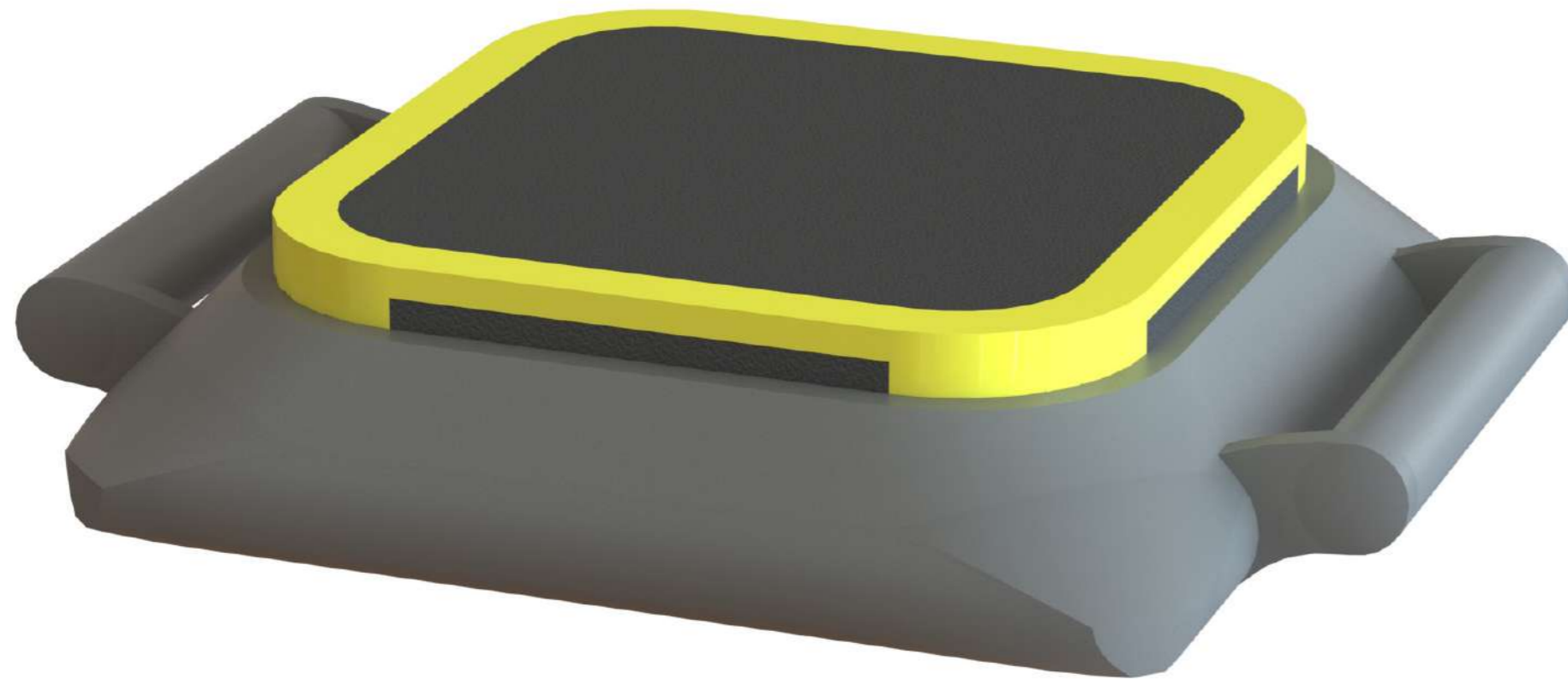
A prototype was then created to assess the scale and functionality of the device and to explore if the concept would still work at a smaller scale

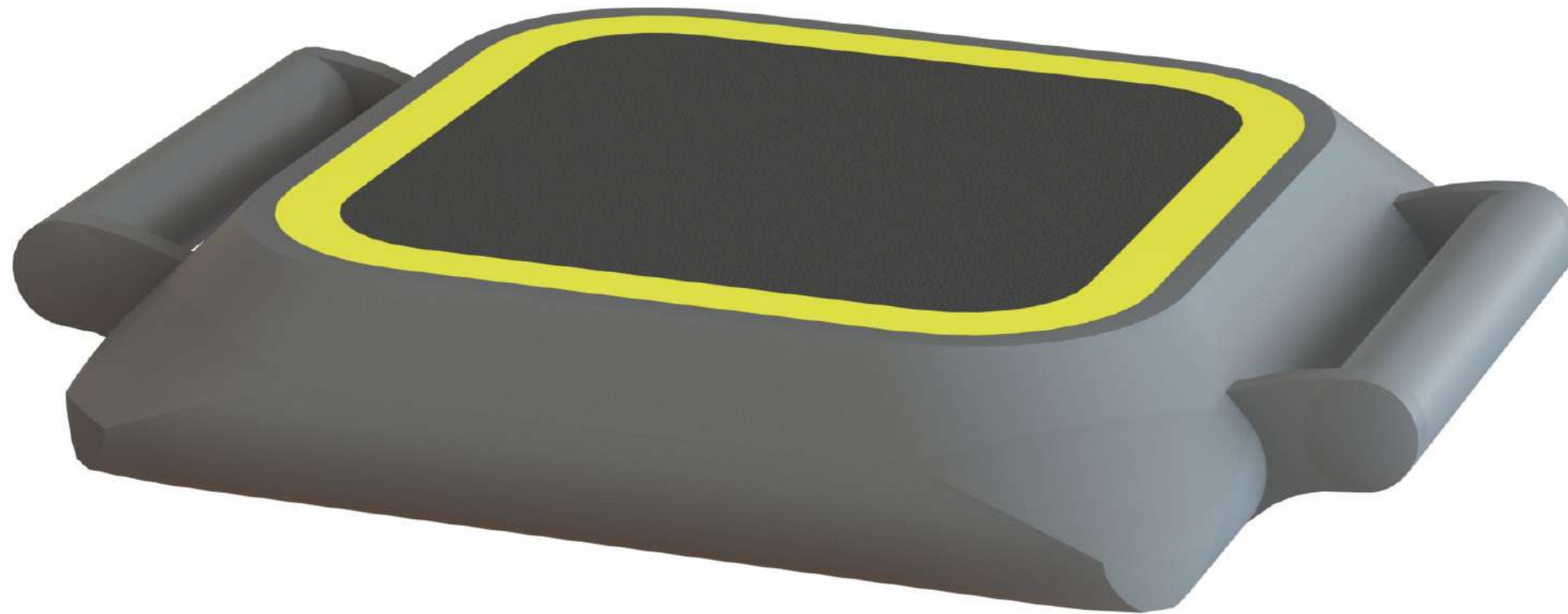


## Mechanism

Exploring adapting the original concept

This also addressed a number of issues participants had with the first prototype such as sharp edges and ill fitting straps.





Exploring adapting the original concept

Minimum device height was also explored in this model, optimizing different aspects of the device such as the wall thickness, the needle bed thickness and the distance the bed has to move in order to get the minimum insertion depth

## Prototype 3



Exploring adapting the original concept

A 3d printed model was then created in order to get real world testing done for the device.

An elastic strap was fitted to the device and it was packaged neatly within a first aid kit

This was conducted on remote trails during active training to best simulate real world use

A - 8, A - 9

# Testing Methods

## How

The prototype was tested by 3 users, as there due to the restrictions brought on by the Covid 19 pandemic.

The process of putting on the strap, inserting the capsule and activating it was tested.

### Tasks

- Put on the strap in a comfortable position to slap with your opposite arm
- Put in the capsule
- Slap the capsule whilst in position

## What

The users were then asked a number of set questions in order to evaluate the usability of the concept and ways to improve the concept.

These questions were as followed

1. Would you feel comfortable using this device
2. How did you find the securement method
3. How did you find the dimensions of the device
4. Did you find the device comfortable
5. Did you find the device intuitive to use
6. Is there anything you would change on it?

## Why

- Would you feel comfortable using this device  
To determine acceptability of the device by the user group
- How did you find the securement method  
To determine the usability of the device and its fitment
- How did you find the dimensions of the device  
To determine the scale and shape of the device that is most favoured
- Did you find the device comfortable  
To determine the users comfort levels in both using and wearing the device
- Did you find the device intuitive to use  
To determine the devices inherent understandability

# Prototype Testing

Male  
23

Ultra-marathon Runner

"It keeps falling out when I move twist my arm"

"How am I going to clean this?"

Female  
20

Mountain Biker

"Its really hard to get the cartridge thingy out"

"Which way do I put the cartridge in?"

Male  
29

Endurocross Rider

"I like the elastic strap"

"Wouldn't you stab yourself putting the thing in it?"

[Design History File - 2. Verification - Testing Results - Prototype Test 3](#)

## Key changes to be made

Cleaning/Hygiene

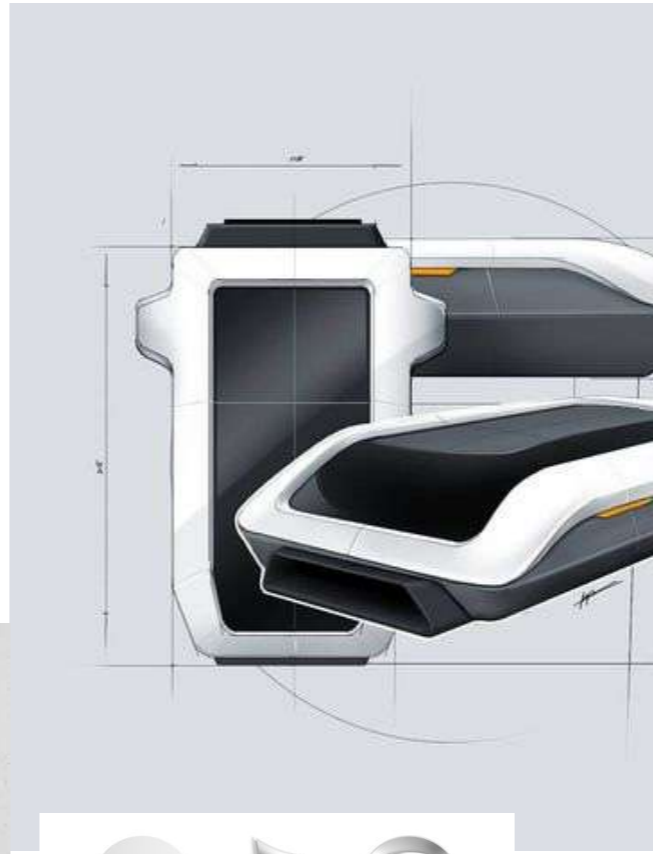
Cartridge installment and orientation

How to "reload" the device

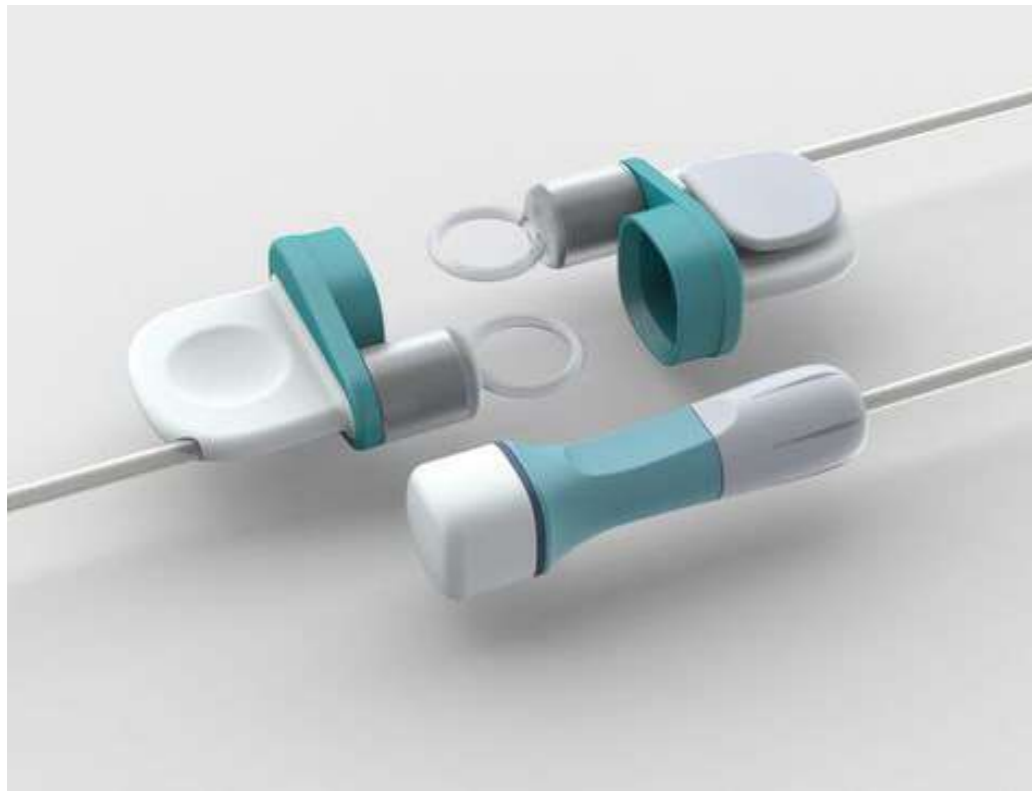
# Style Board



# Details Board

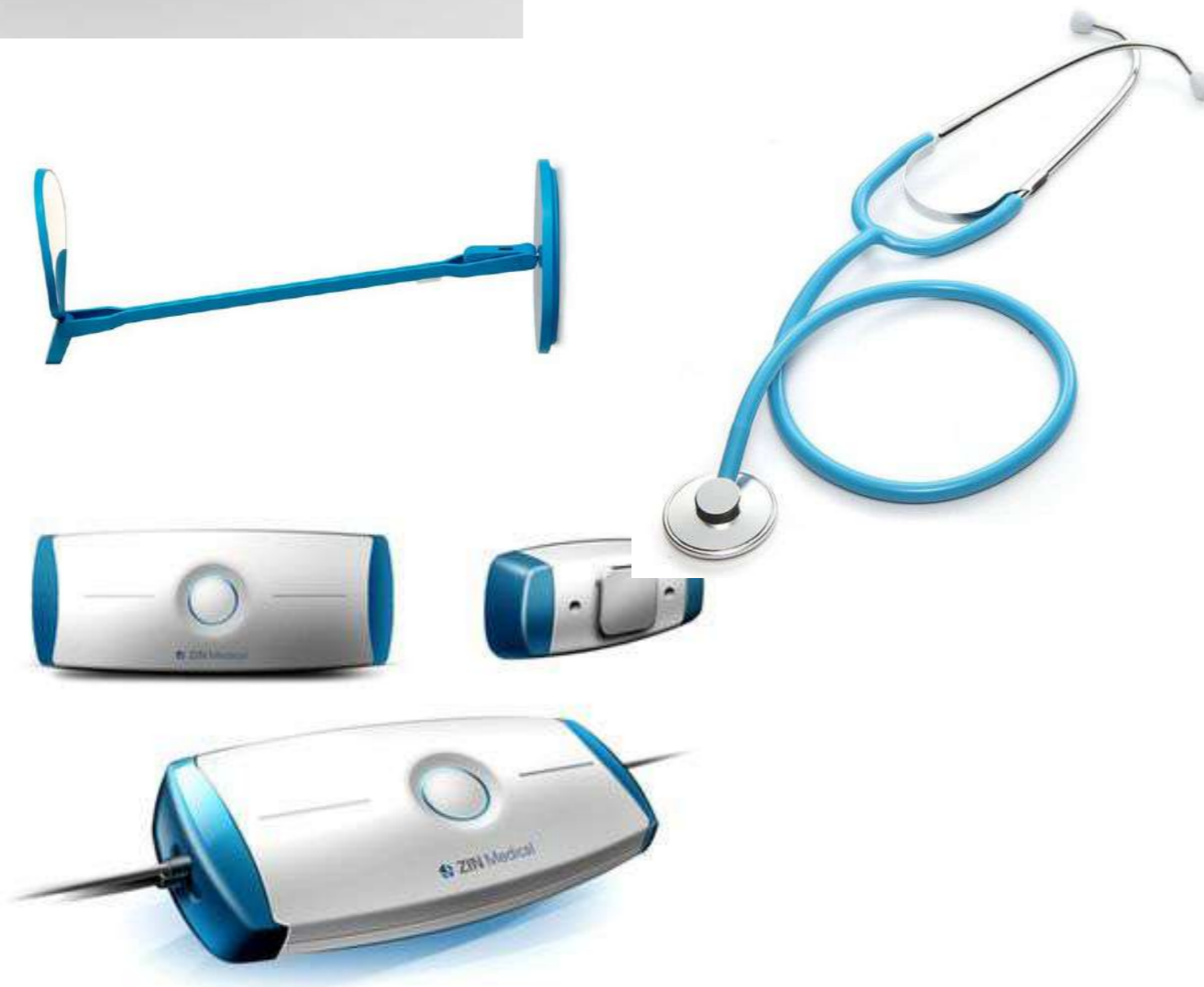


# Colour Board



## Why

Blue is often used to represent calmness and responsibility and the light blues are typically refreshing and friendly, aspects that I believe are important to the acceptability of the device and uptake of its use



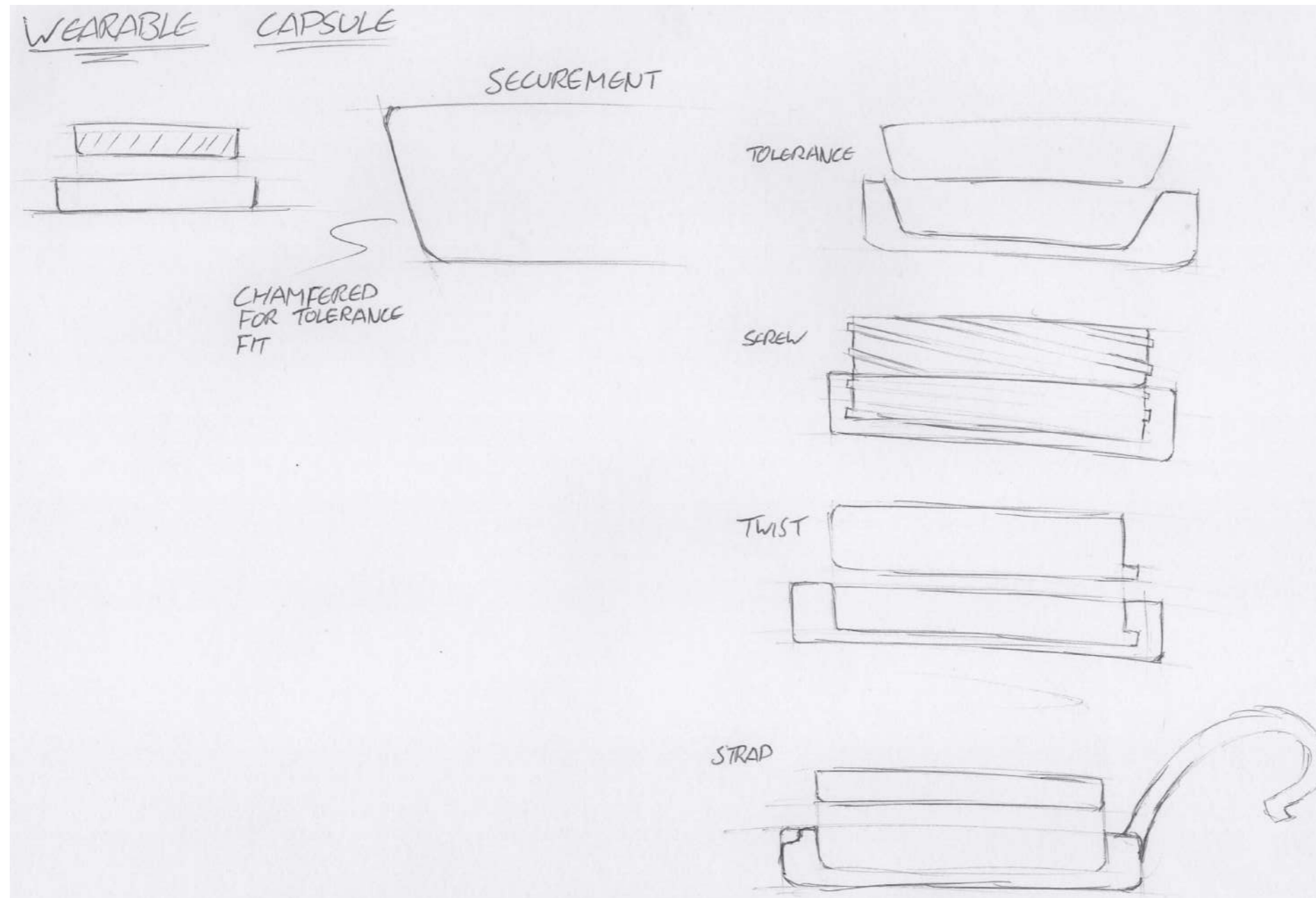
CMYK  
56 - 1 - 3 - 0

RGB  
92 - 199 - 235

Hex  
#5cc7eb

Pantone  
Pantone 2985 C

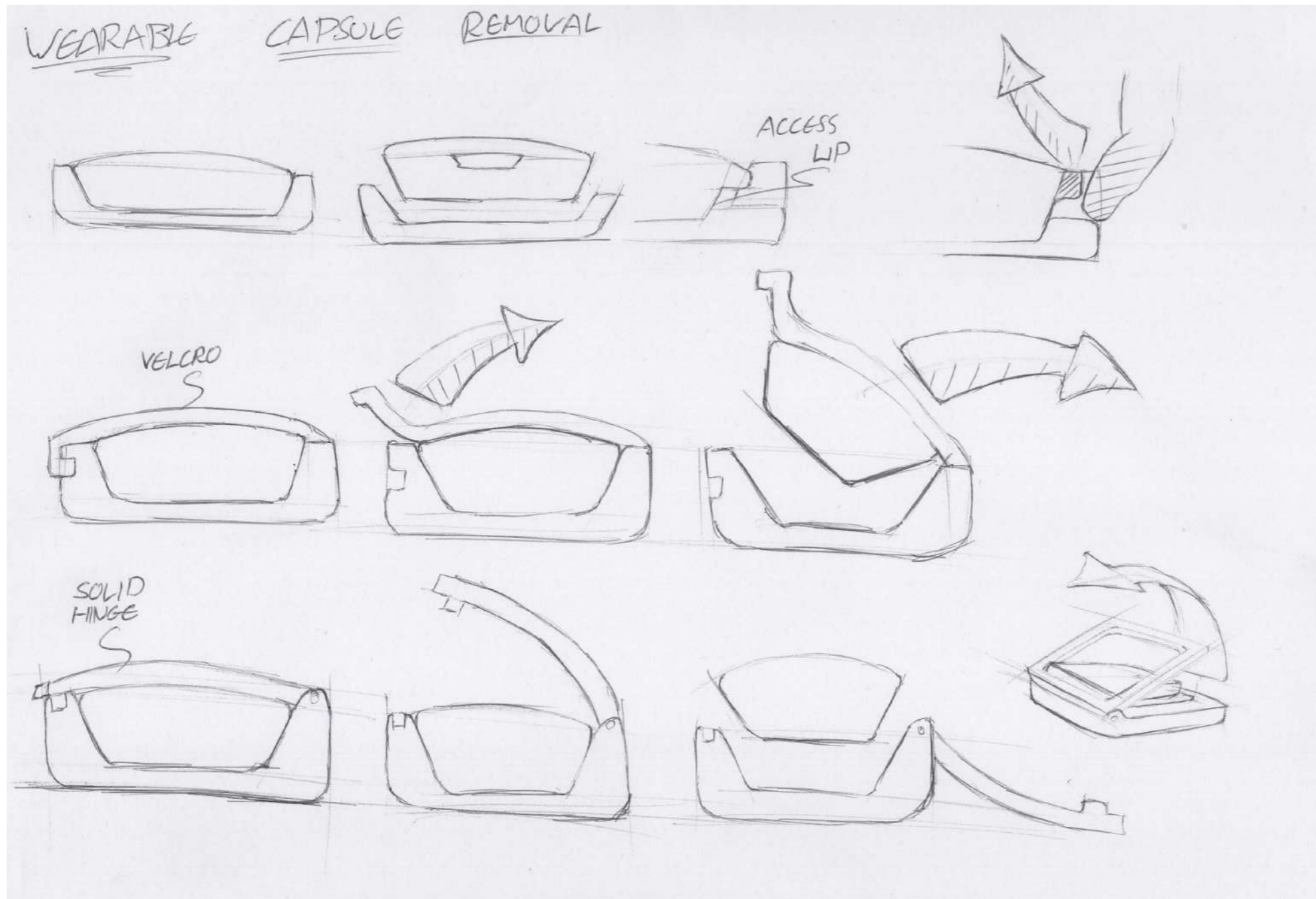




## Exploring cartridge retainment

Methods of cartridge retainment were explored in order to prevent the cartridge from expelling from the device prematurely, which may contaminate it in poor conditions and remote areas.

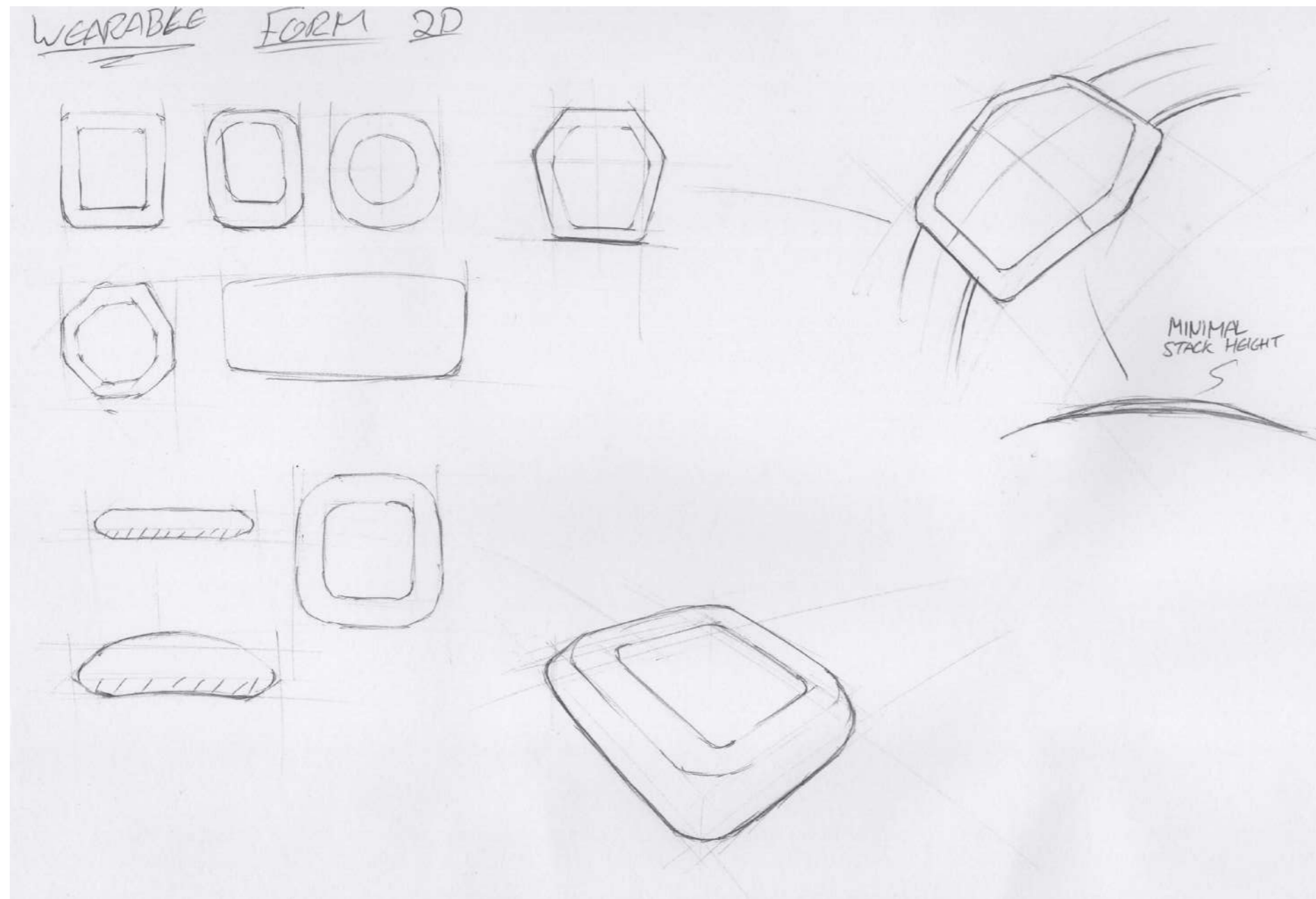
# Mechanism



## Exploring cartridge retainment

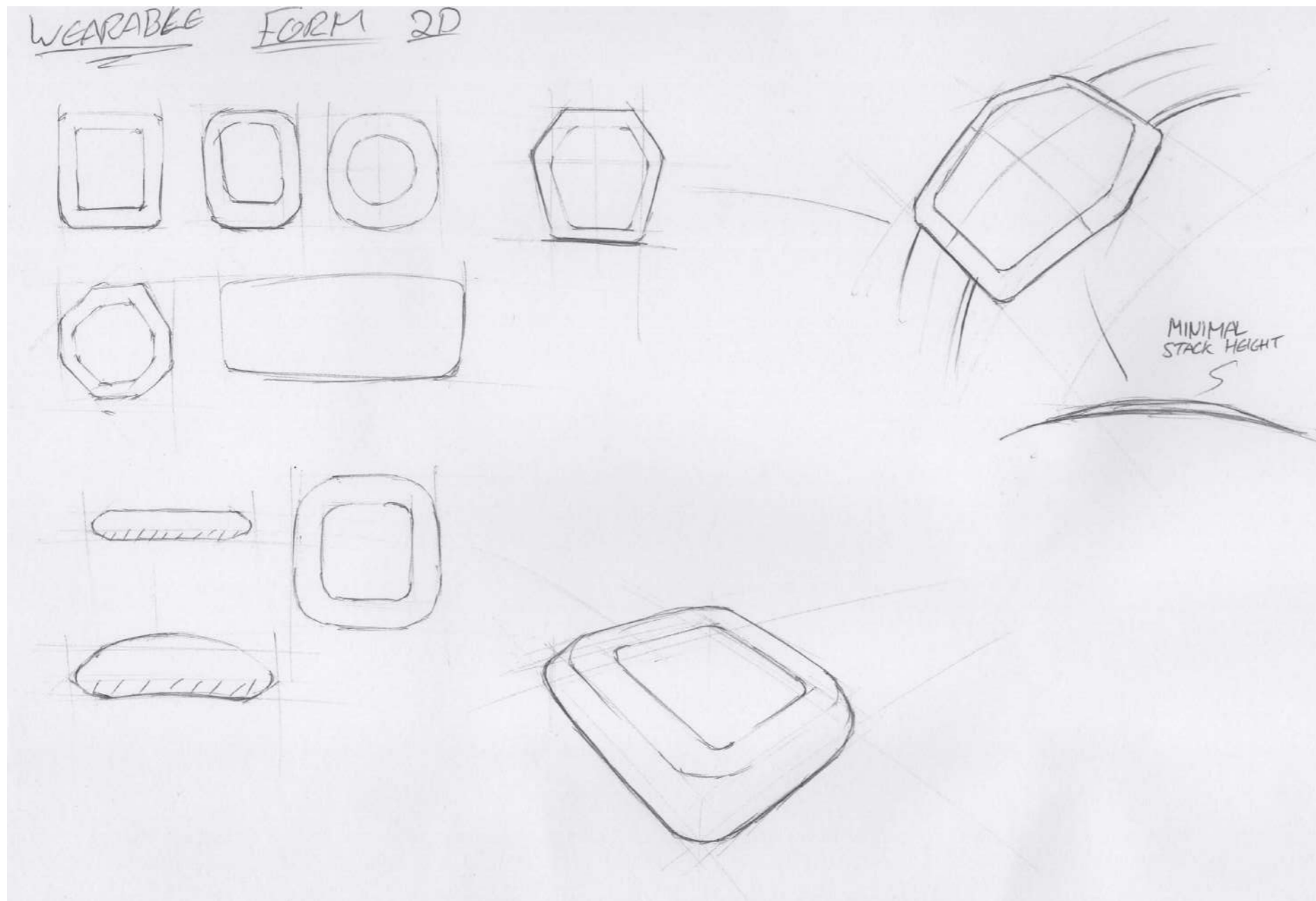
A number of methods were explored but a simple tolerance fit created the most reliable containment with the least added complexity and manufacturing cost for a single use aspect of the device

# Mechanism



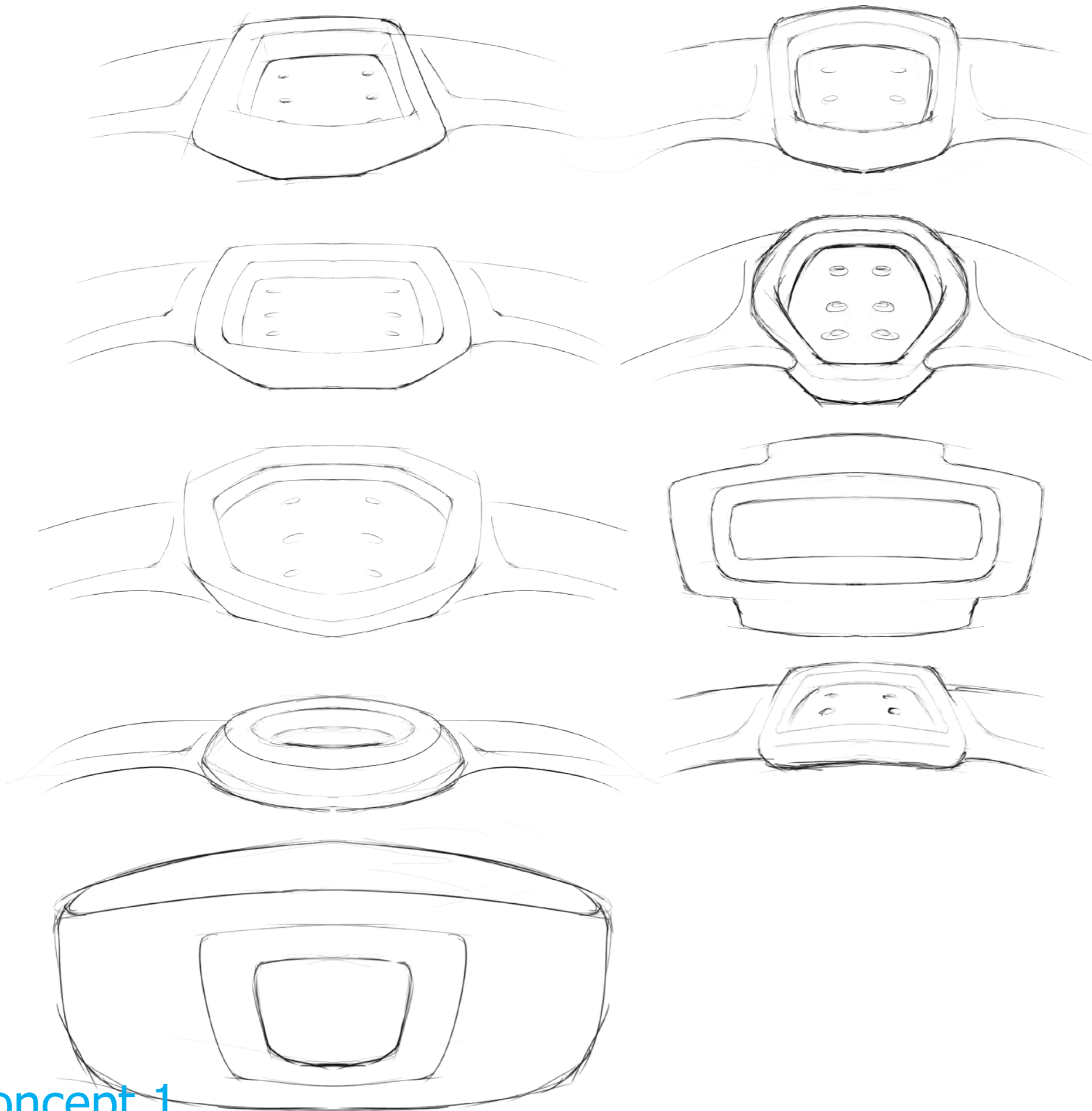
## Exploring Aesthetic pre style board

A number of forms were explored prior to creating a styleboard which were not carried forward



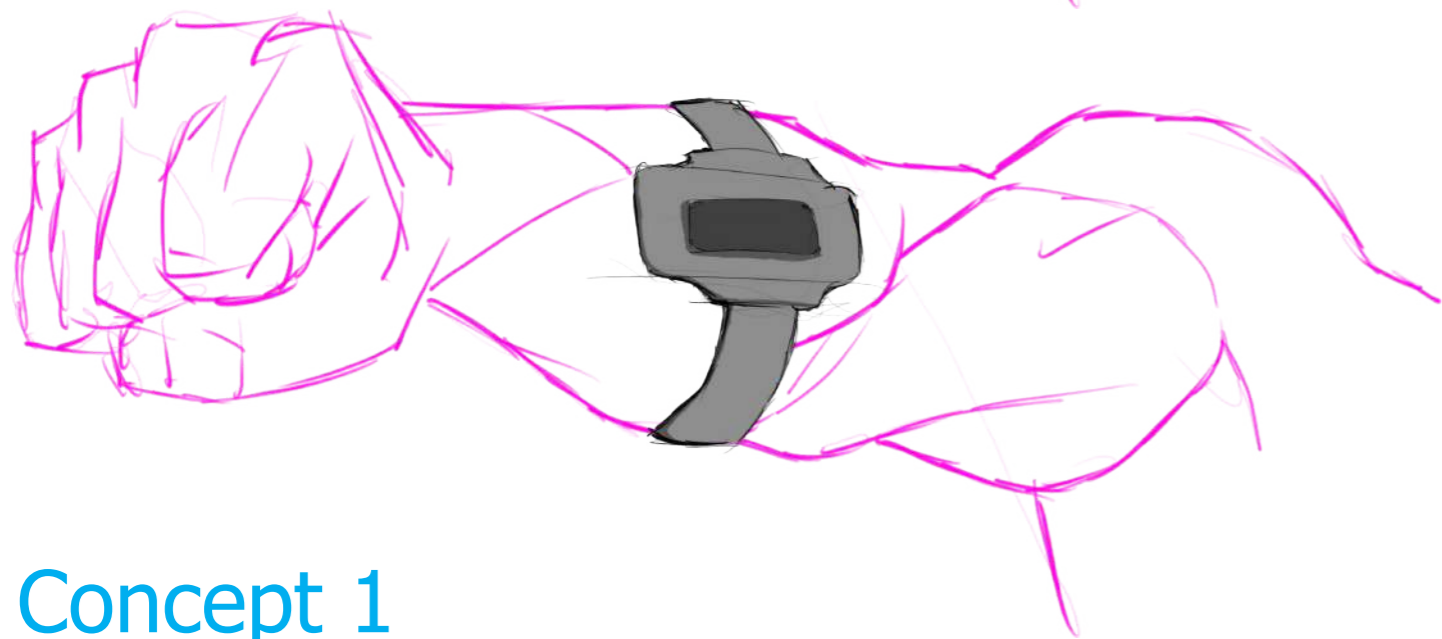
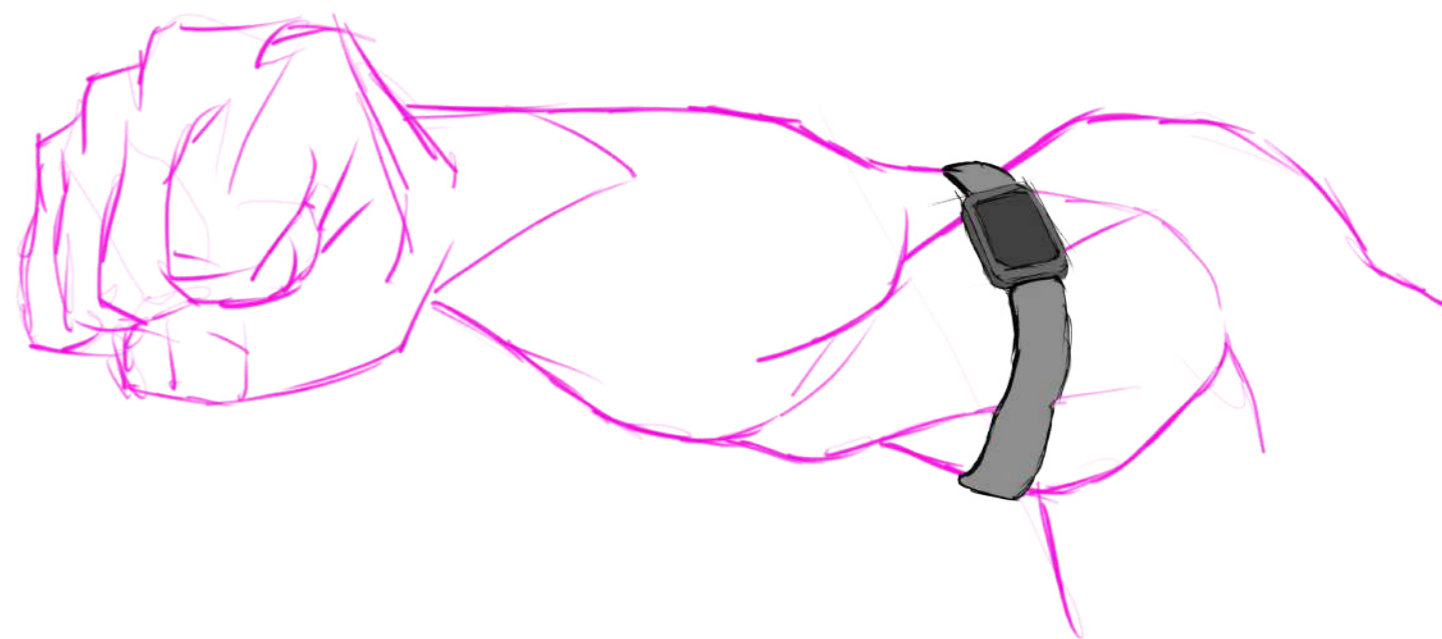
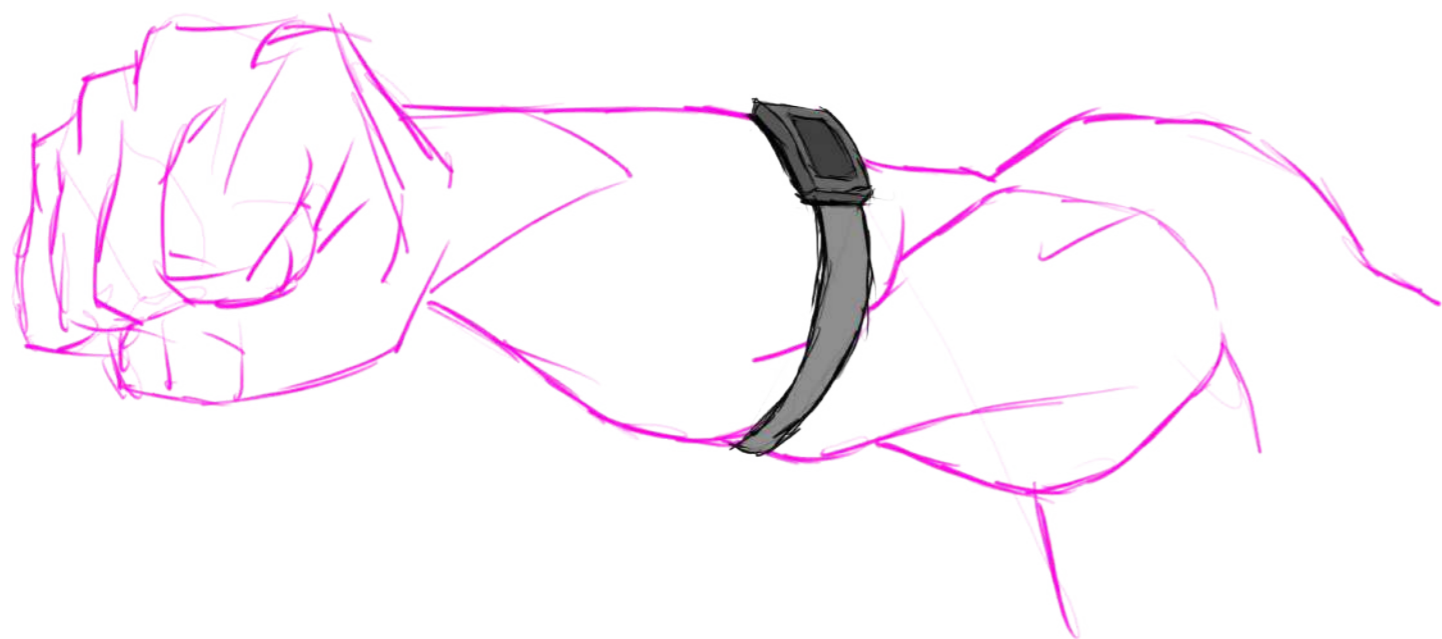
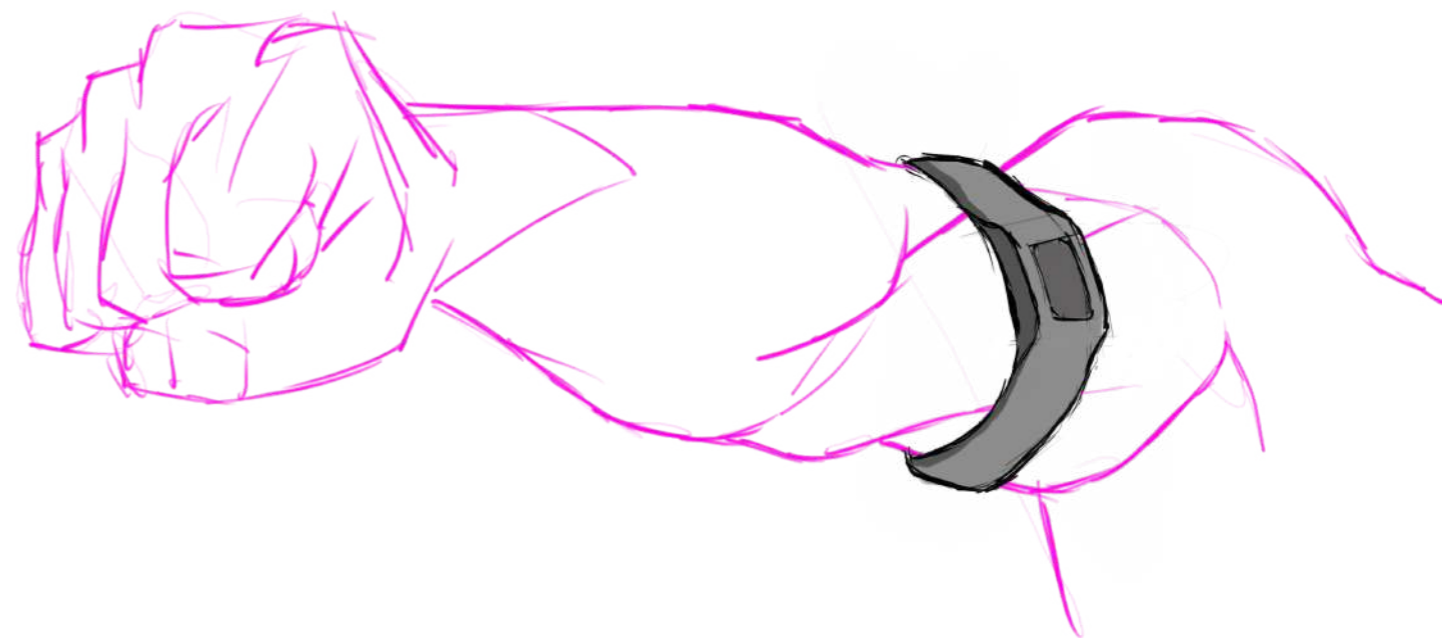
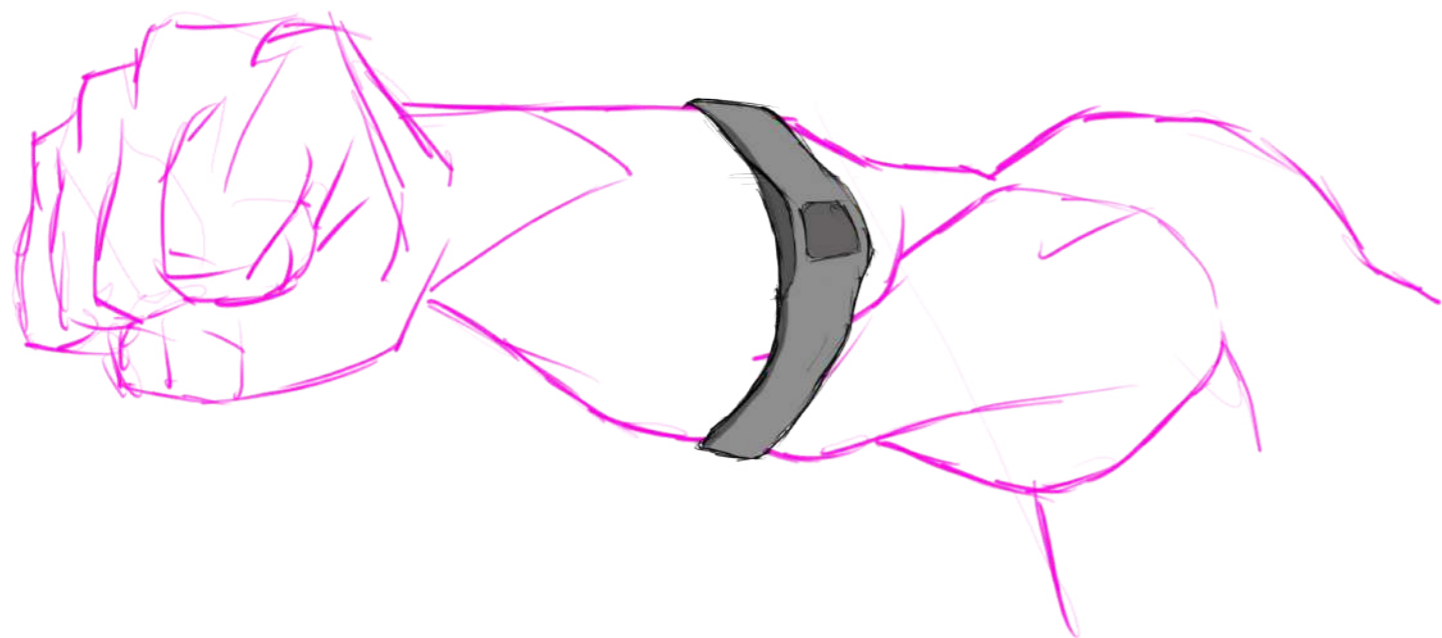
## Exploring Aesthetic pre style board

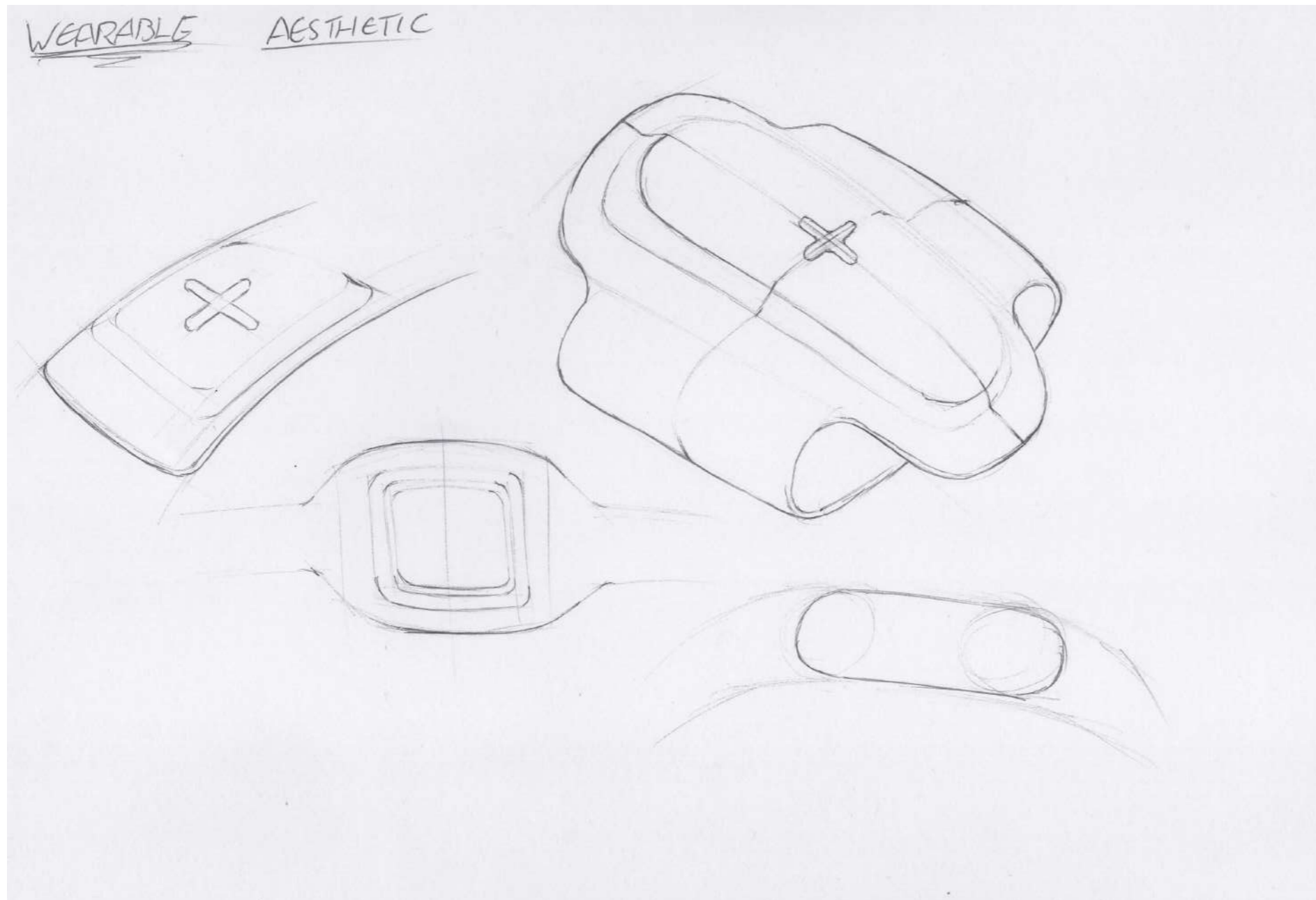
A number of forms were explored prior to creating a styleboard which were not carried forward



## Exploring Aesthetic pre style board

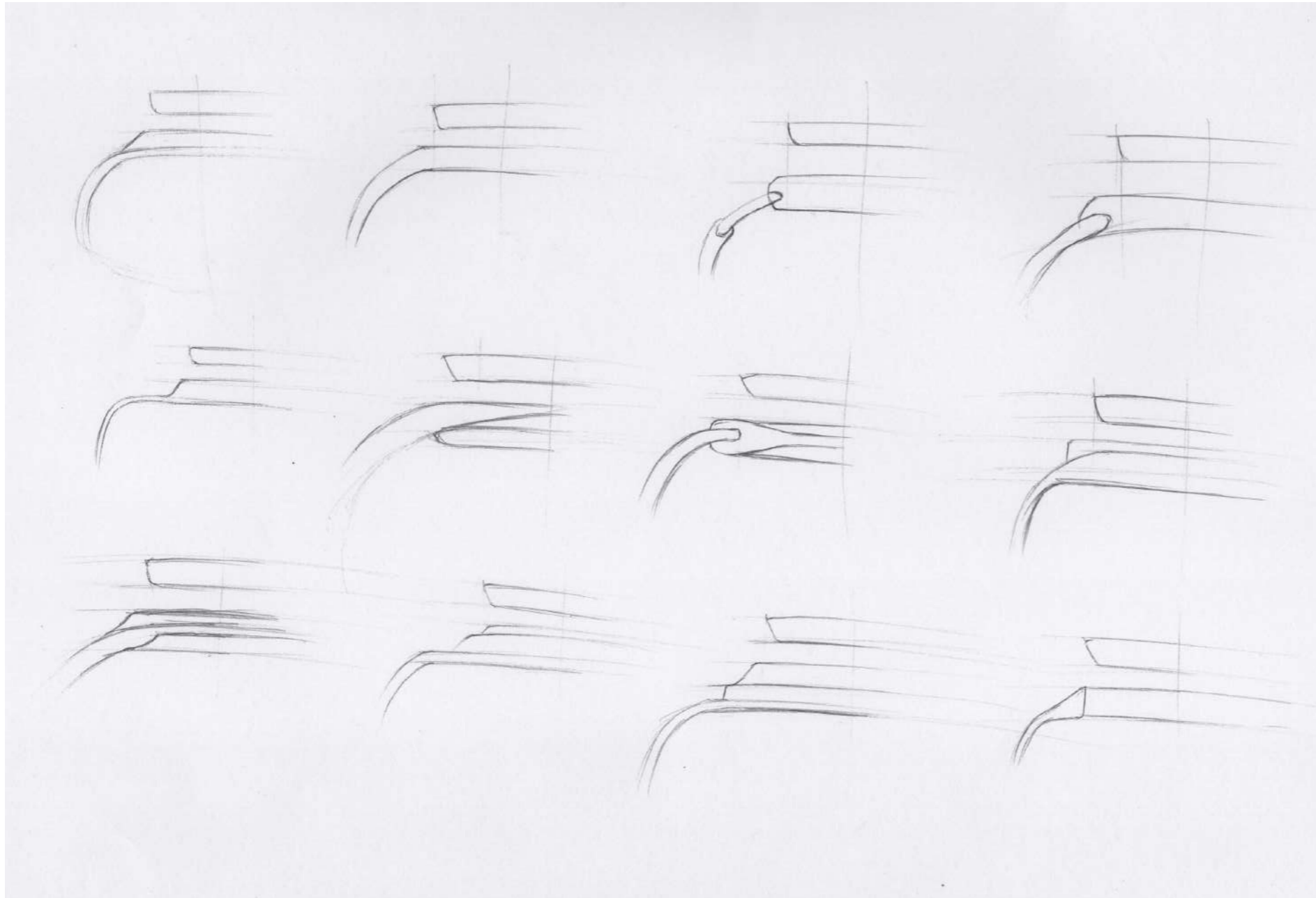
A number of forms were explored prior to creating a styleboard which were not carried forward





## Exploring Aesthetic pre style board

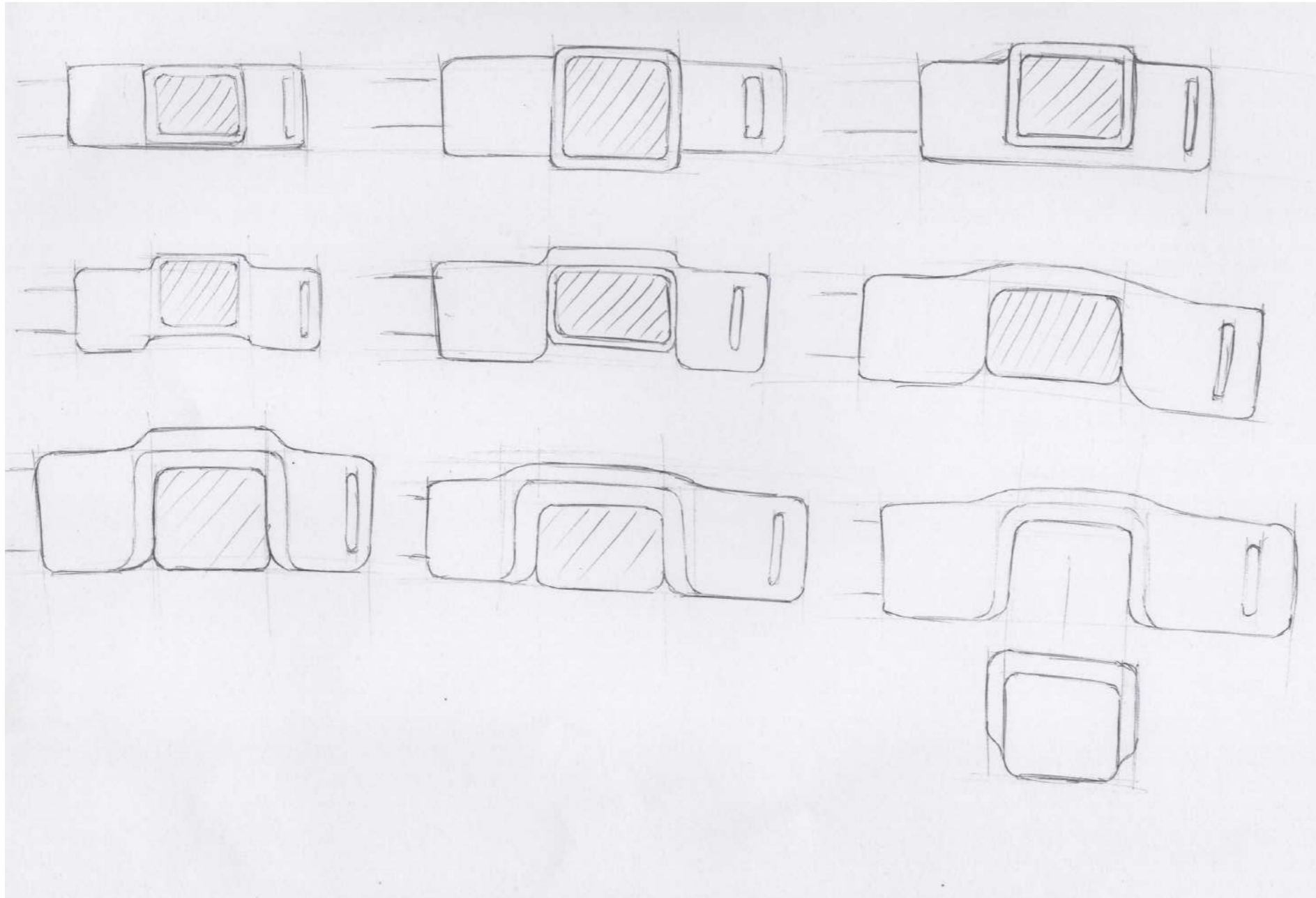
A number of forms were explored prior to creating a styleboard which were not carried forward



## Exploring Aesthetic pre style board

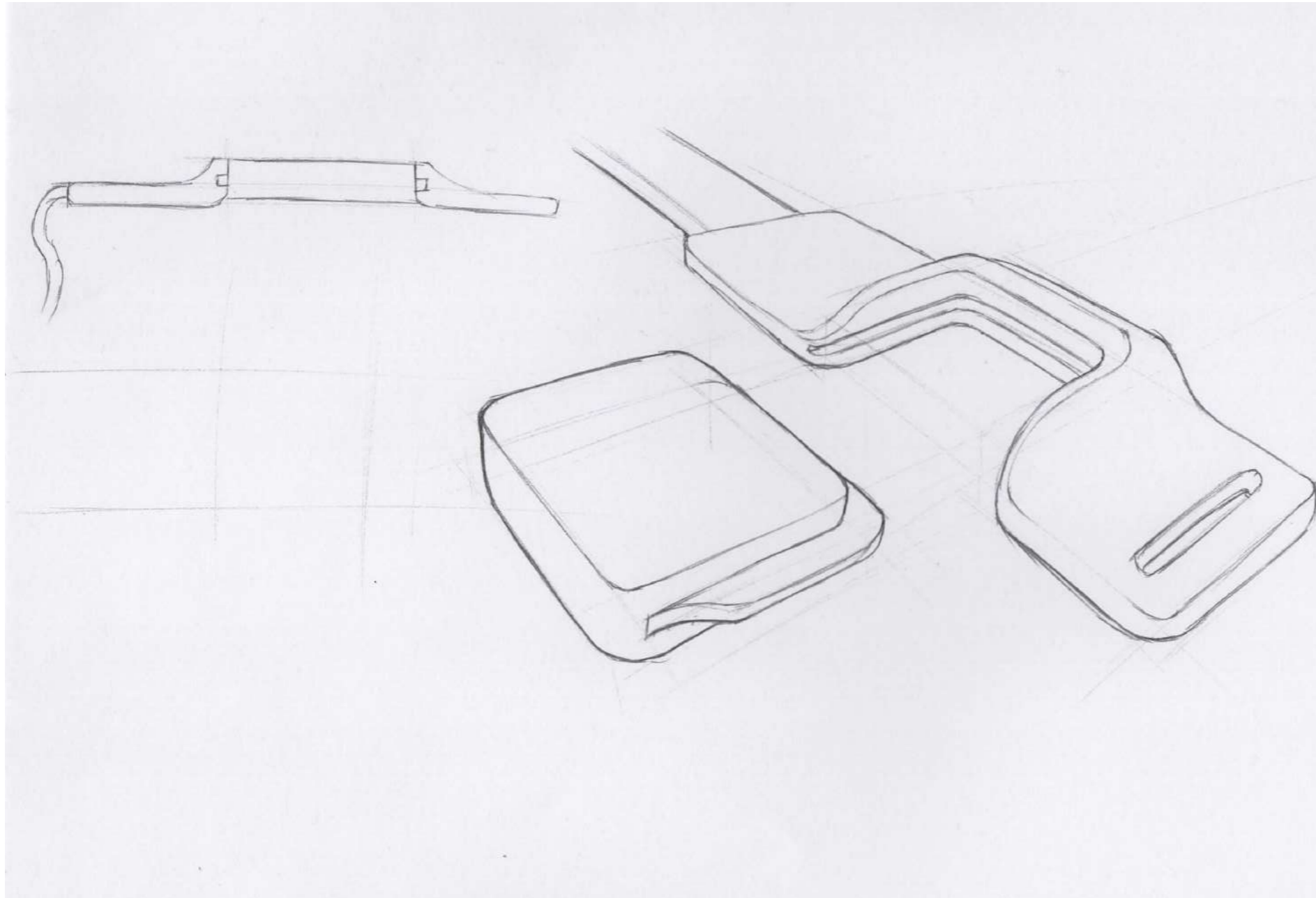
A number of attachment methods were also considered prior to creating a style board which did not add to the form of the device





## Exploring Aesthetic

After creating the style board, an aesthetic direction was chosen and further aesthetic study was put developed



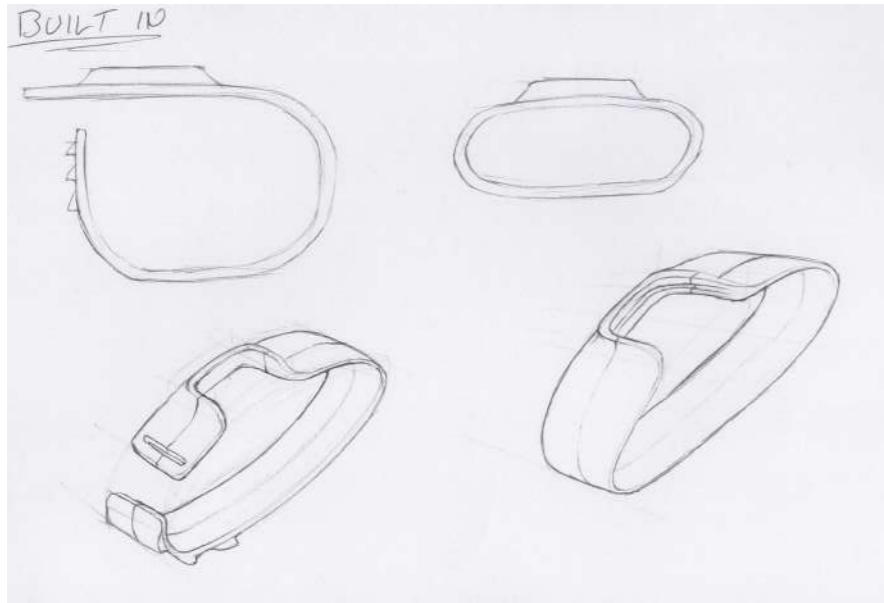
## Exploring Aesthetic

The aesthetic choices also informed the usability of the device, changing the orientation of the cartridge installment.

This mitigated a number of the drawbacks of the previous arrangement such as the cartridge falling out during installation and the issue of cleaning the device post use

# Securement

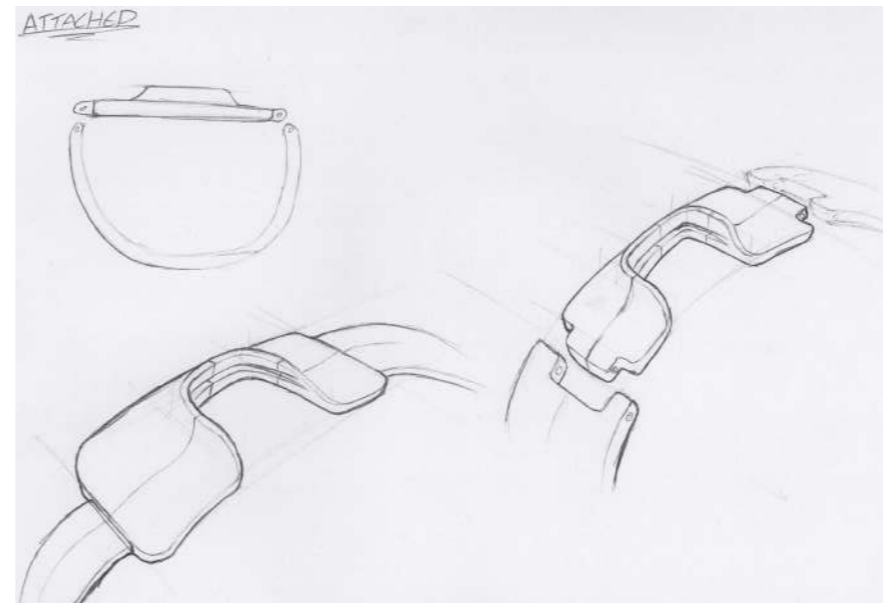
## Built in



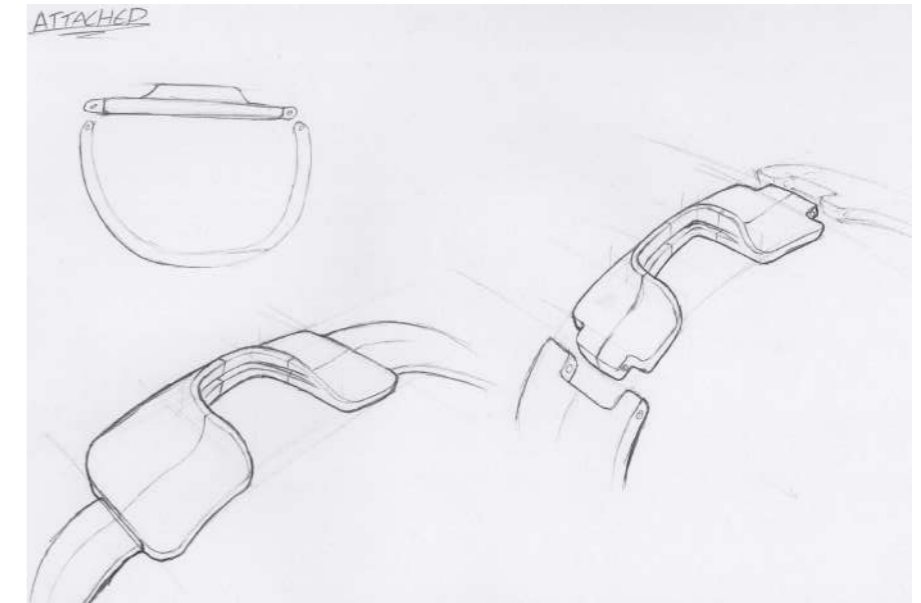
A built in securement system or a closed loop method would rely on elastic compression to adapt to different user sizes which worked well in the 3rd prototype

## Attached

A separately attached strap would allow for replacement straps if one became damaged but would add cost and manufacturing cost to the device



## Detachable

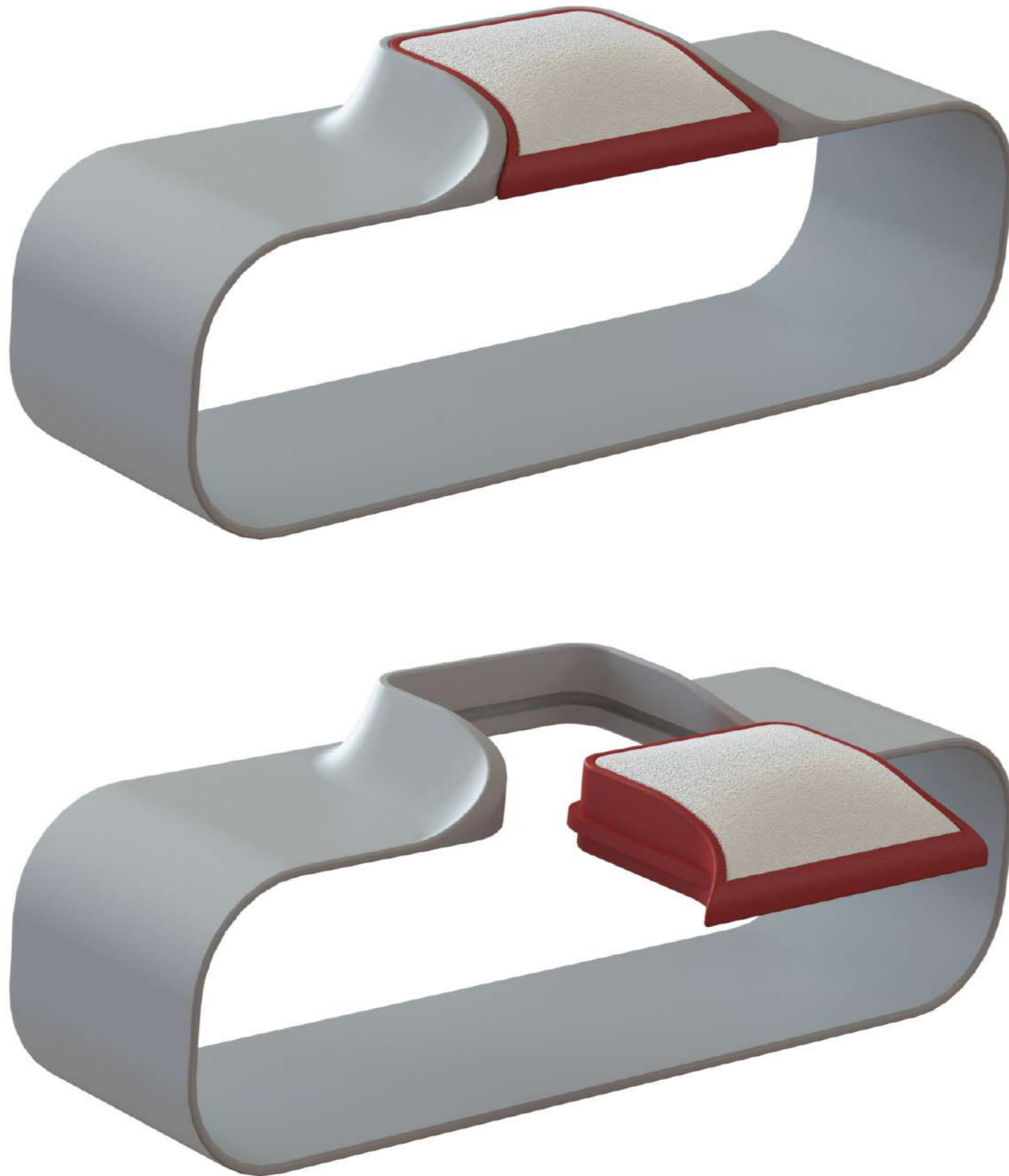


A detachable strap would allow for users to put the device on in a number of areas of the body or with potentially more ease if the user is unresponsive

## Exploring 3D aspects

A 3D model was created to explore a number of the challenges associated with connections such as tolerances and the scale of the device

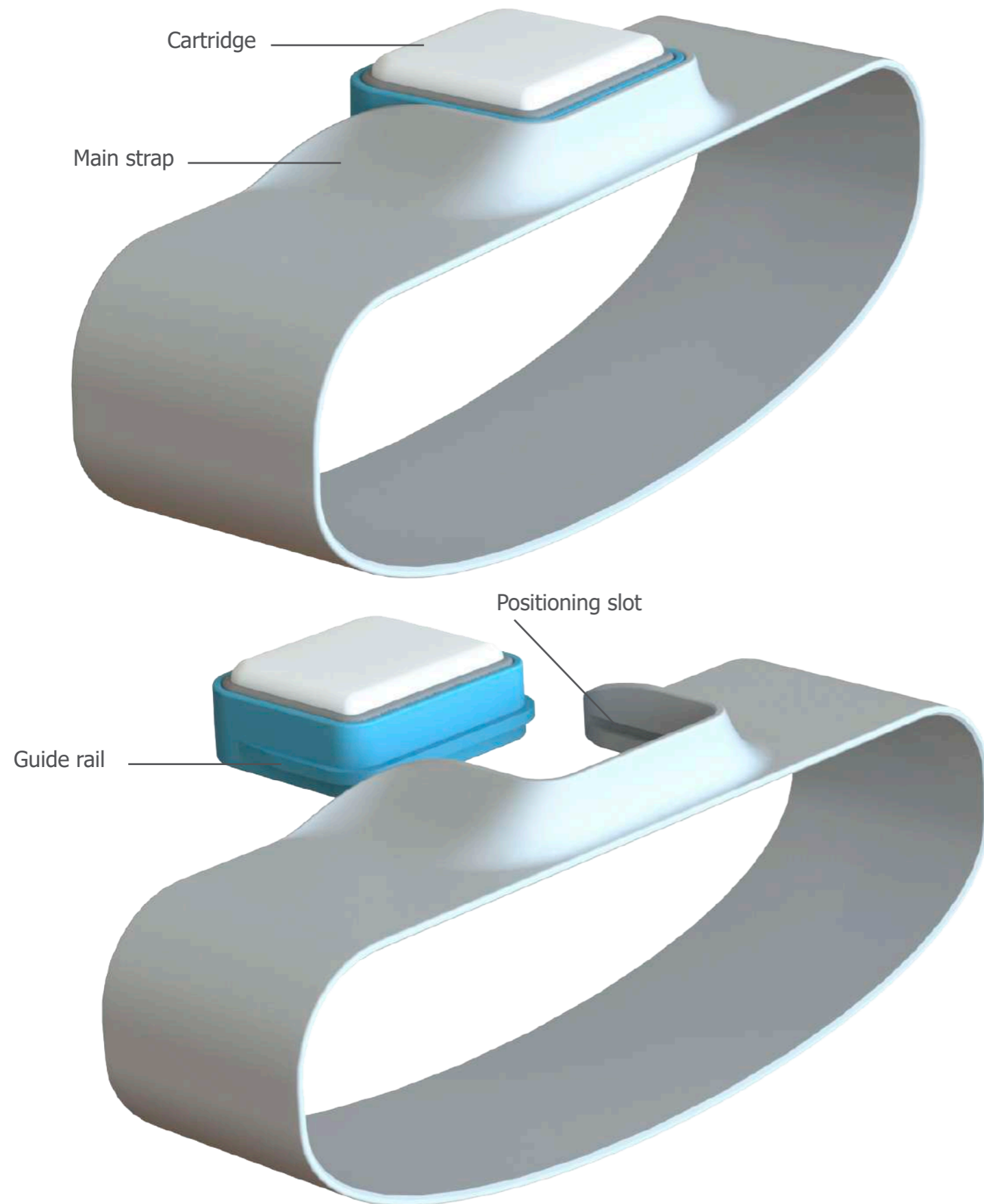




## Exploring 3D aspects

The initial model had a swept profile on the cartridge to match that of the device itself but this had a number of drawbacks such as potential activation when installing the device or removing it and the ability for user to grasp it in poor conditions

# Final Design

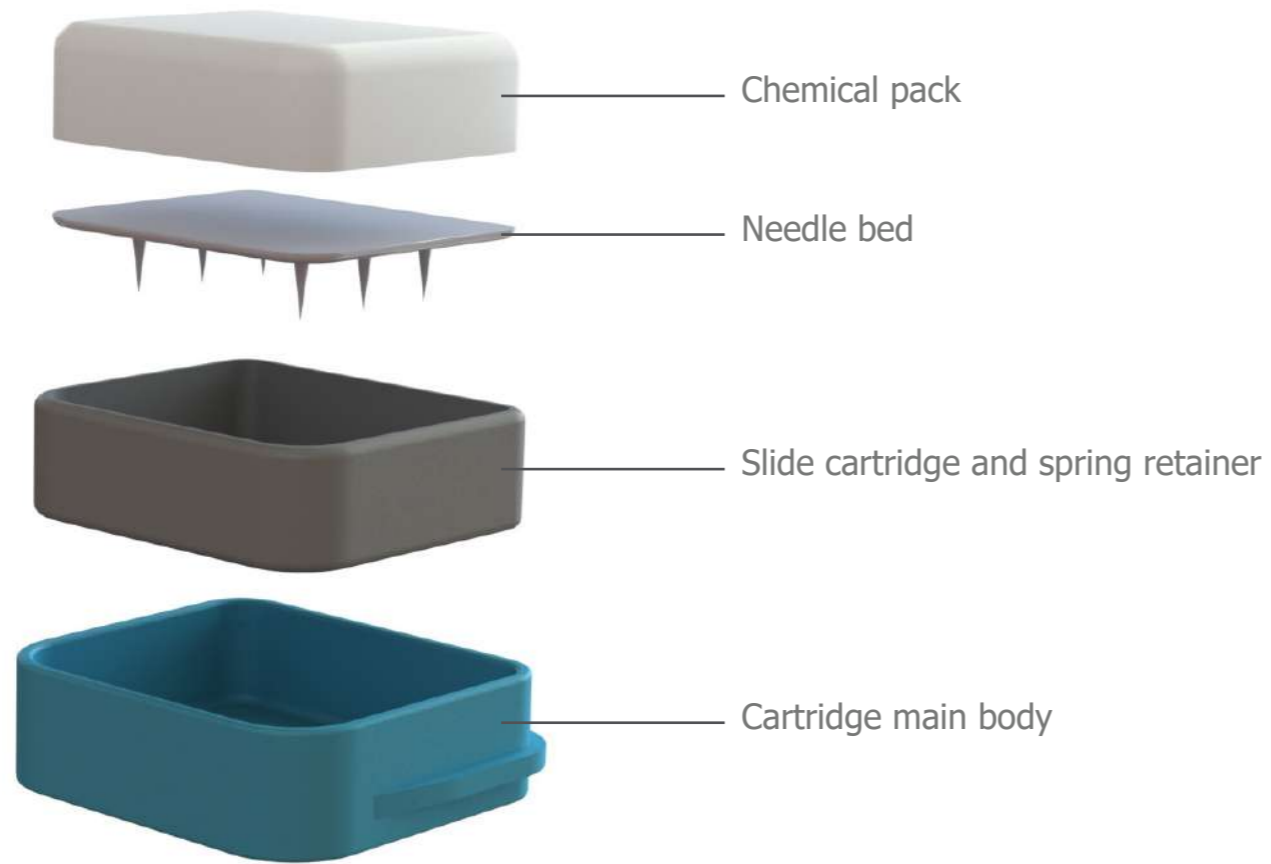


## Exploring 3D aspects

The cartridge was changed to a squarer profile to allow for greater control over it whilst installing and uninstalling the cartridge.

This would also reduce manufacturing complexity

# Final Design



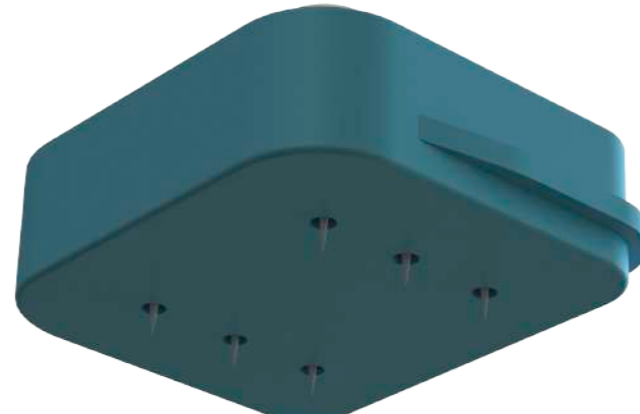
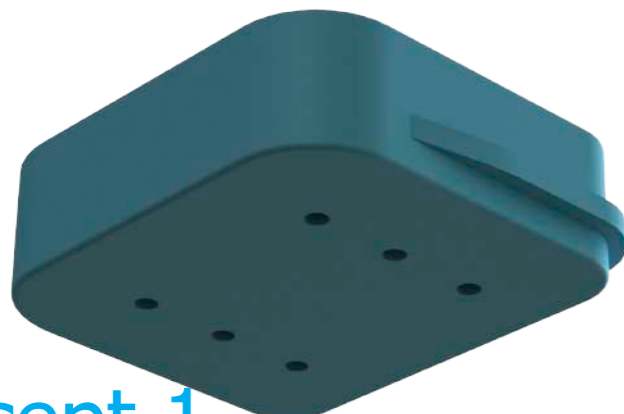
## Exploring 3D aspects

The cartridge would be a self contained blood testing kit that contains a number of components which are necessary for sampling such as the needle beds and chemical pack

Decompressed State



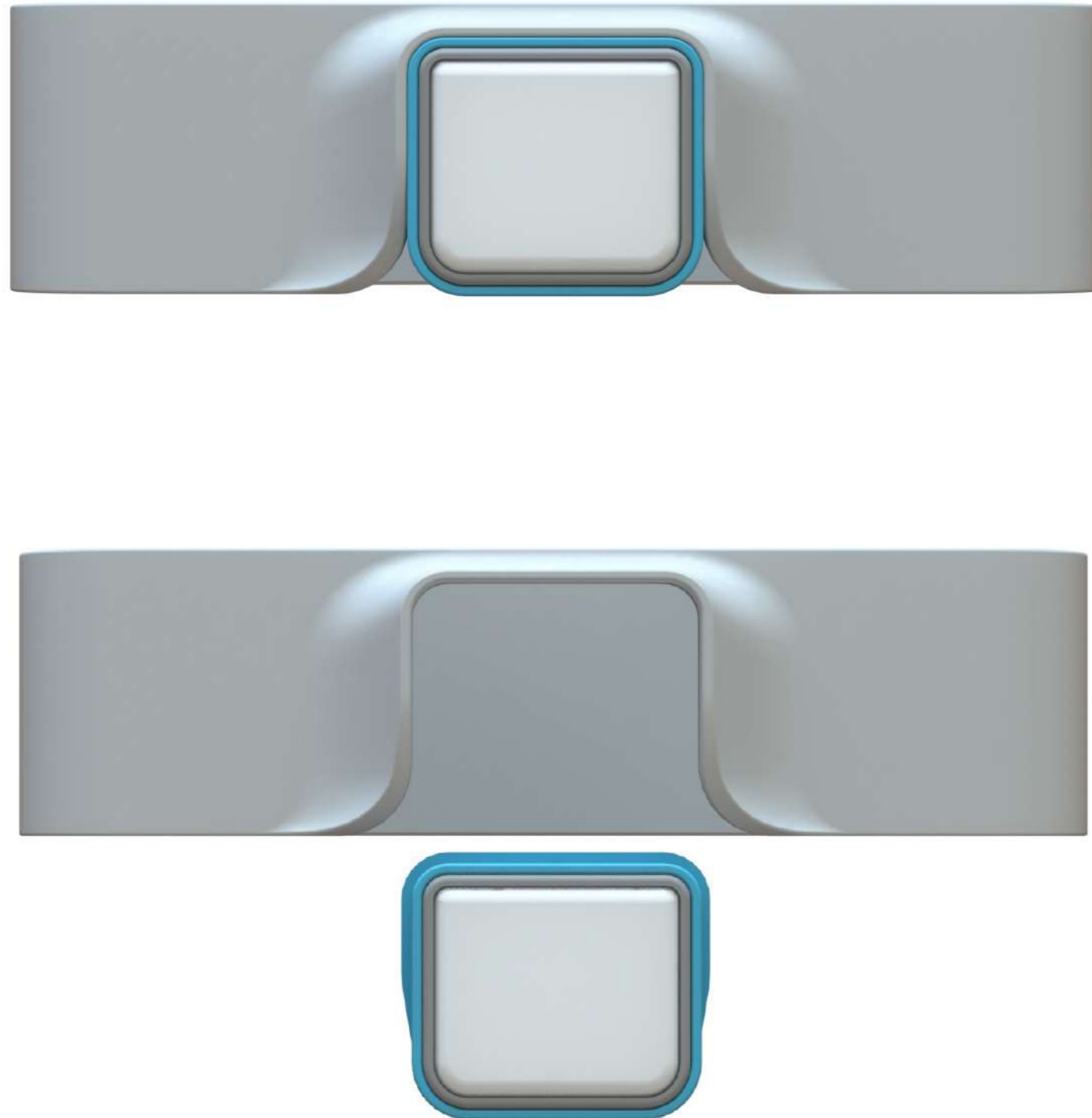
Compressed State



## Exploring 3D aspects

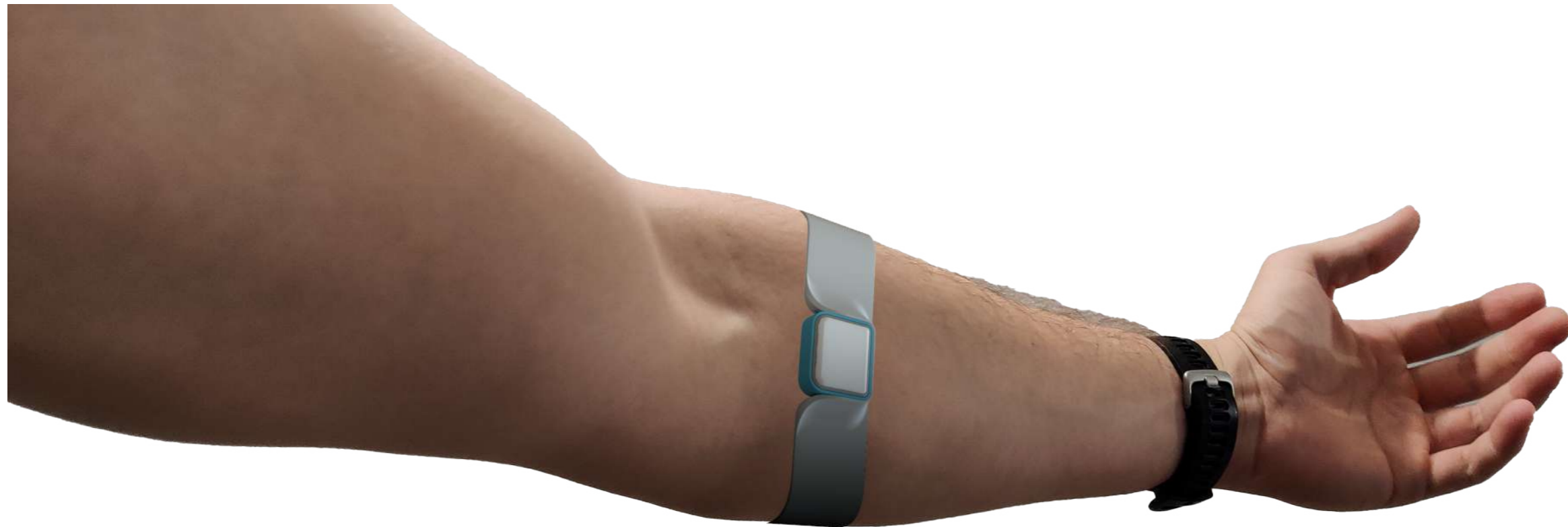
Cartridges would be installed by sliding them into the slots aligned in the main strap which are slightly tapered to create a tight tolerance fit.

Once installed and worn by the user, friction would also keep the cartridge in position.





# Final Design



## Concept 1

# The System as a Whole

The cartridge would display a colour after a number of minutes developing which would correspond to the severity of concussion sustained. Potentially green for minimal detection and red for severe detection.

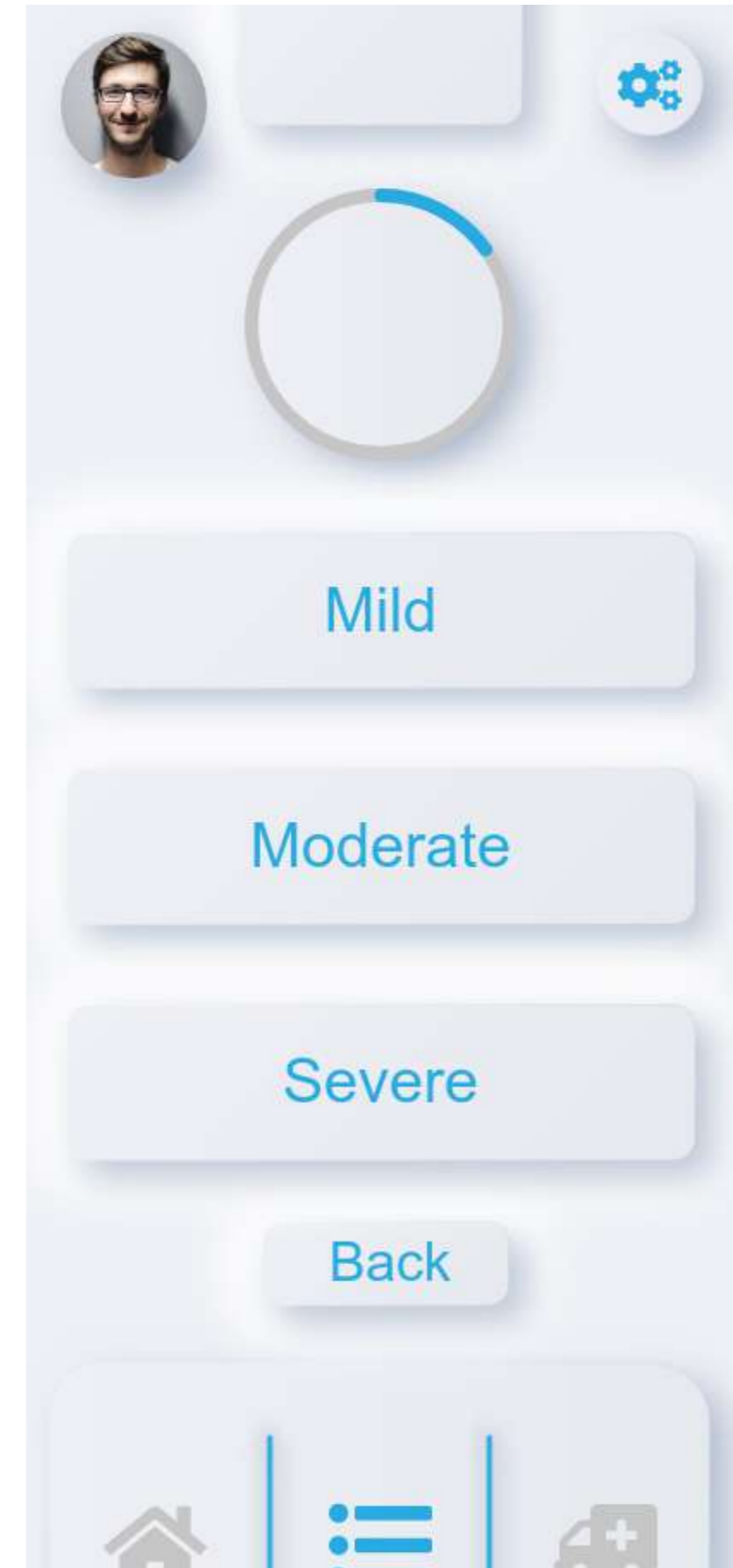
This result can then be fed into the application during the testing phase in order to give a more accurate test and better tailored test to the user

The app would also contain a reminder to use and instruction for use for the device to complement the IFU in the devices packaging

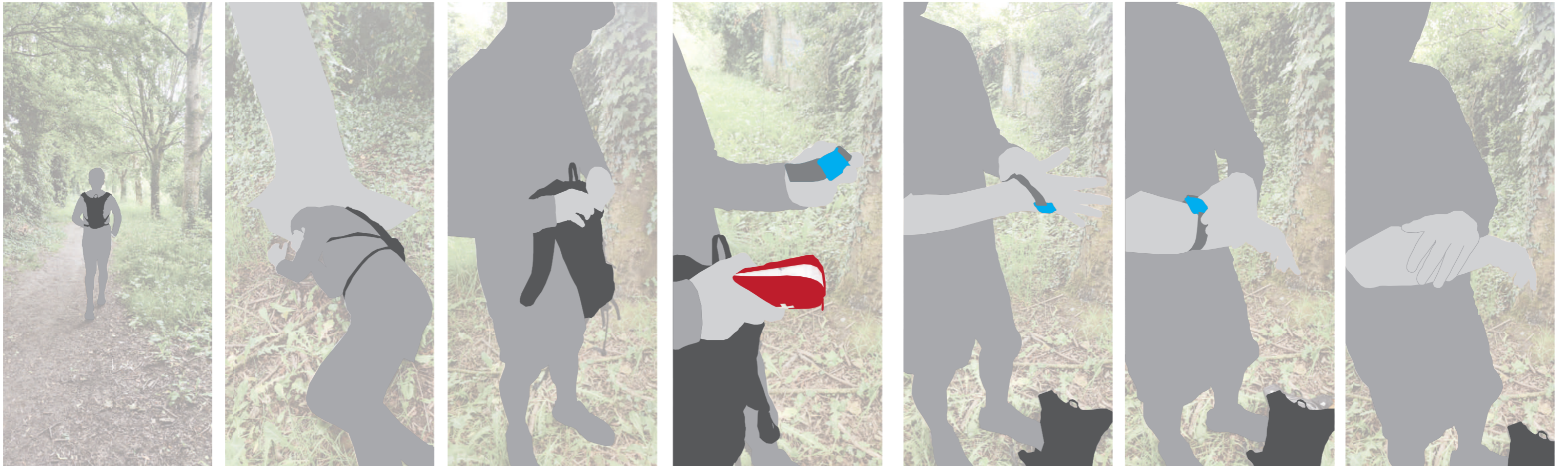
Physical Detection Device



Cognitive Test App



# Storyboard



# Concept 2.

Cognitive Detection & Situational Recovery

## Breakdown

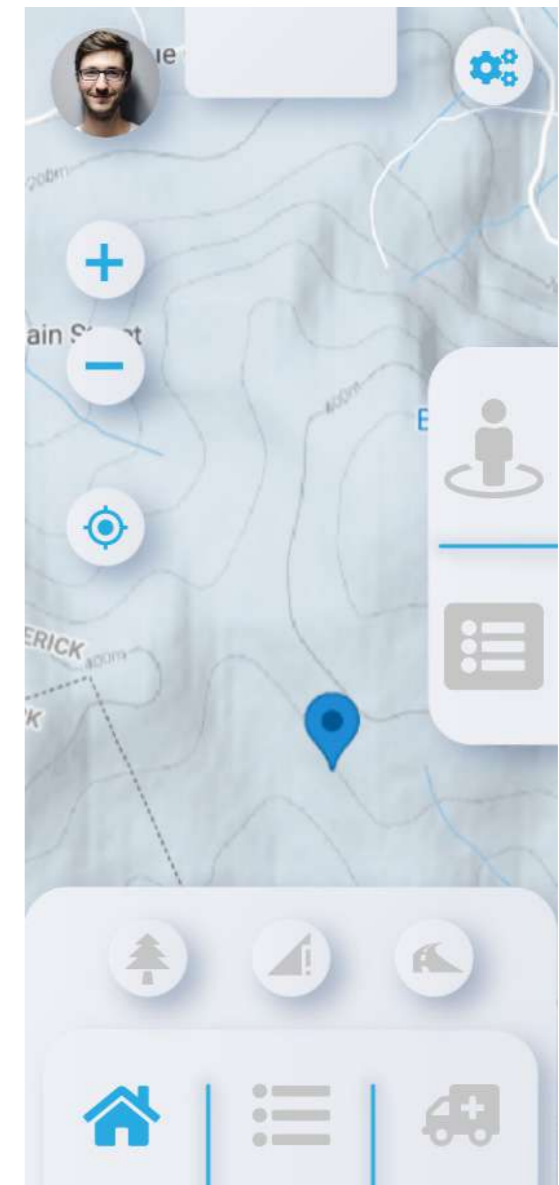
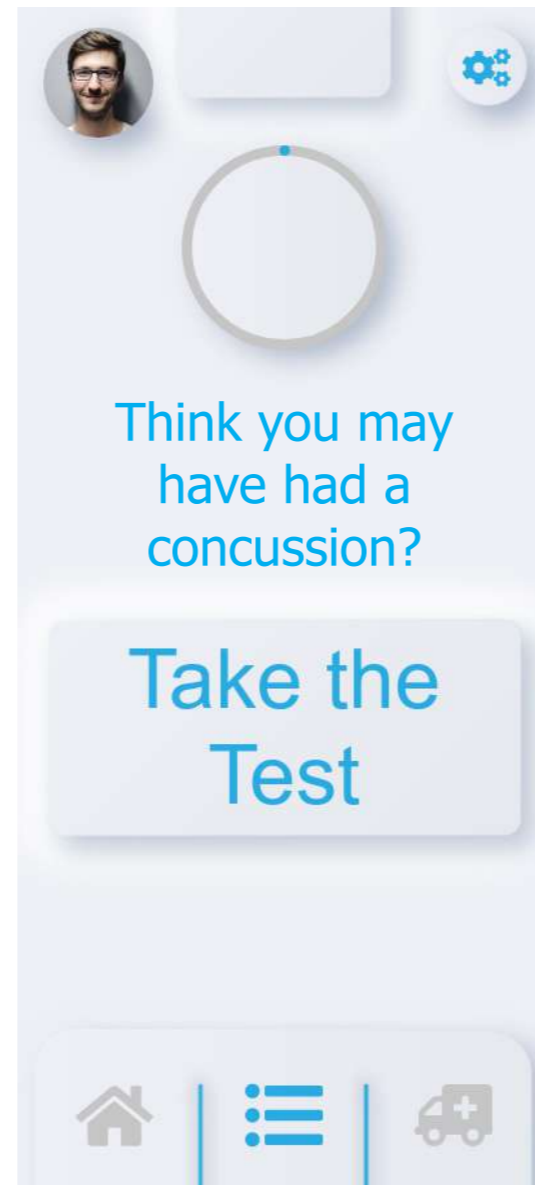
What it is	pg 182
How it works	pg 183
Interface	pg 187
Prototype 1	pg 193
Prototype 2	pg 206
Development	pg 210
Prototype 3	pg 213

## What is The Concept

Building a cognitive detection test into an application

This is an application that would contain either a cognitive test or a number of cognitive tests depending on the severity of the concussion indicated by the device itself.

It would also contain a socially driven recovery system which would allow users to request help from other app users to get to safety.

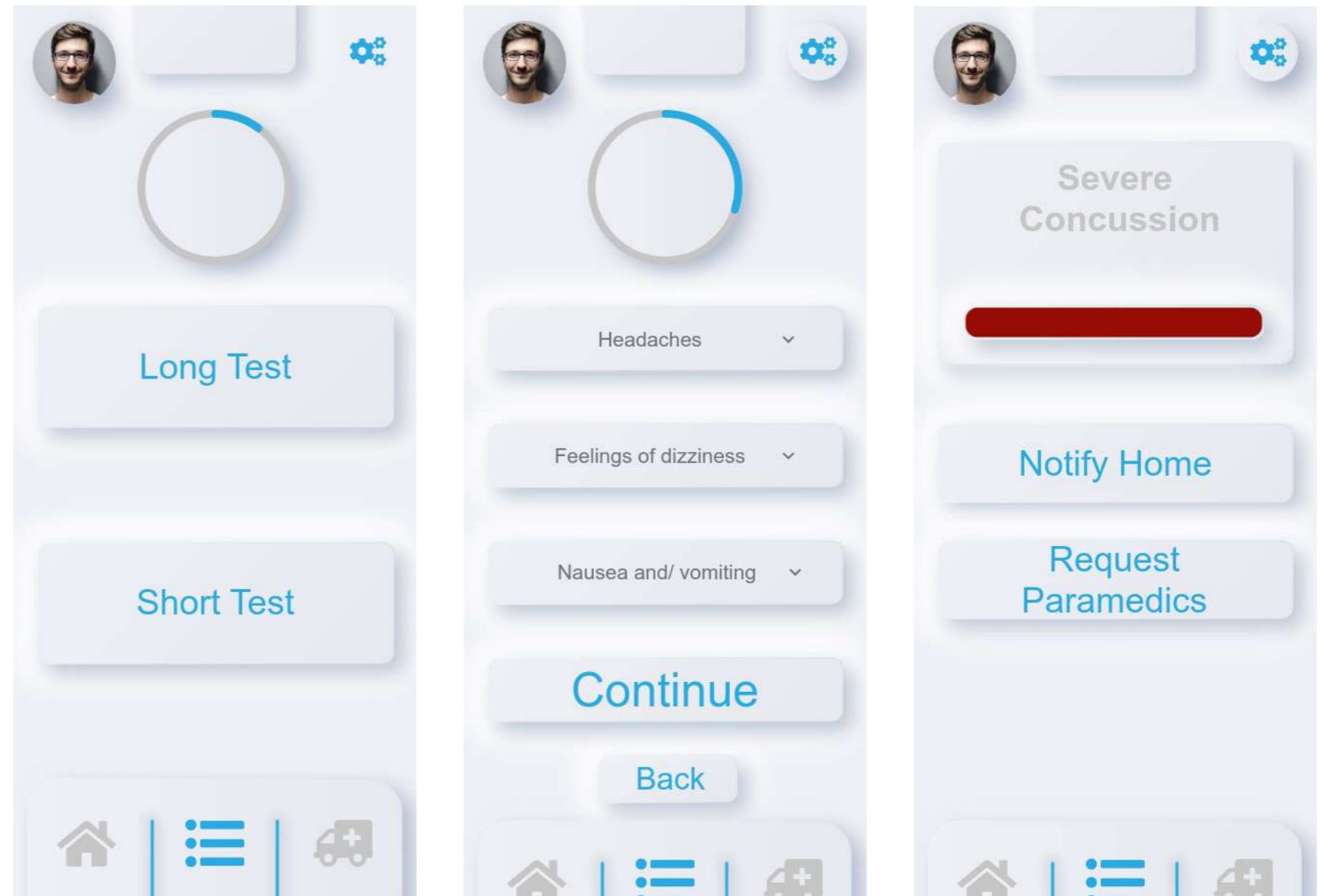


The app would have to be simple to use, usable by potentially impaired individuals, display rapid results and have the potential to alert authorities to the location and state of the impaired user.

## How it Works

Creates a simple to interact with questionnaire that encompasses current concussion detection methods

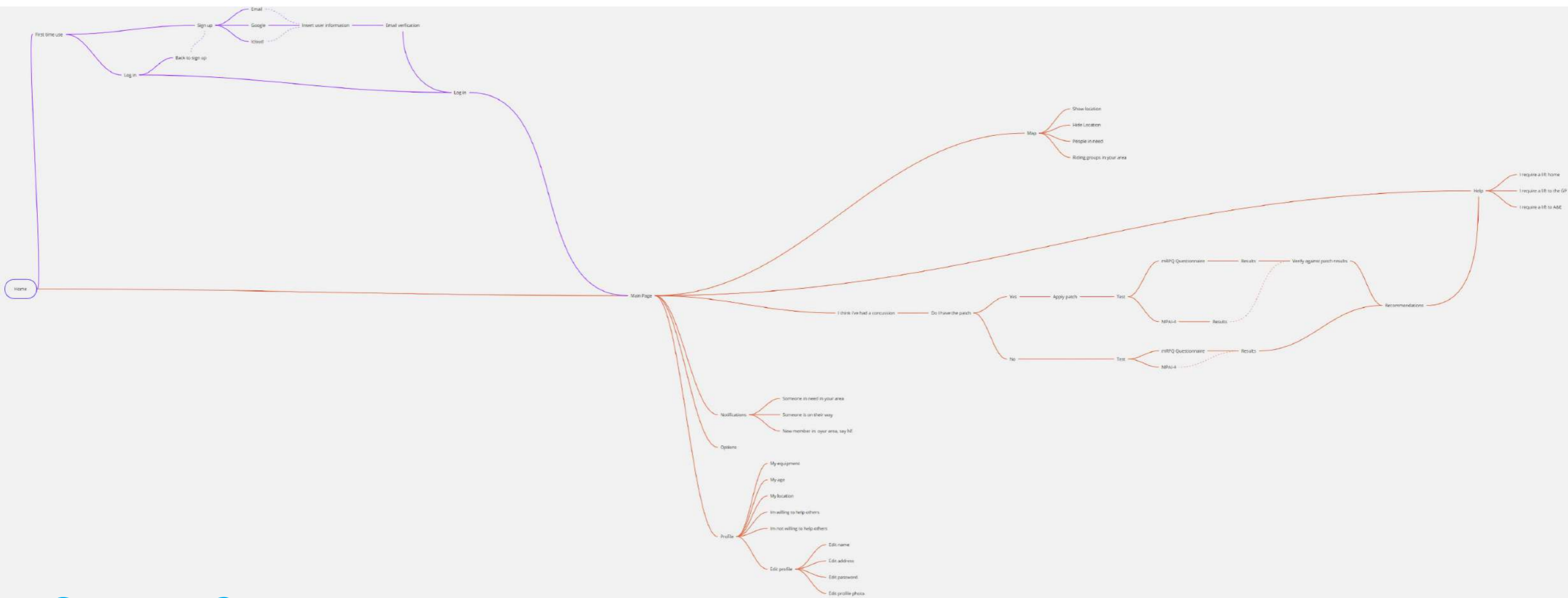
The application contains a number of different cognitive tests such as the mRPQ test and MPAI-4 test along with modified variants of each to better and more accurately test users cognitive impairment either in conjunction with the device or independently of the device



The app would also contain an interactive activity page and live tracking (optional) of users a current activities to quickly assess where the nearest source of help is for a distressed user. The app would also have regulated contact with emergency services to request emergency medical help if the user is in a fully impaired state.

# Mapped

Due to the limitation of the Miro program used to initially map out and interact with the journey path of the app, the quality of the image showing the over arching map of the app is of poor quality





# Mapping Verification

Test 1 involving 2 users that gave feedback on the flow mapping sequence and the map was edited as issues arose

The journey map was created in Miro and edited live as issues arose for the users thus creating a living document that adapted in conjunction with the users needs and issues as they arose

Male  
23  
Ultra-marathon Runner

Female  
20  
Mountain Biker

"I wasn't sure where to go on a few junctions"

"Is there a way other users could come help you if they are close?"

"What test is what?"

"Are you meant to ask for help after or before the test?"

"Why would I use this instead of Strava?"

## Key changes to be made

Mapping

Order of actions

Guide user to right test

## Cognitive Test

Using either the mRPQ or MPAI-4 cognitive concussion test set out as a questionnaire within the app to help diagnose concussions.

The language and number of questions per section would be changed depending on the severity of the concussion detected in the device.

## Help Requesting

Using GPS tracking to locate the nearest active user and allowing users to request help from this user to get them to a safer space to be recovered from or for a better assessment

## Activity logging

Allows user to log their progress and activities in a social way to help encourage them to continue to be active

Incorporate the gamification of activities with a level up system and gives user a fitness/activity score based on their activity level and intensity

## Shelter Pinning

Allows user to locate the nearest form of shelter in poor conditions on a map

Allows users to upload new shelter locations and review the effectiveness of current location

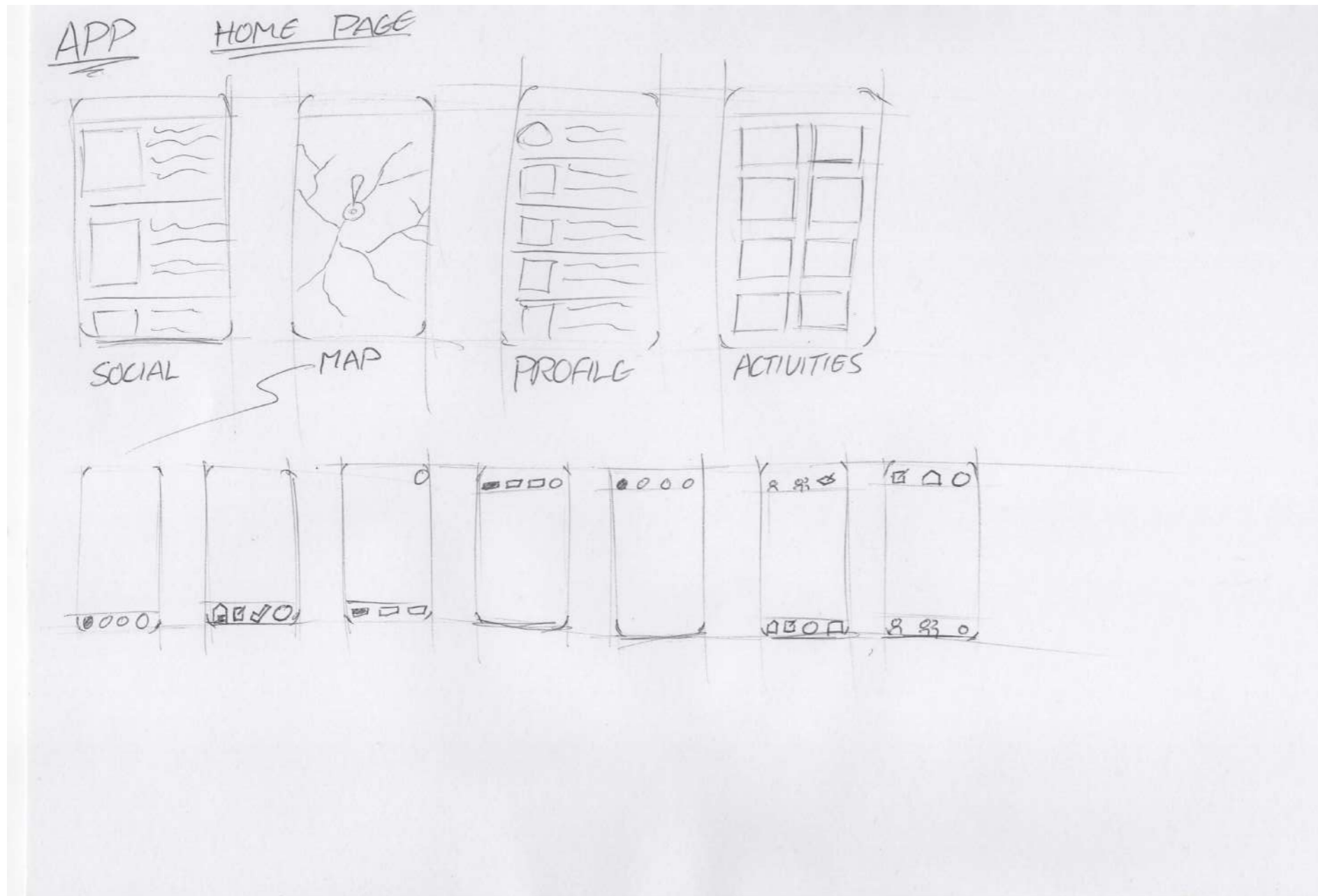
## Live Activity Joining

Allows users to see what active members are doing around them and allows users to request to join, this, if accepted by the other user, would give directions to the nearest meeting point or the accurate location of the accepting user.

## Emergency Contacting

Allows the application to contact emergency services on behalf of the user if their concussion severity is above a certain threshold.

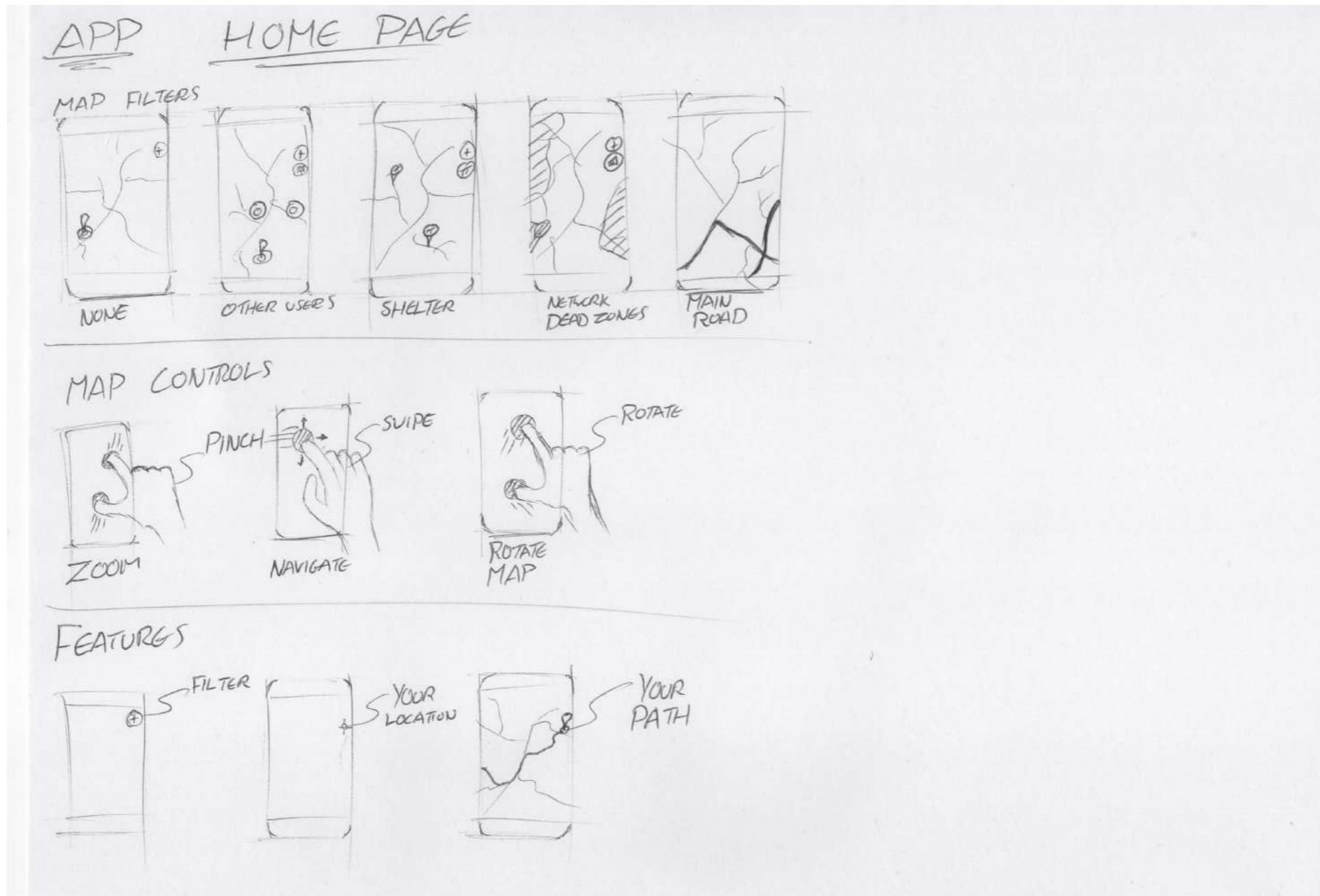
# Interface



Exploring the basic interface

Exploring the initial basic interface element of the app and how users would navigate the app

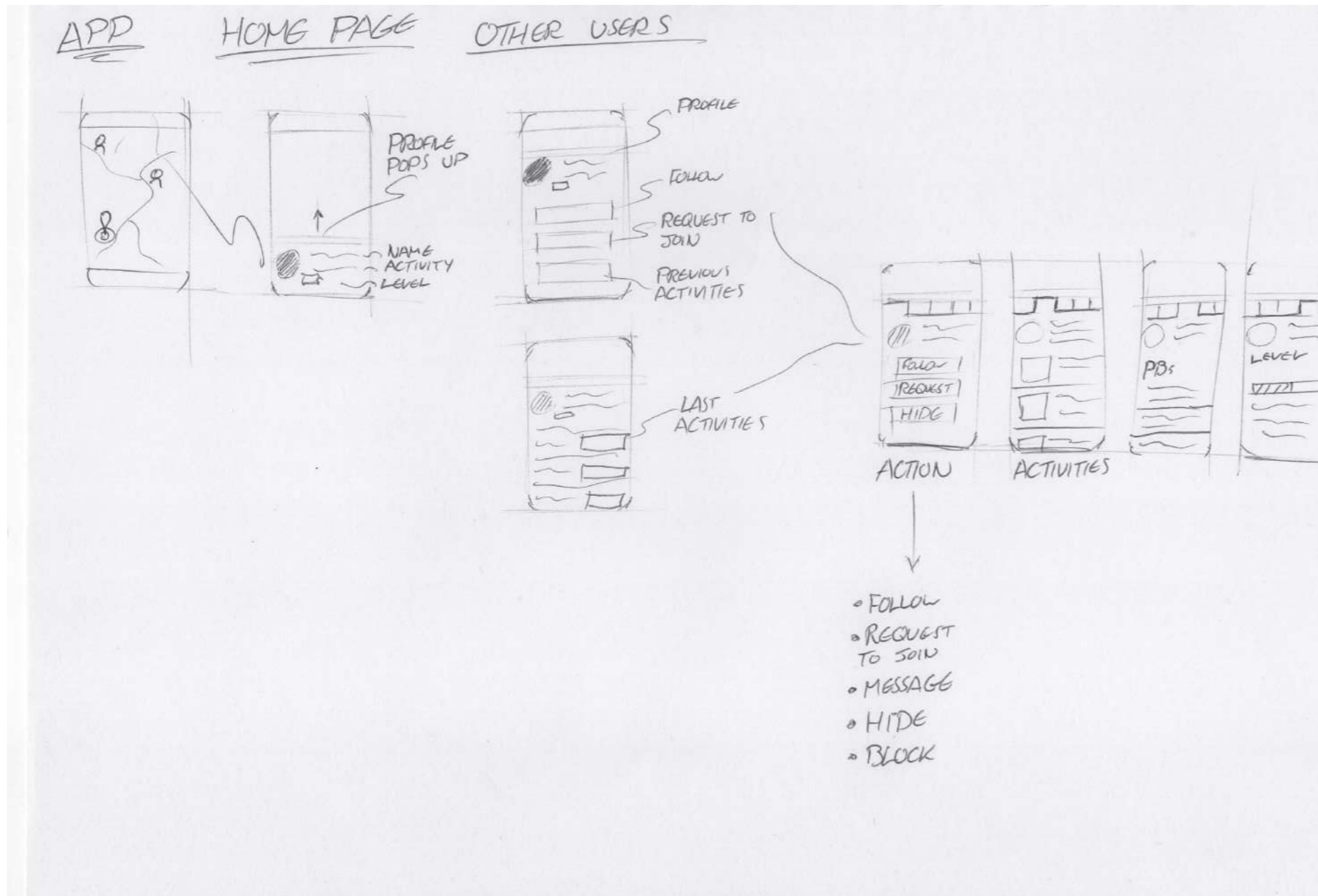
# Interface



Exploring the basic interface for the map

Exploring the initial basic interface element of the apps home page which would be the map section. Exploring how users would navigate the map itself, taking cues from other popular apps such as Strava and Komoot

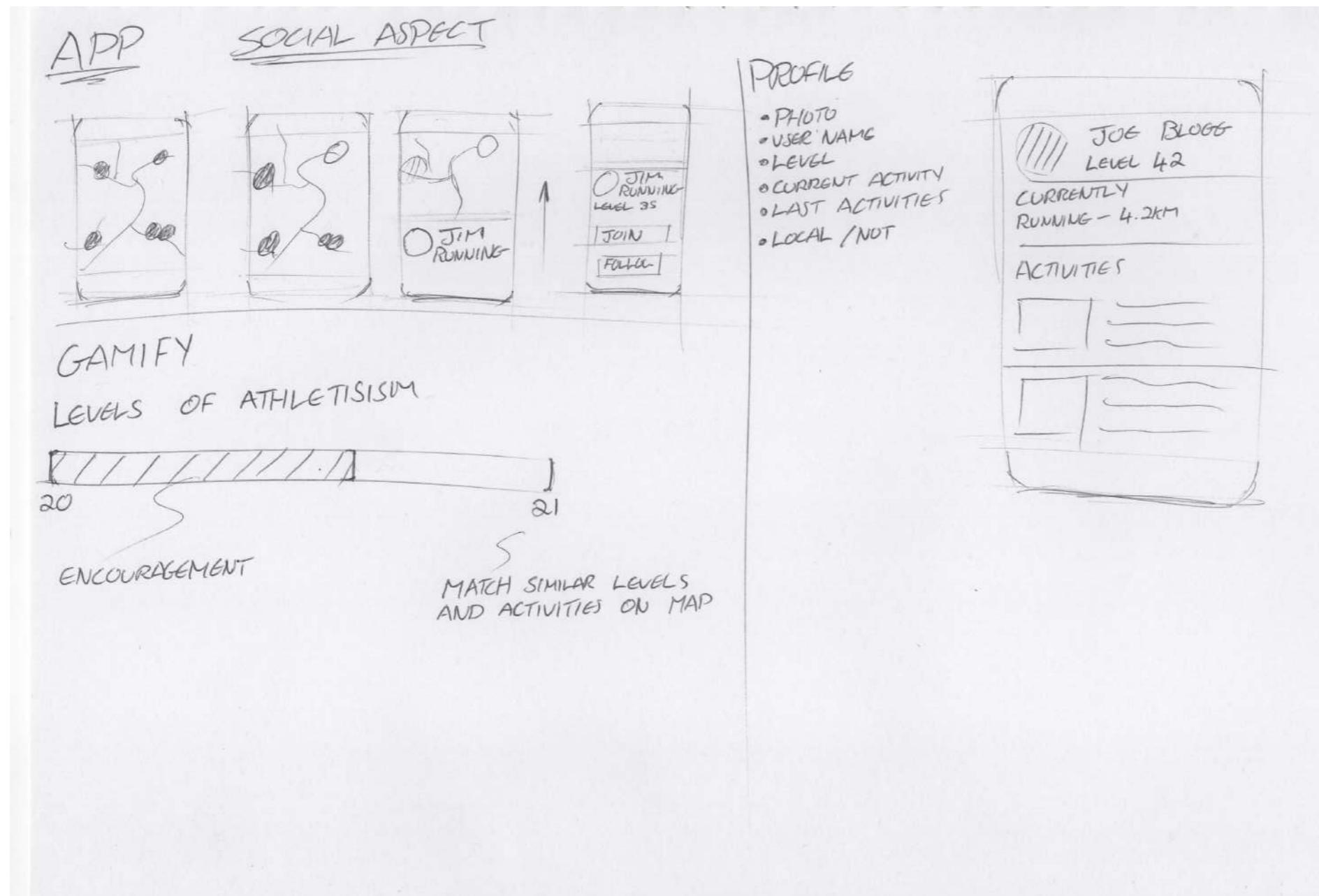
# Interface



Exploring the basic interface for the active users

Exploring the initial basic interface element of the social and activities aspect of the app.

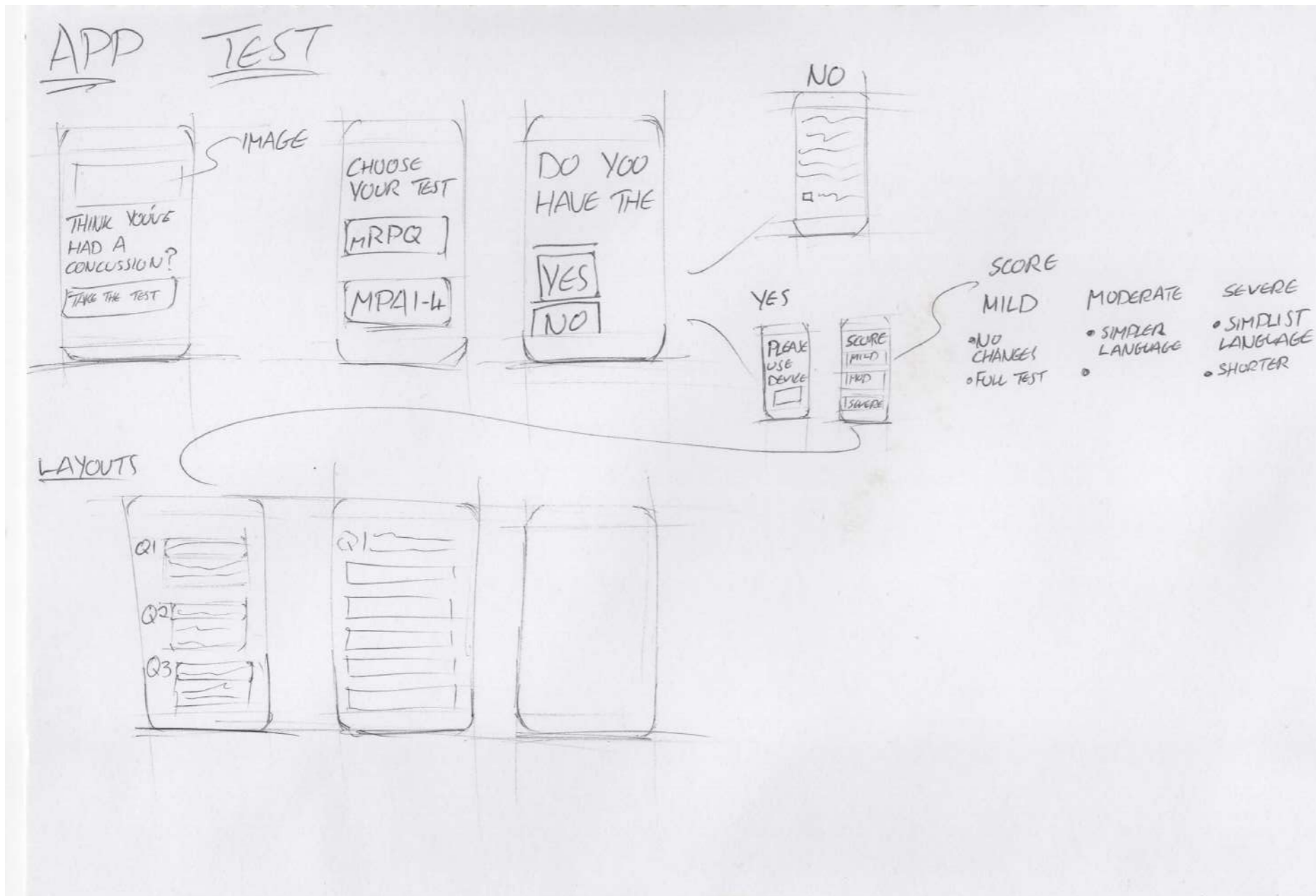
Exploring opportunities interactions between users



Exploring the social aspect of the app

Exploring different ways for people to interact with the app and create positive engagement. Developing what the users profile will contain and what can be interacted with

# Interface

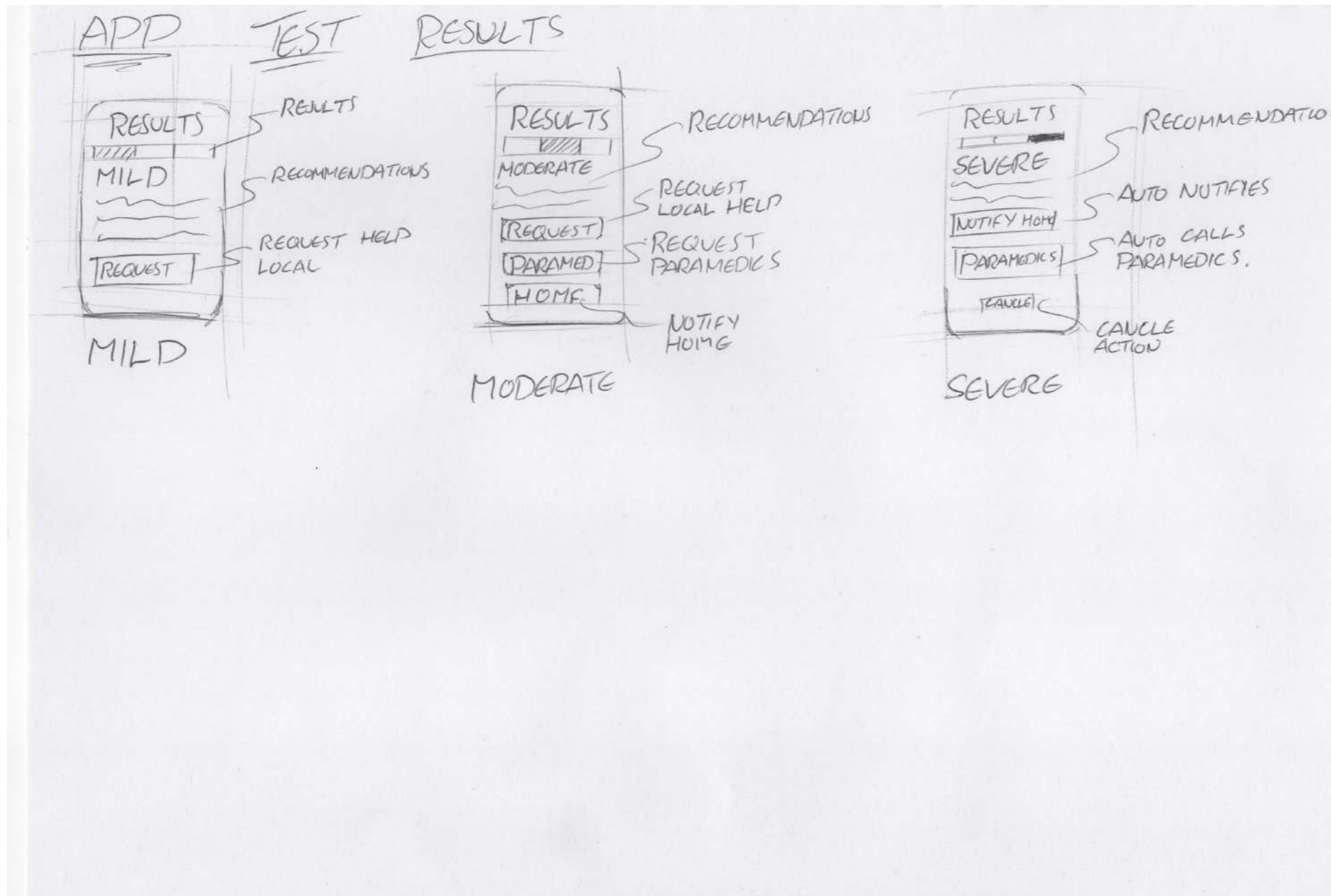


Exploring the cognitive test

Exploring different options for creating the questionnaire test and the differences between each test

Developing the initial layouts and the actions and pathways available once results are shown

# Interface



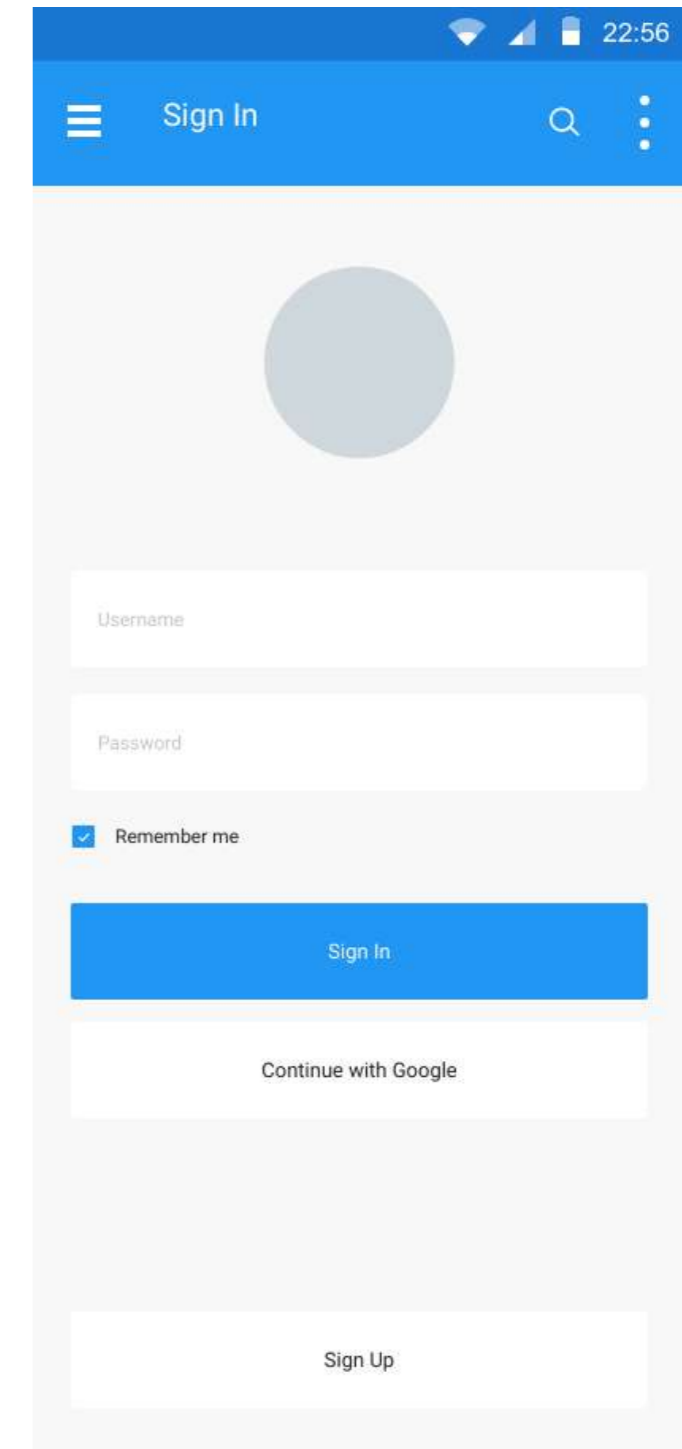
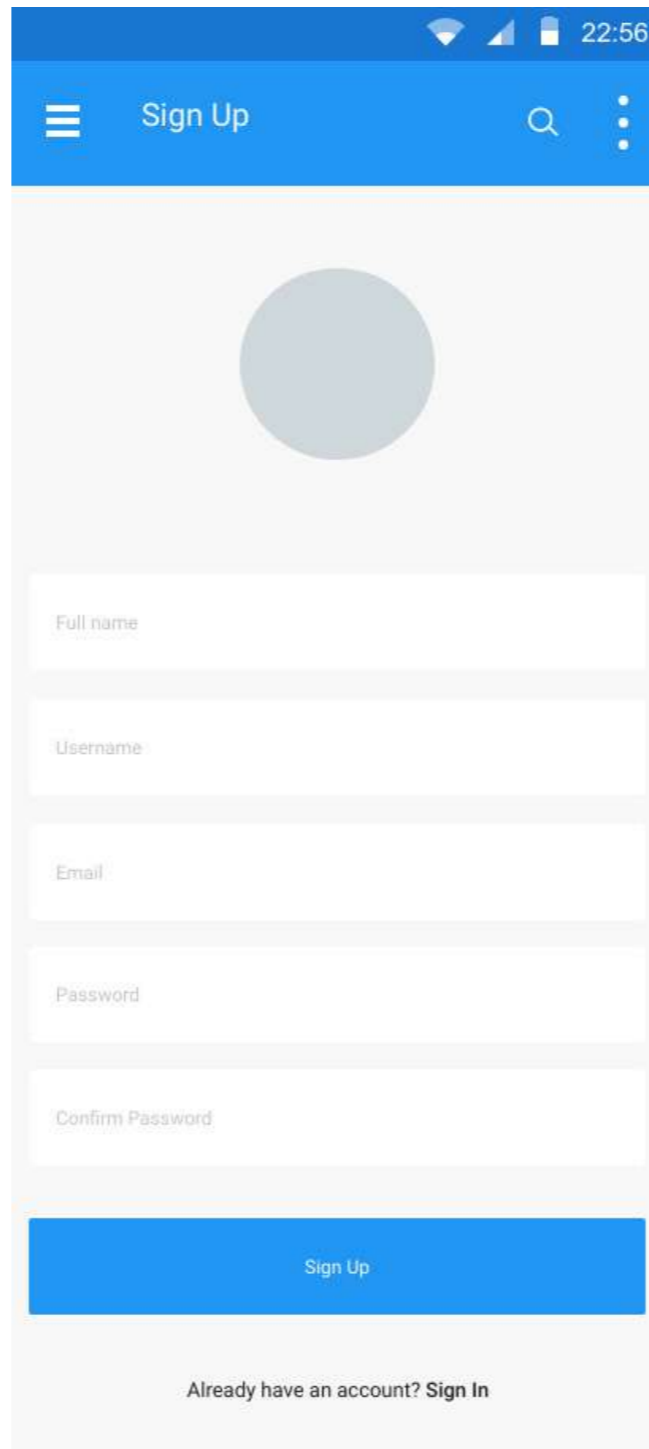
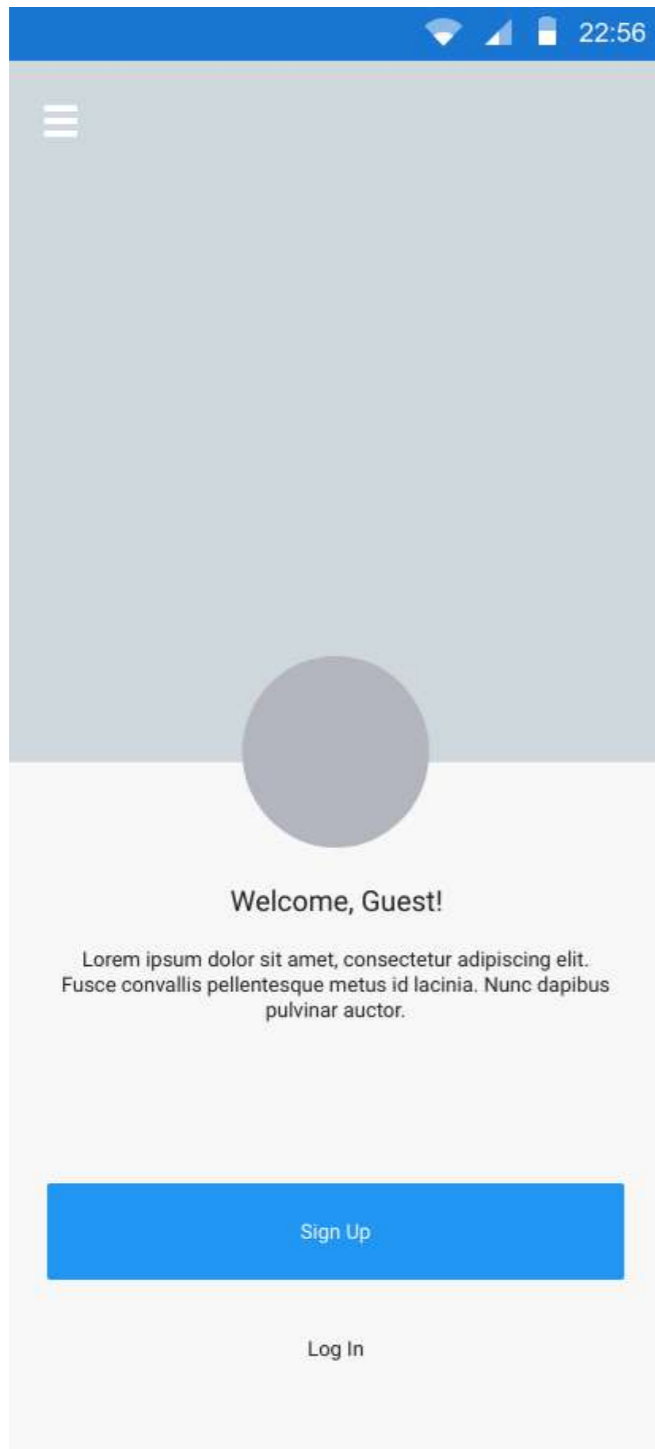
Exploring the cognitive test

Further exploring how the results are shown to the users and the option paths available once results have been shown

A - 1, A - 2

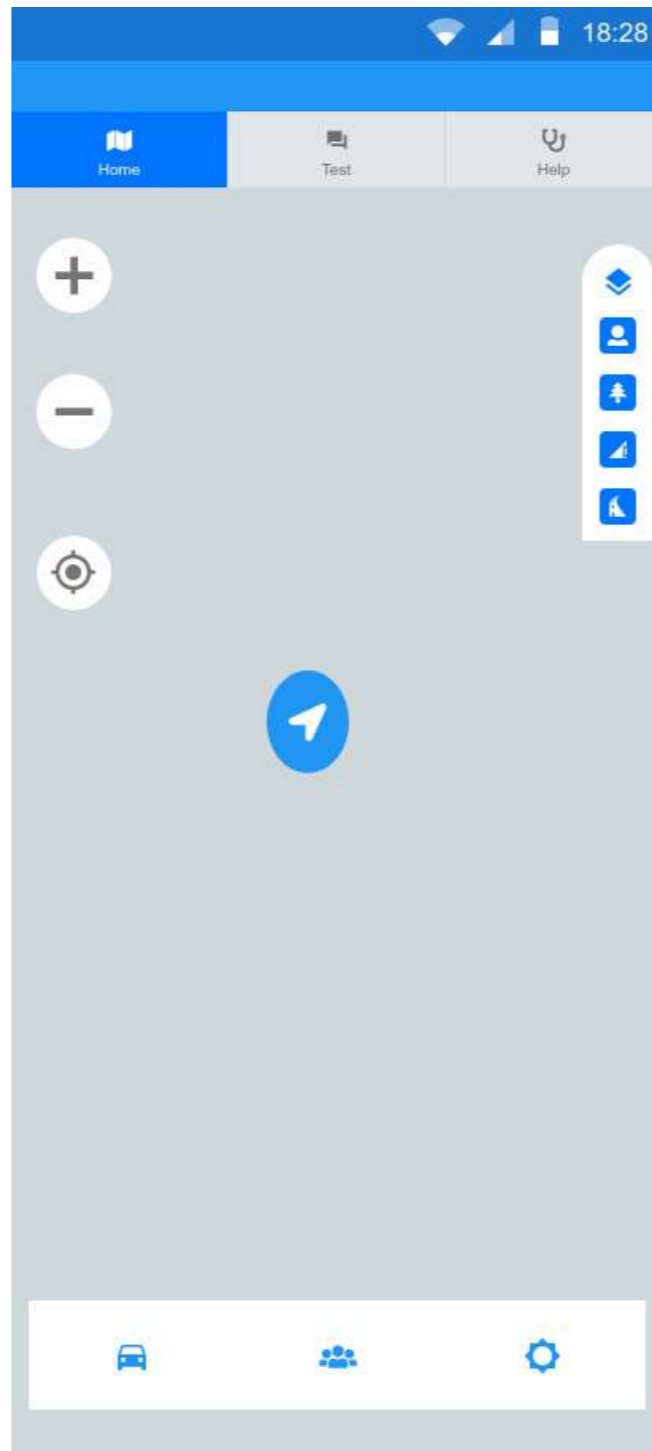
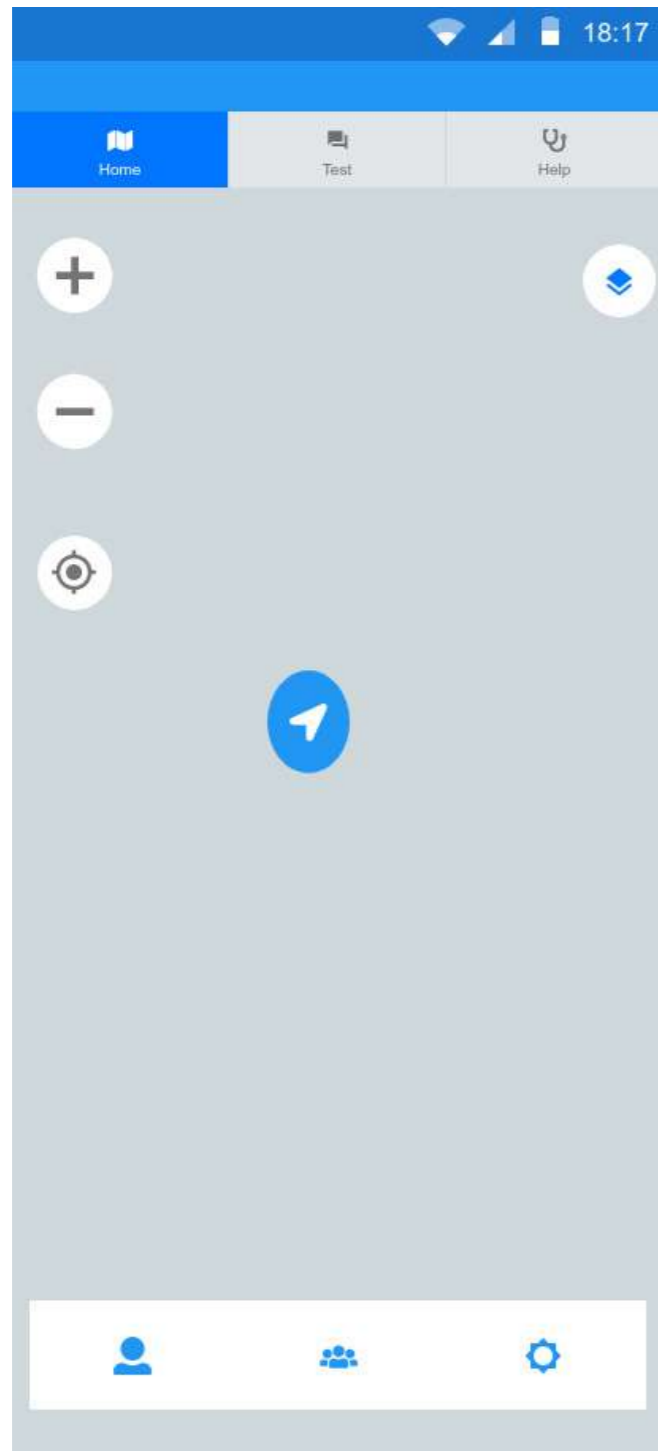


# Prototype 1

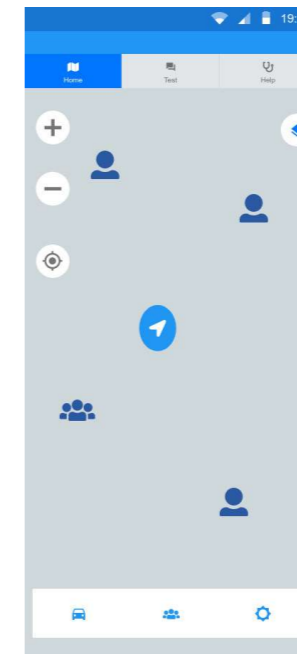


First time/one time use  
pages

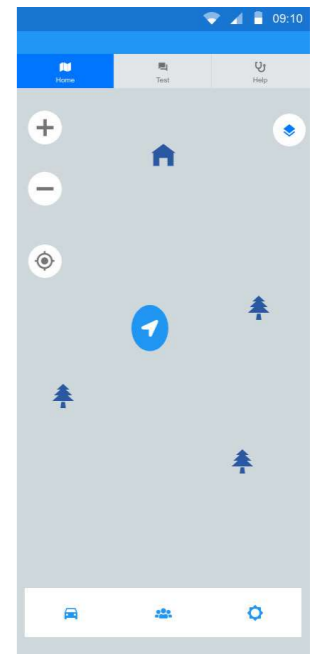
# Prototype 1



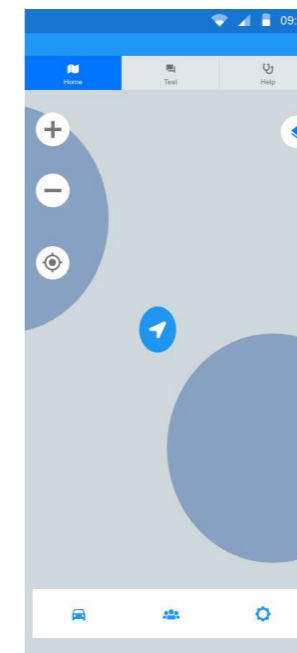
Main/Home page and options available



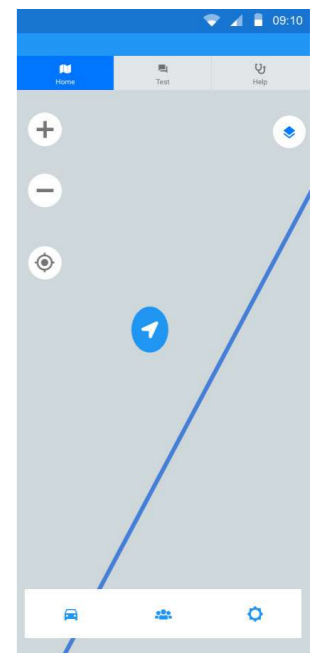
Active users



Nearest shelters

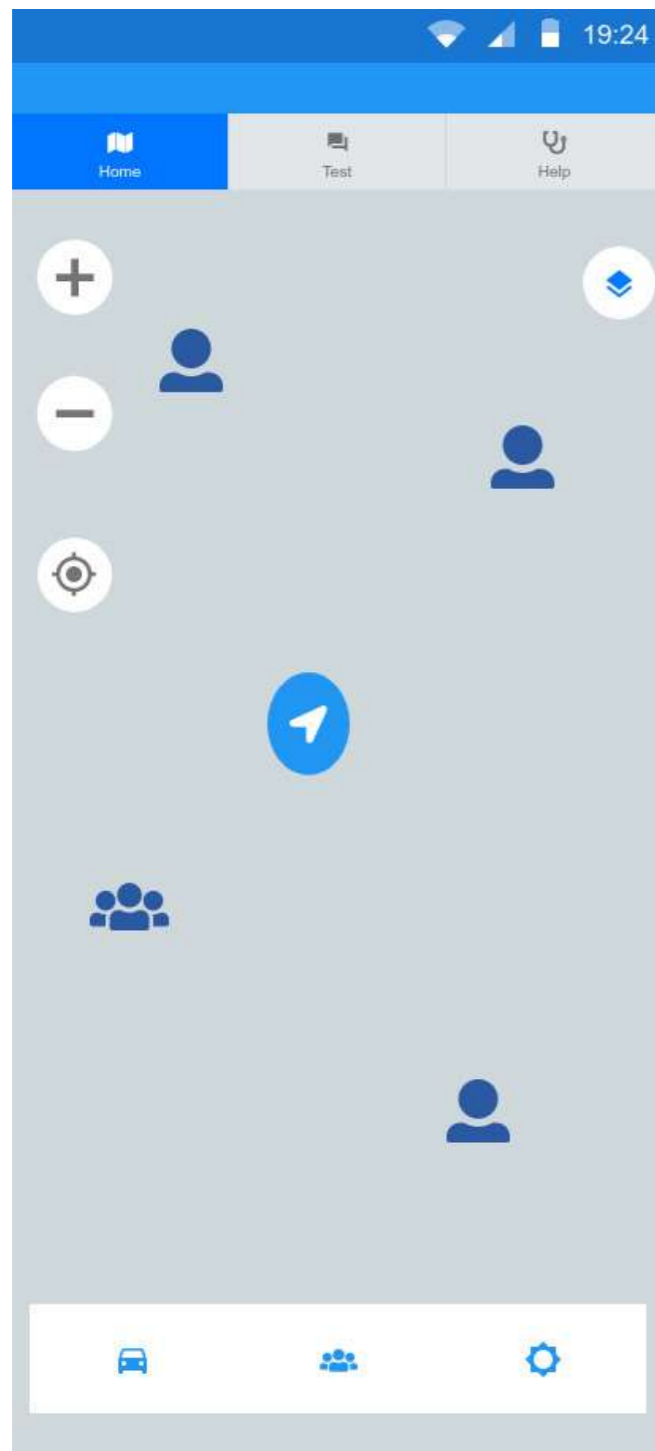


Network deadzones

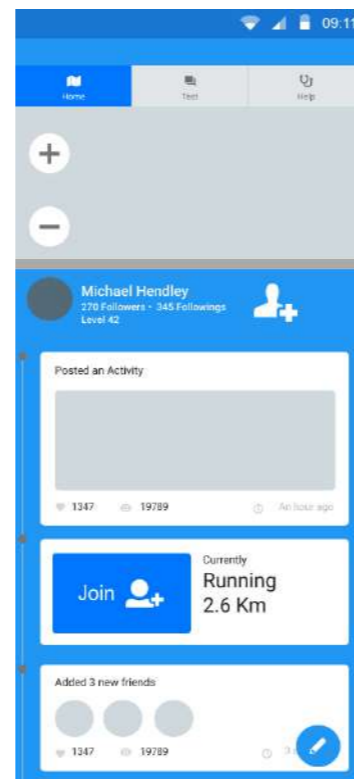


Nearest main road

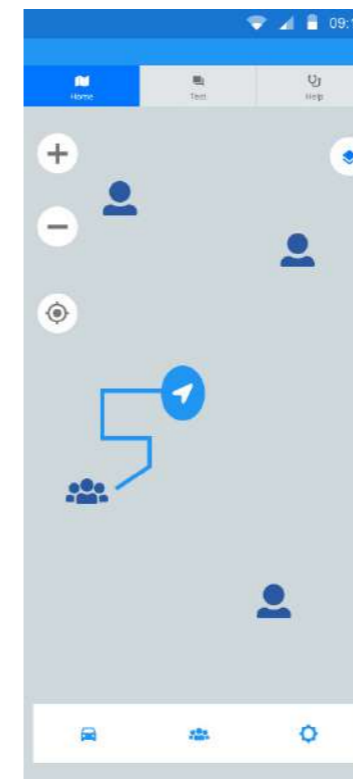
# Prototype 1



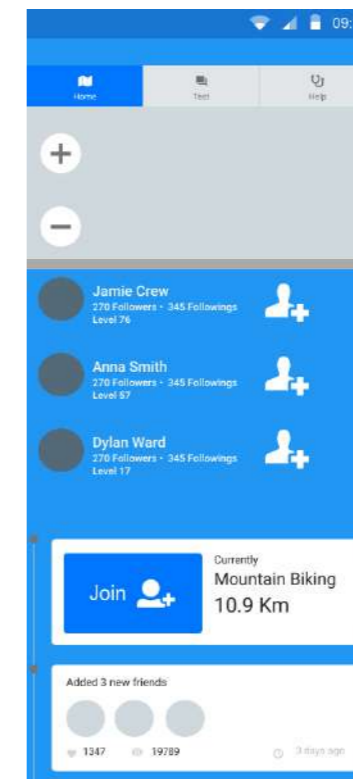
Active users



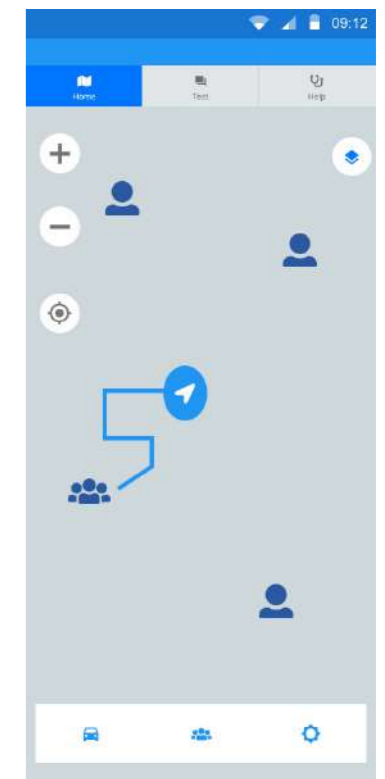
Clicking on the user on the map opens their profile preview



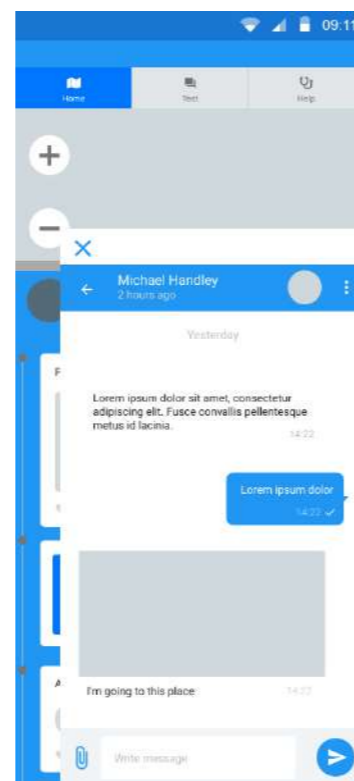
Clicking on the Join button opens the map and route to the user



Clicking on the group on the map opens their group preview



Clicking on the Join button opens the map and route to the group

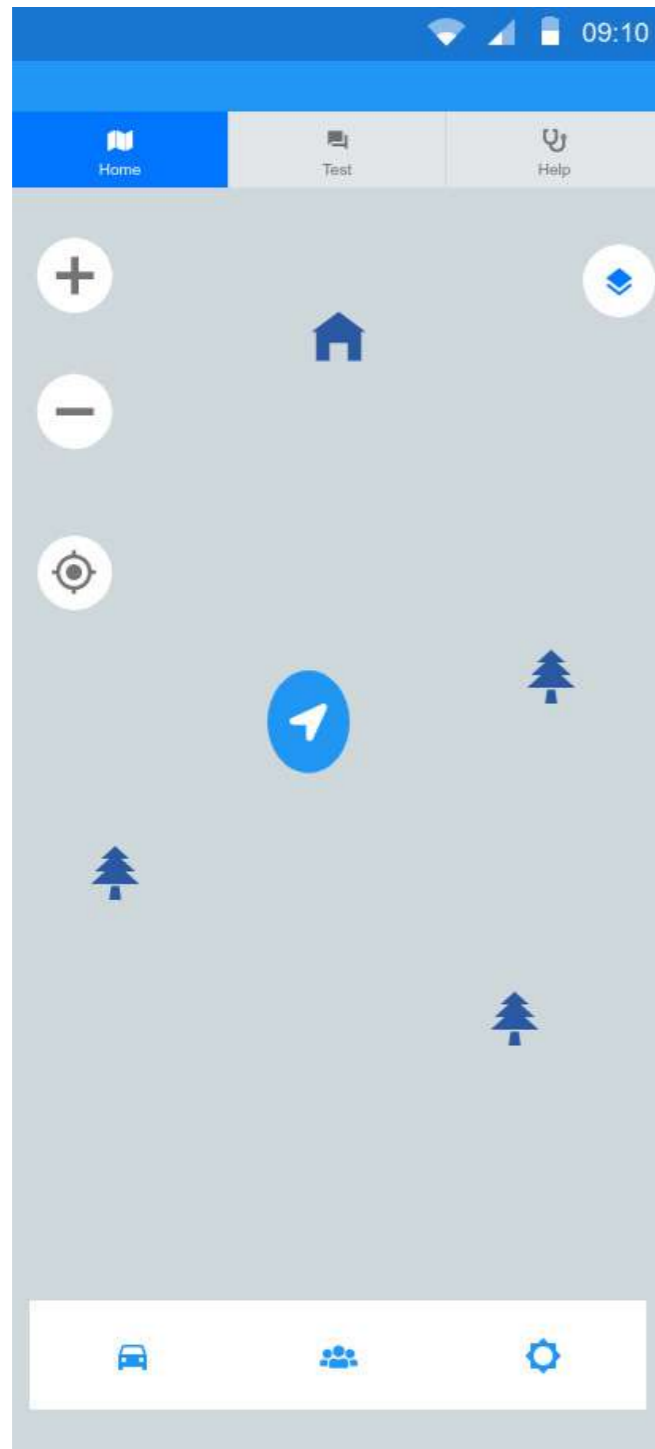


Clicking on the message button allows for contact between users

The active use page allows for users to engage with other users, befriend them and request help in times of need.

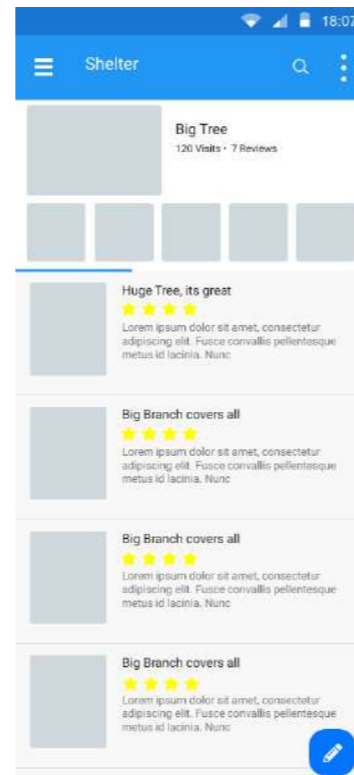
It also allows for people to request to join them on their activity as it is underway

# Prototype 1

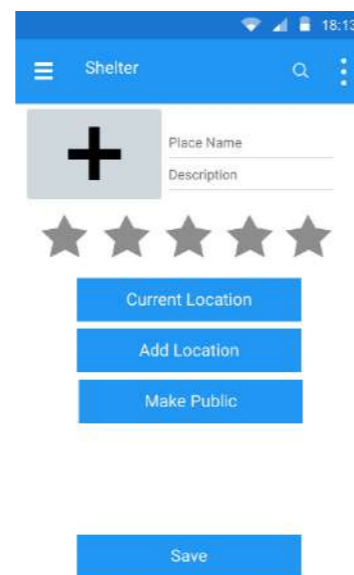


Active users

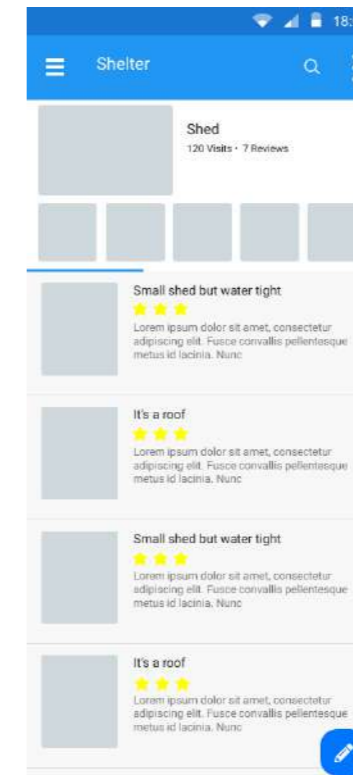
## Concept 2



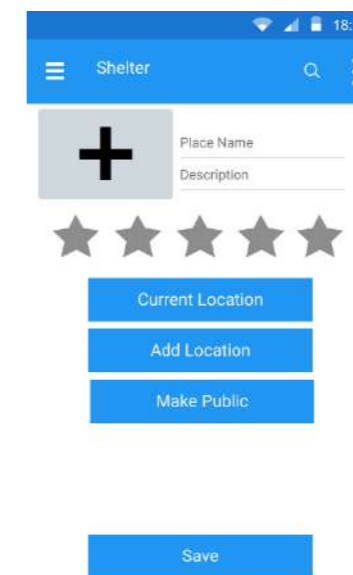
Clicking on the natural icon brings up reviews of the natural shelter



Clicking on the pen icon allows users to leave a review of the shelter

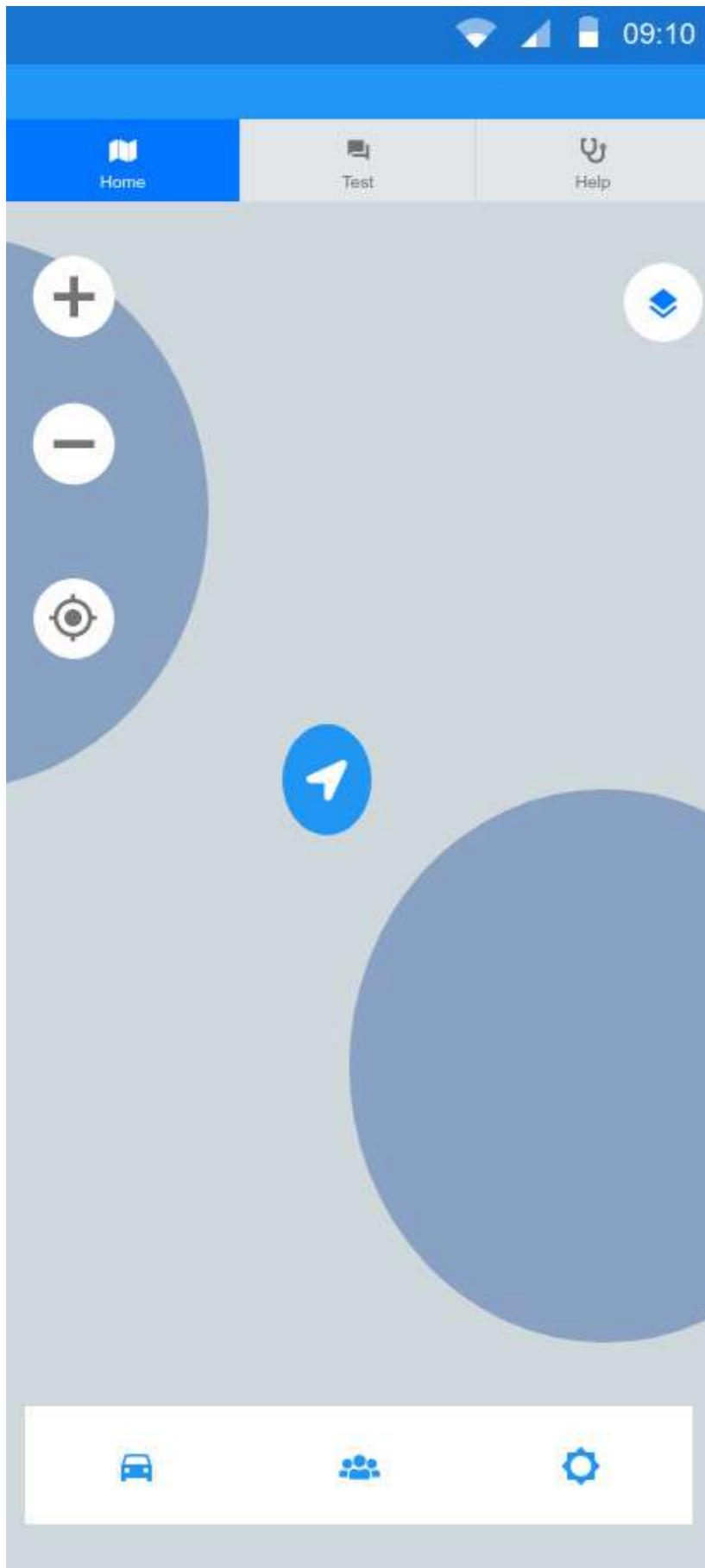


Clicking on the building icon brings up reviews of the man made shelter

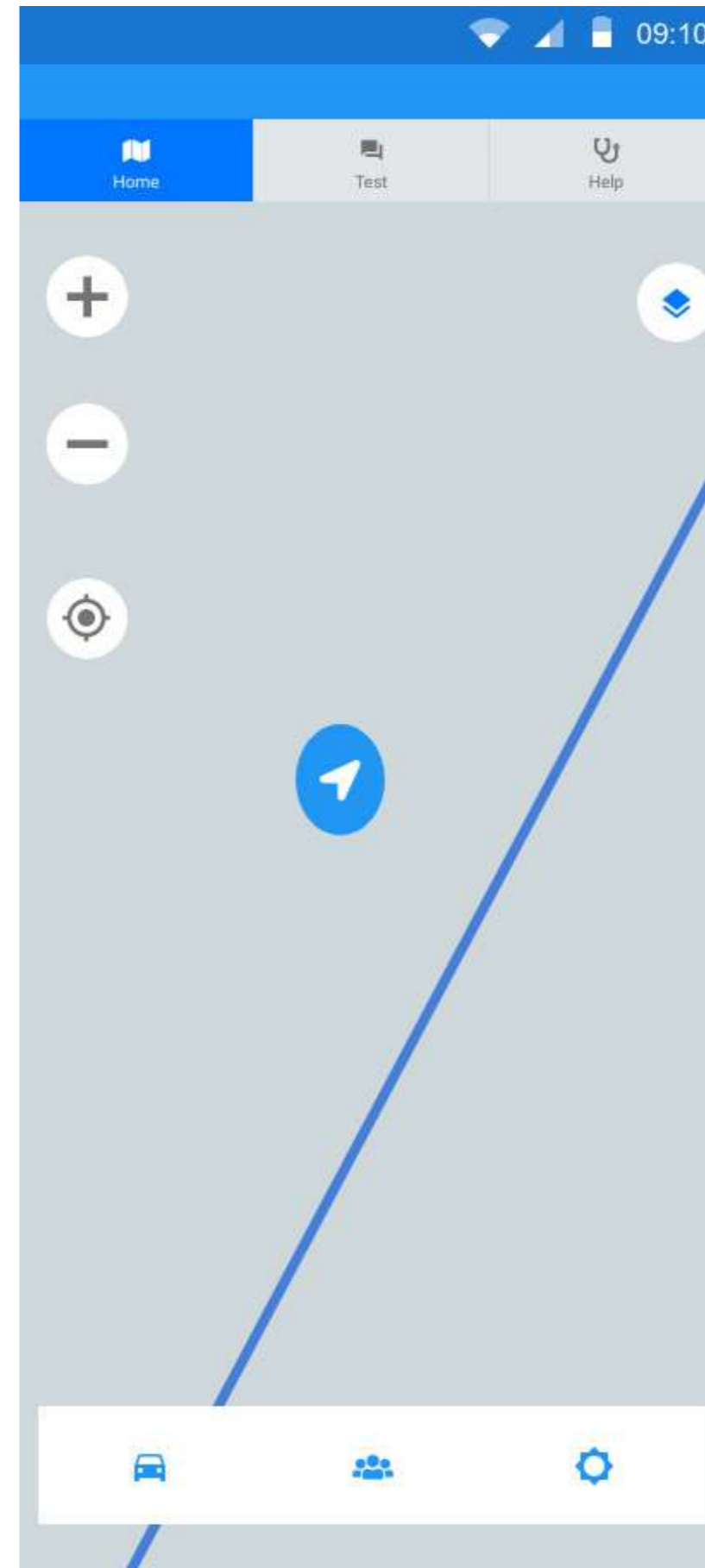


Clicking on the pen icon allows users to leave a review of the shelter

# Prototype 1



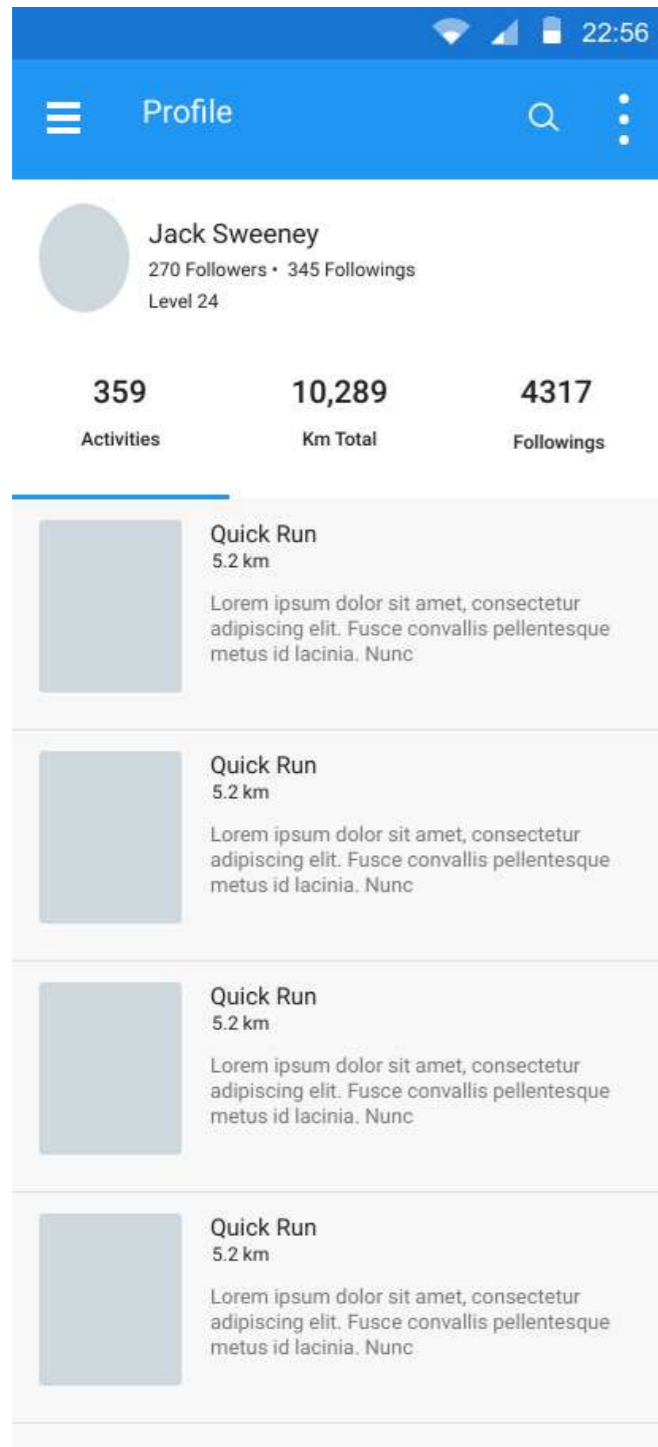
Filter option shows network deadzones



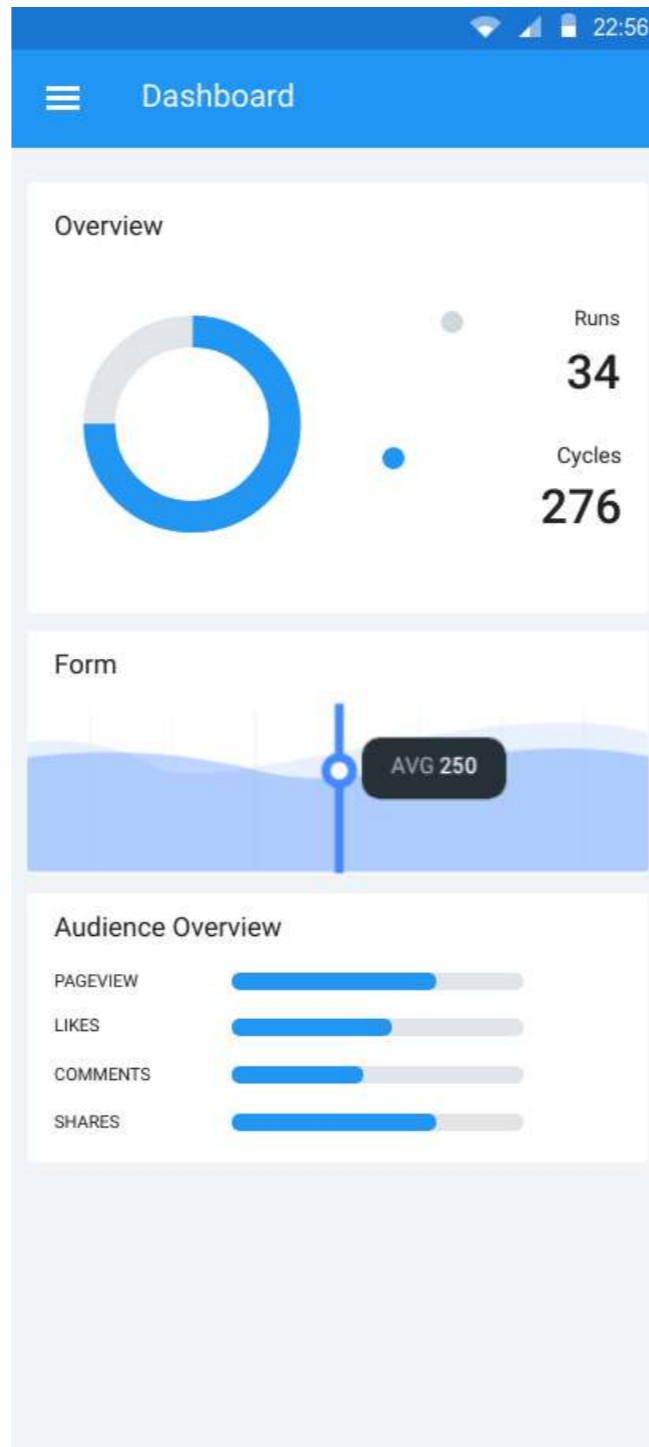
Filter option shows nearest main road

Concept 2

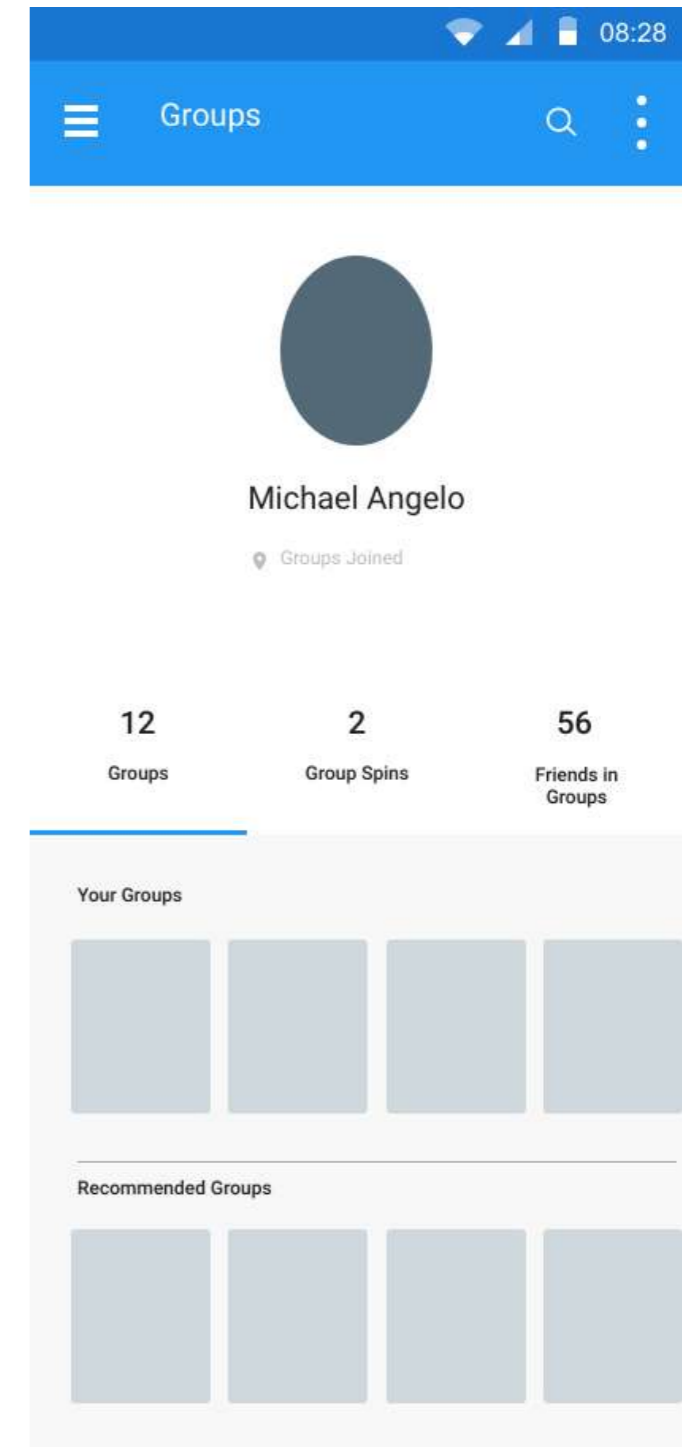
# Prototype 1



Users profile

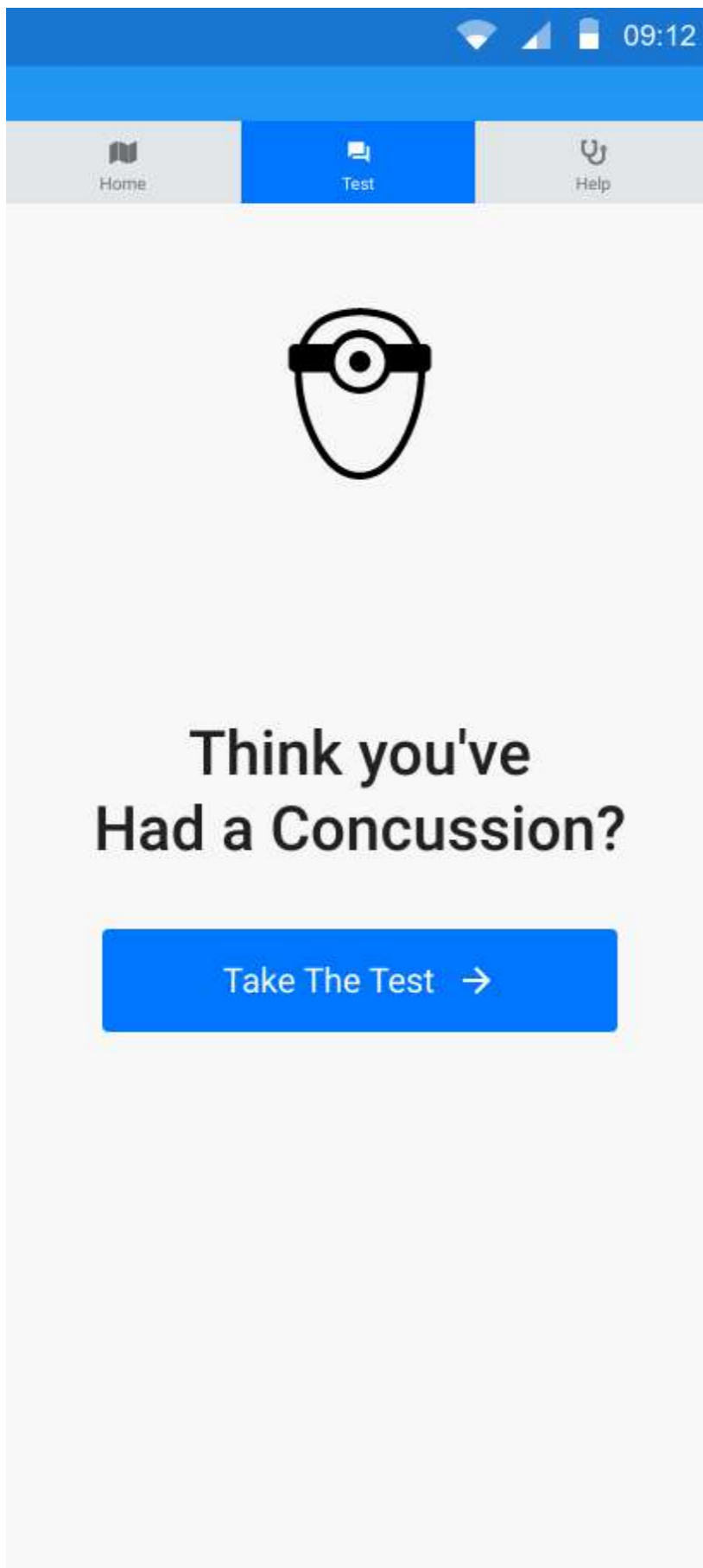


Users stats

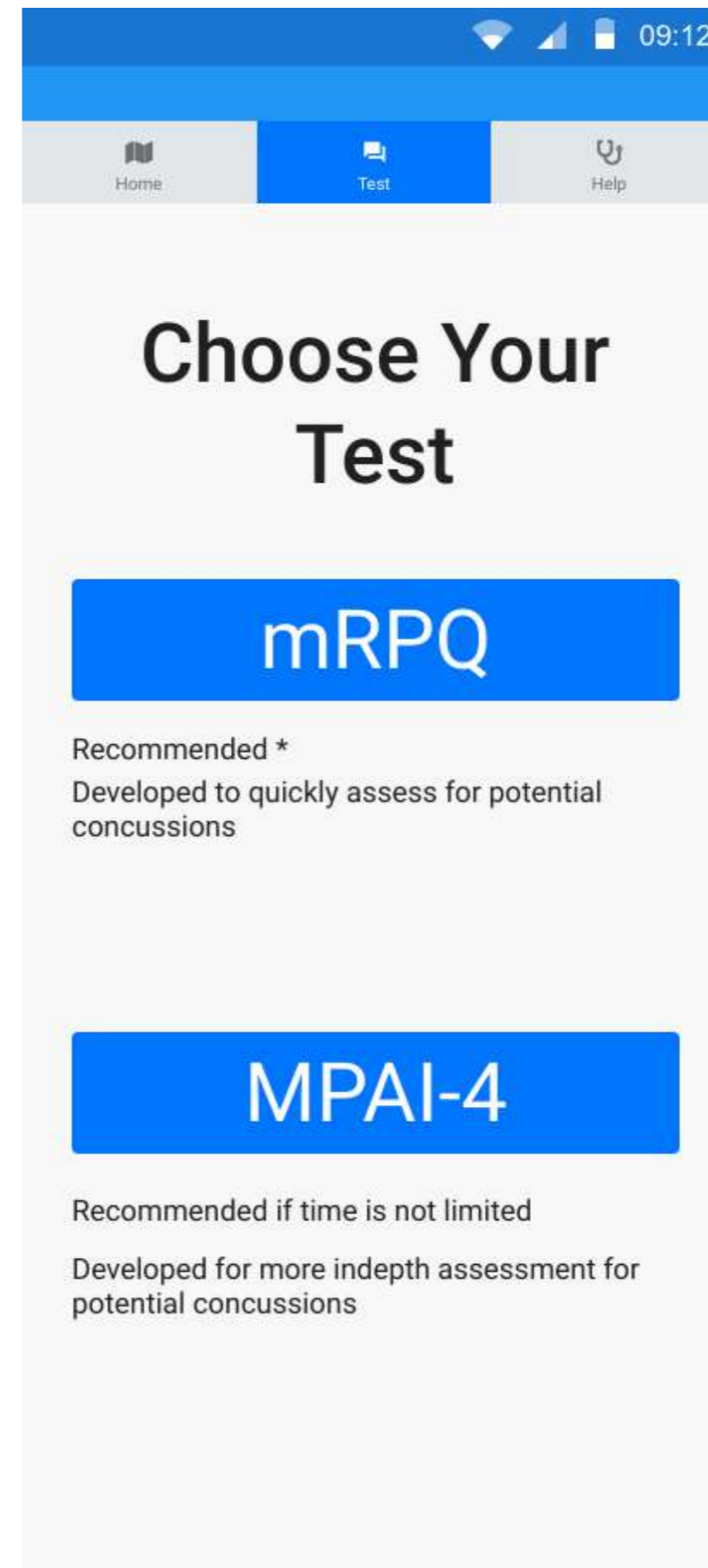


Groups the user is active in along with suggested ones

# Prototype 1

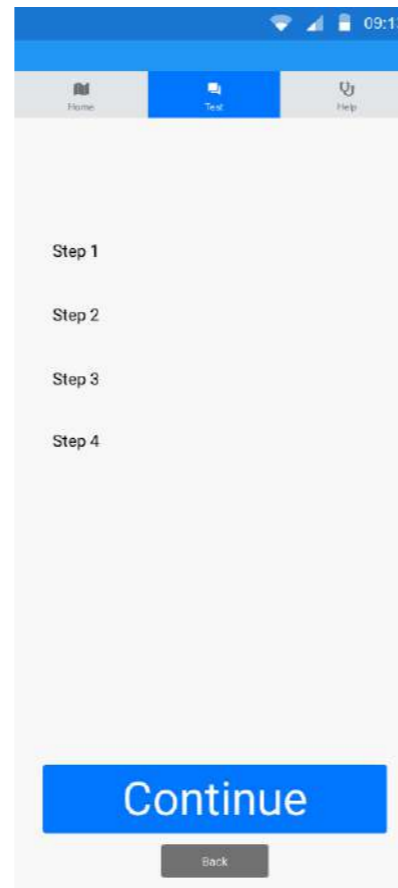
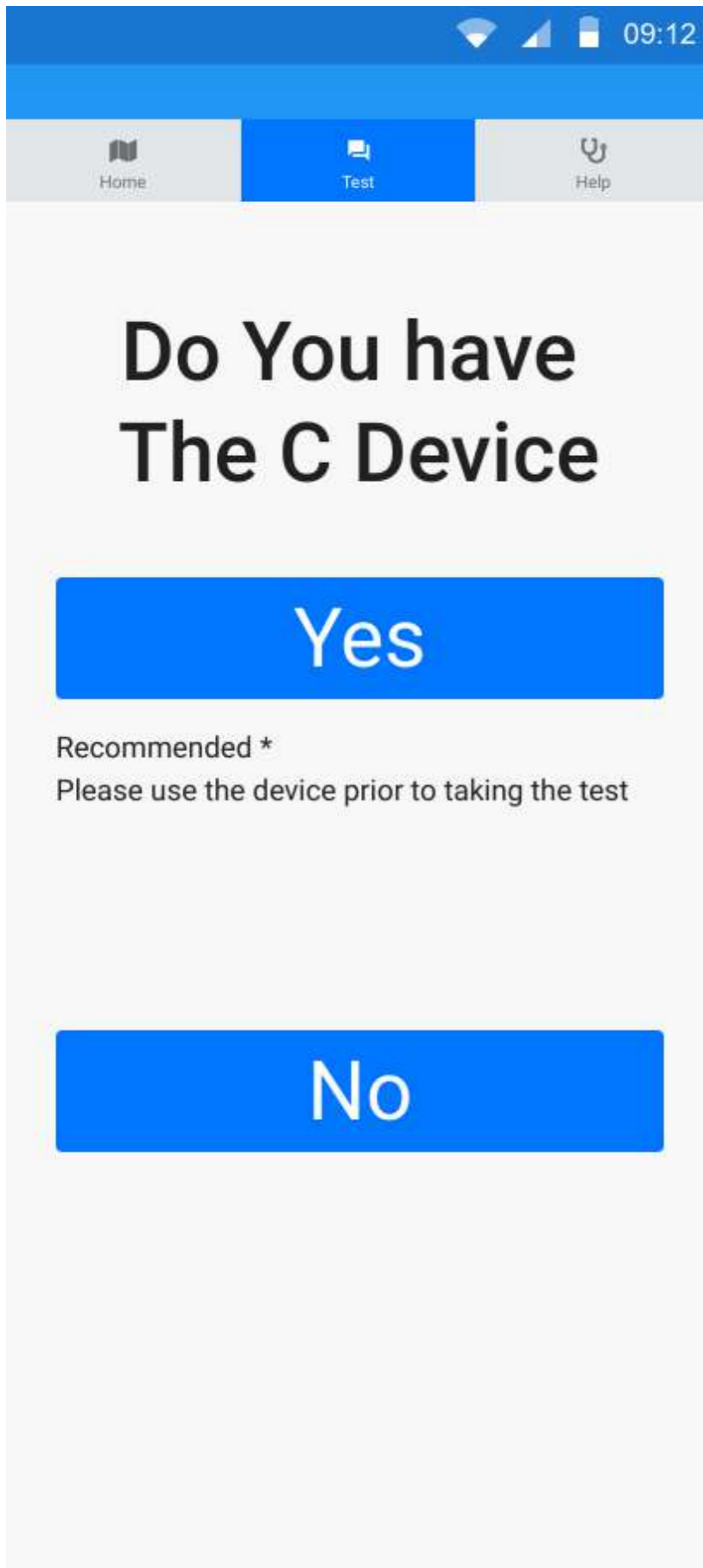


## Concept 2

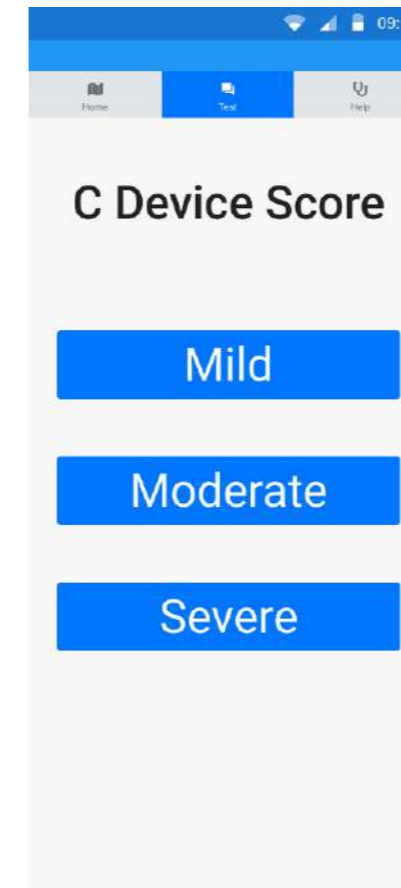


Options available to the user depending on time sensitivity

# Prototype 1



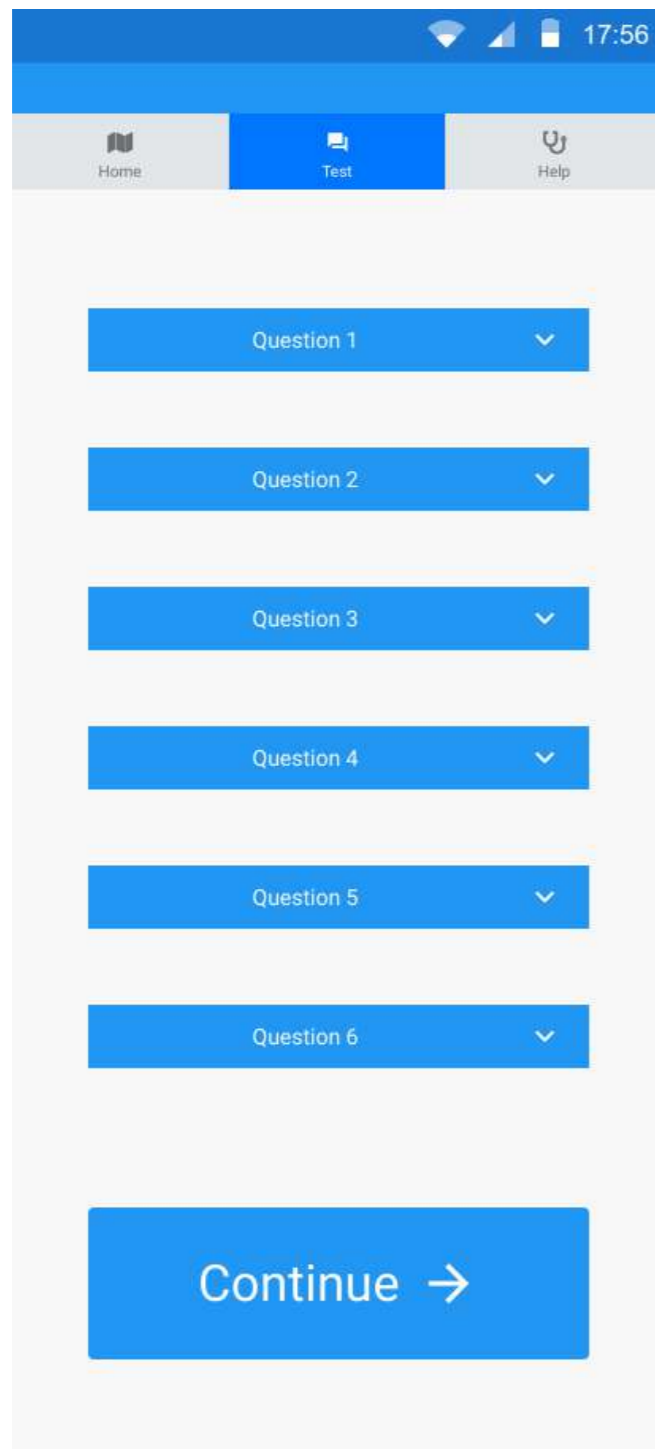
If the user has a physical detection kit, they are advised and instructed to use it



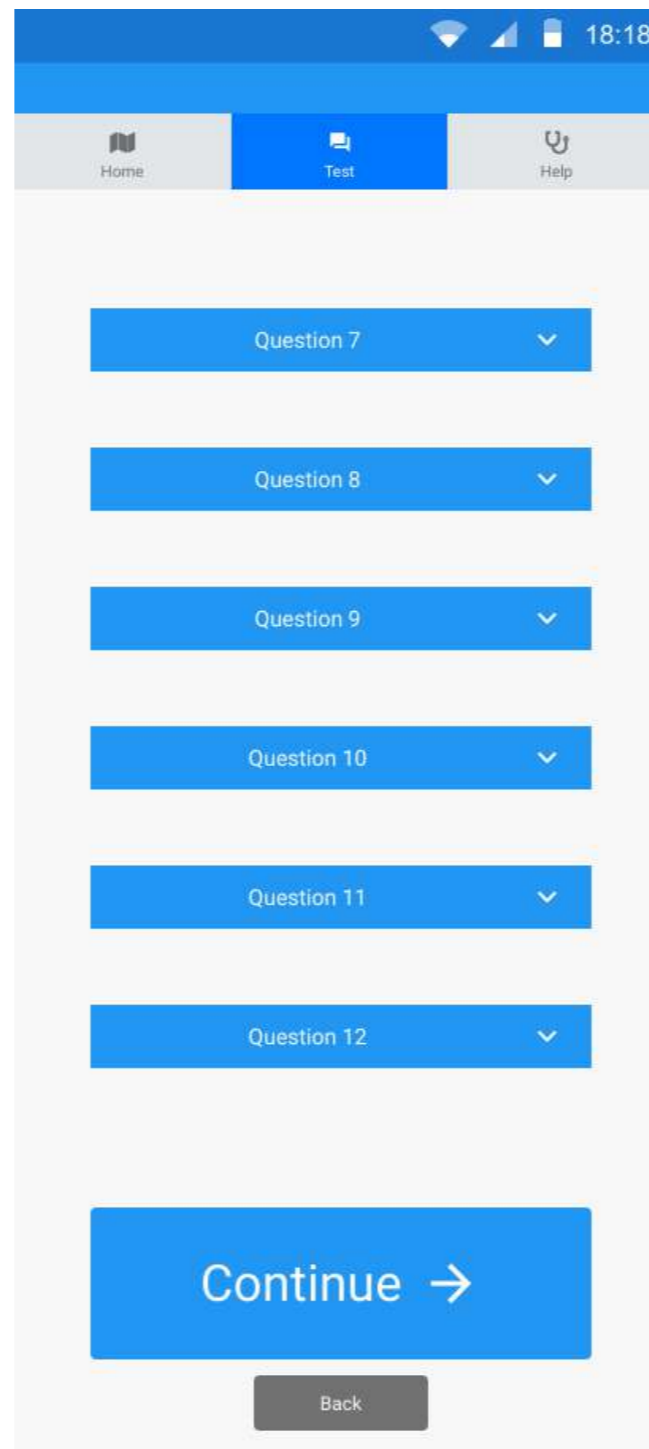
The results of the test are to be inputted in order to give a more accurate result and testing procedure



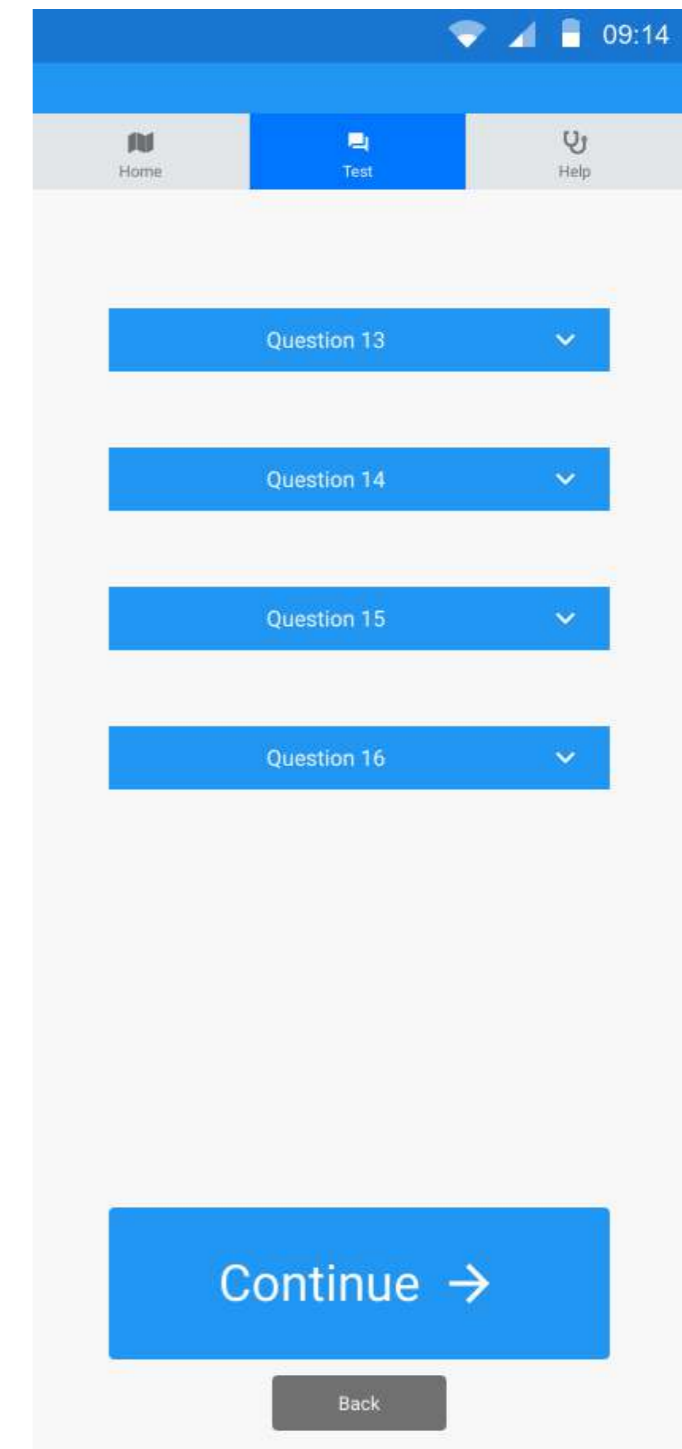
# Prototype 1



Page 1 of testing

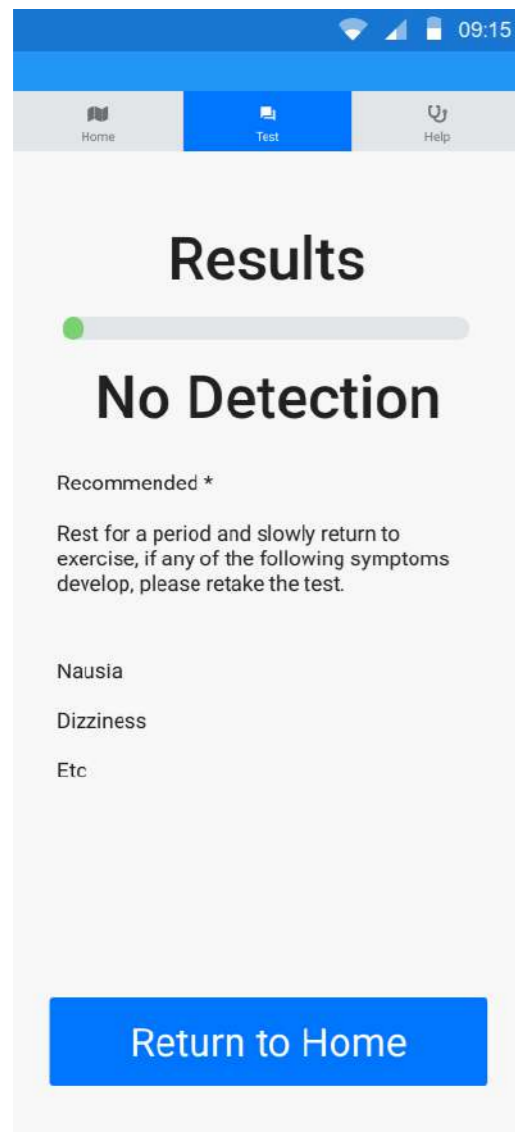


Page 2 of testing



Page 3 of testing

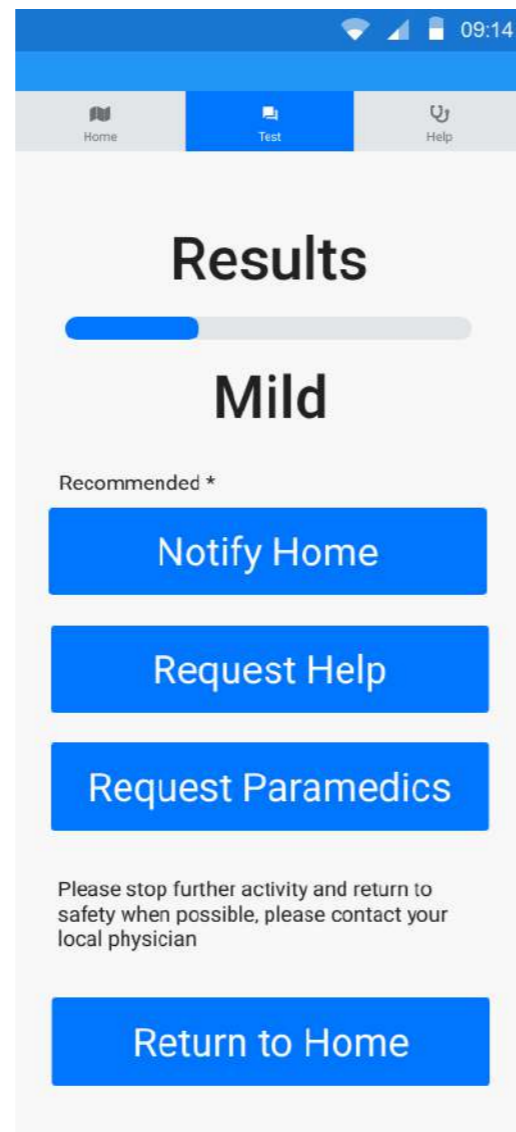
# Prototype 1



No detection

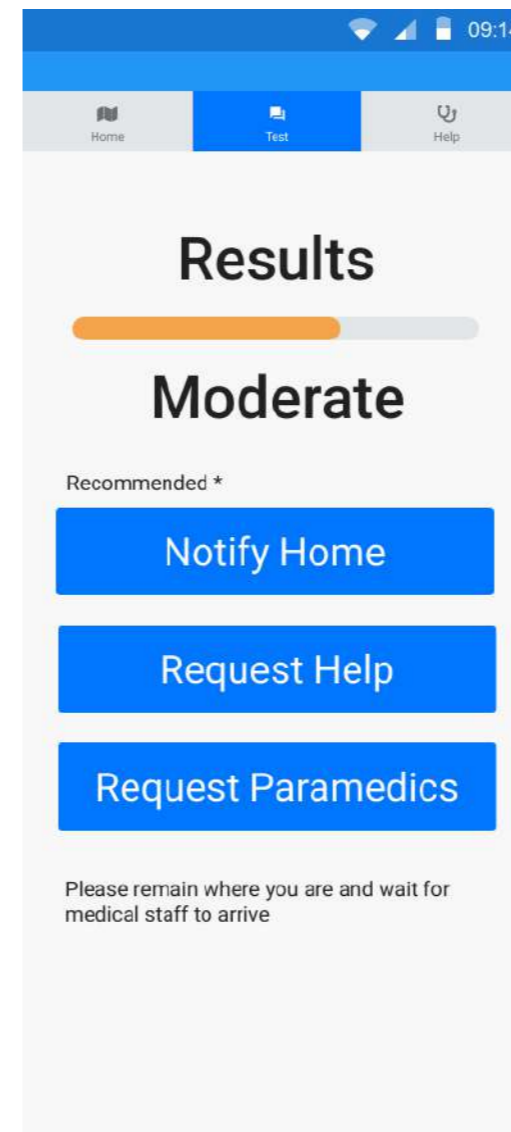
The user is advised to redo the test if they have the following symptoms but otherwise return to home

## Concept 2



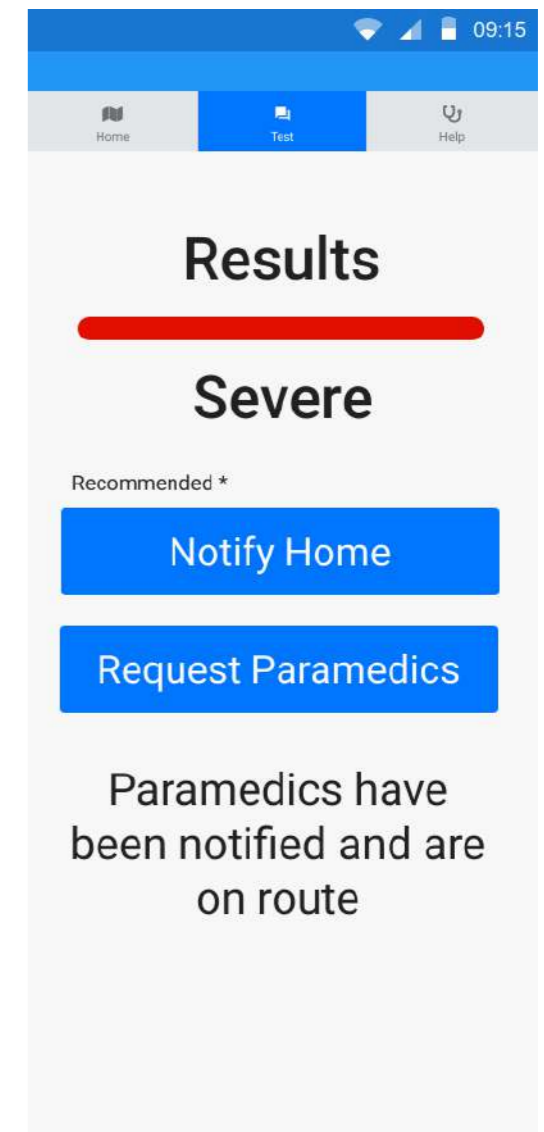
Mild Concussion

The user is advised to notify home, stop their activities and return to a safe space



Moderate Concussion

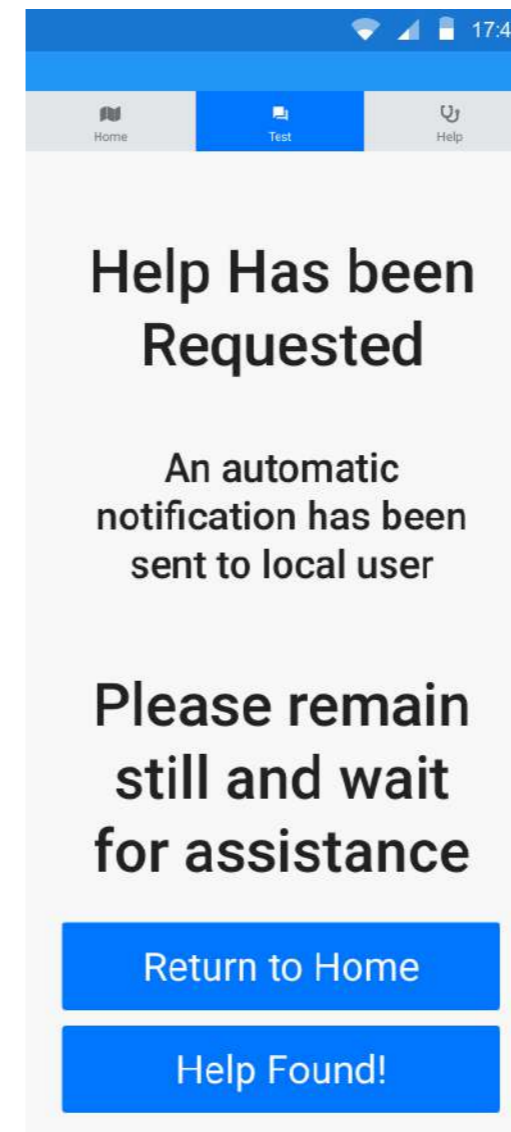
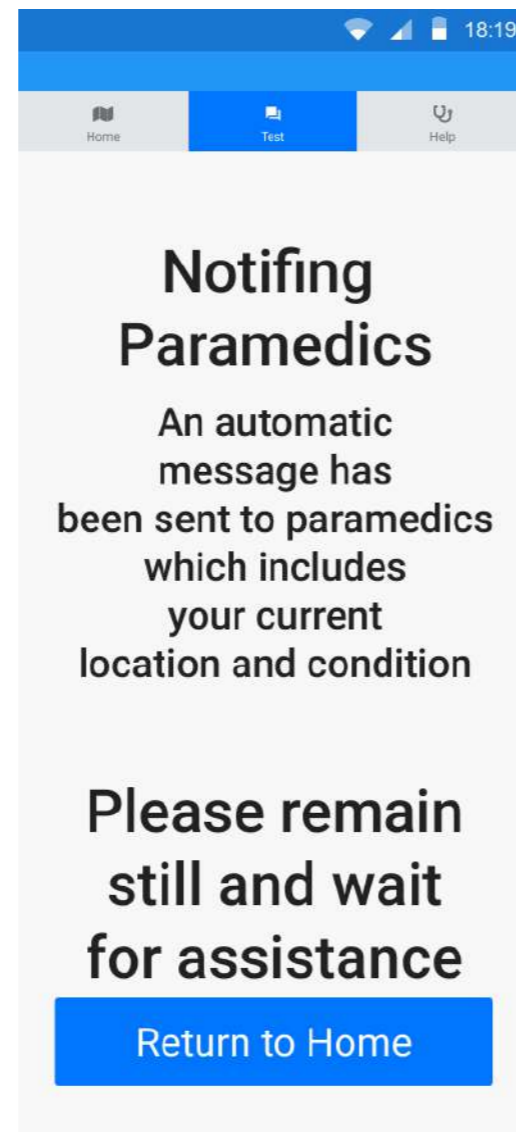
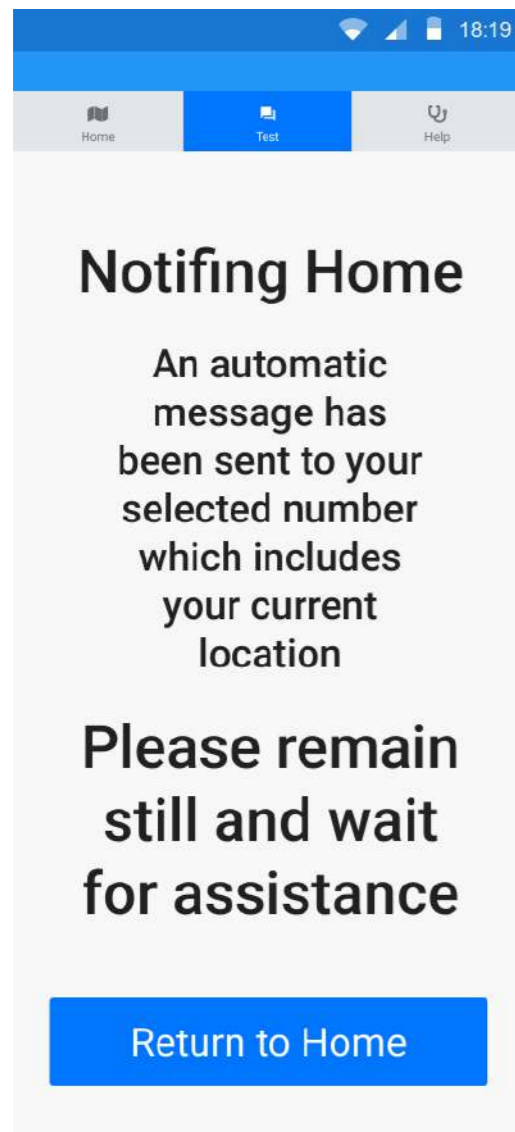
The user is advised to remain where they are and notify paramedics of their condition



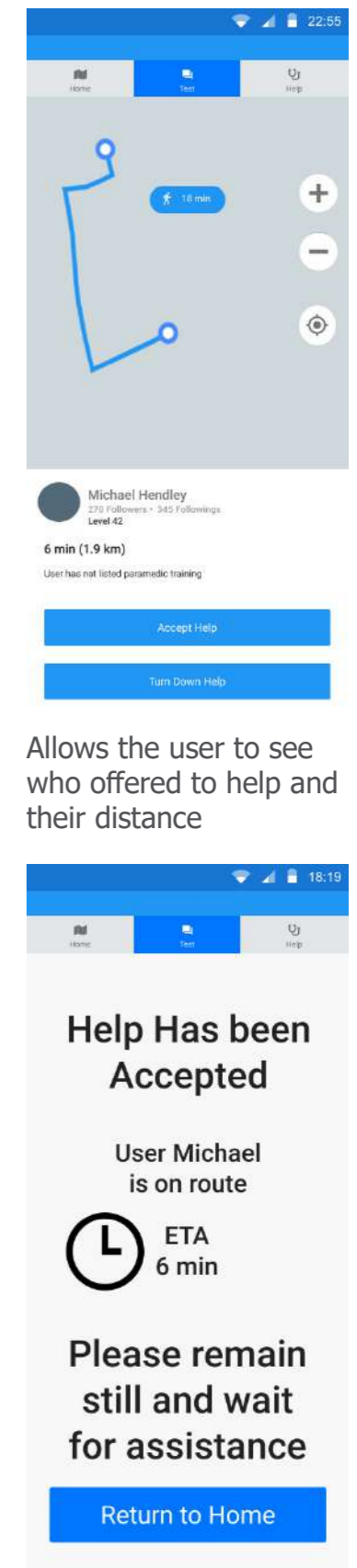
Moderate Concussion

The paramedics and the users emergency contact are notified of their condition and location

# Prototype 1



If the user request help, an alert will be sent to all active users in the area for assistance, once a helpful user responds, the user can see their profile and accept or decline the help



Once accepted, the user is given an estimated time of arrival for the help

# Testing Methods

## How

The prototype was tested by 3 users, as there were restrictions brought on by the Covid 19 pandemic.

The processes of engaging with the social aspect, taking a test, requesting help and exploring one of auxiliary use of the app were tested.

### Tasks

- Request to join a fellow runner
- Take a test and follow the instructions
- Request help from a fellow app user
- Add a new shelter to the community shelters page

## What

The users were then asked a number of set questions in order to evaluate the usability of the concept and ways to improve the concept.

These questions were as followed

1. Were any of the tasks difficult to do?
2. Was the app easy to navigate?
3. Could you take the test with ease
4. Did you find the app intuitive to use?
5. Is there anything you would change in the app?

## Why

- Were any of the tasks difficult to do?  
To determine the ease of use of the app
- Was the app easy to navigate  
To determine the usability of the app and its UX components
- Could you take the test with ease  
To determine if the test could be completed by a user that may be compromised
- Did you find the app intuitive to use  
To determine the device's inherent understandability
- Is there anything you would change in the app  
To determine changes the users want that may not be picked up during testing

# Prototype Testing

Male  
23

Ultra-marathon Runner

Female  
20

Mountain Biker

"I've no clue what mRPQ or MPAI is?"

"Why would I notify paramedics if they are already on route?"

"The images and icons are a little small to see and press"

"How do I get help?"

[Design History File - 2. Verification - Testing Results - App Prototype Test 1](#)

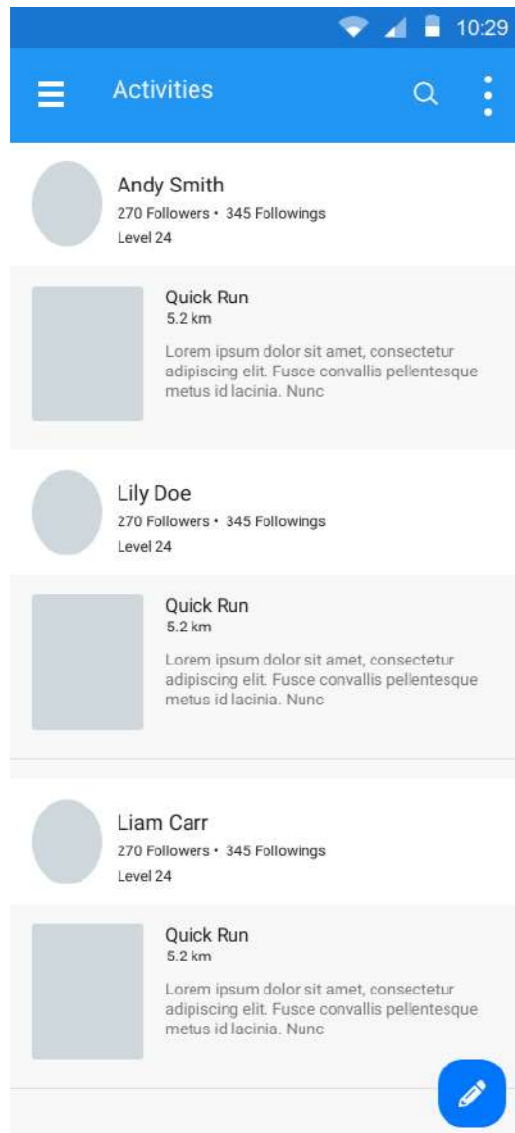
## Key changes to be made

Language used

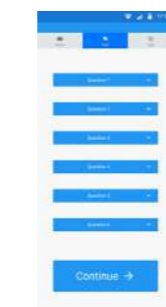
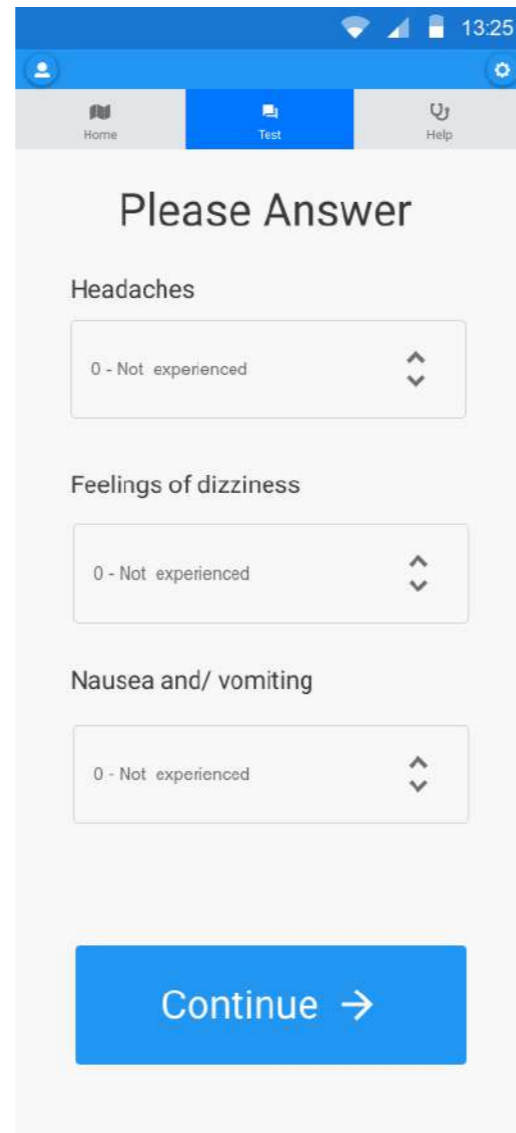
Questions changed for each level of concussion

Change icon size and interactions

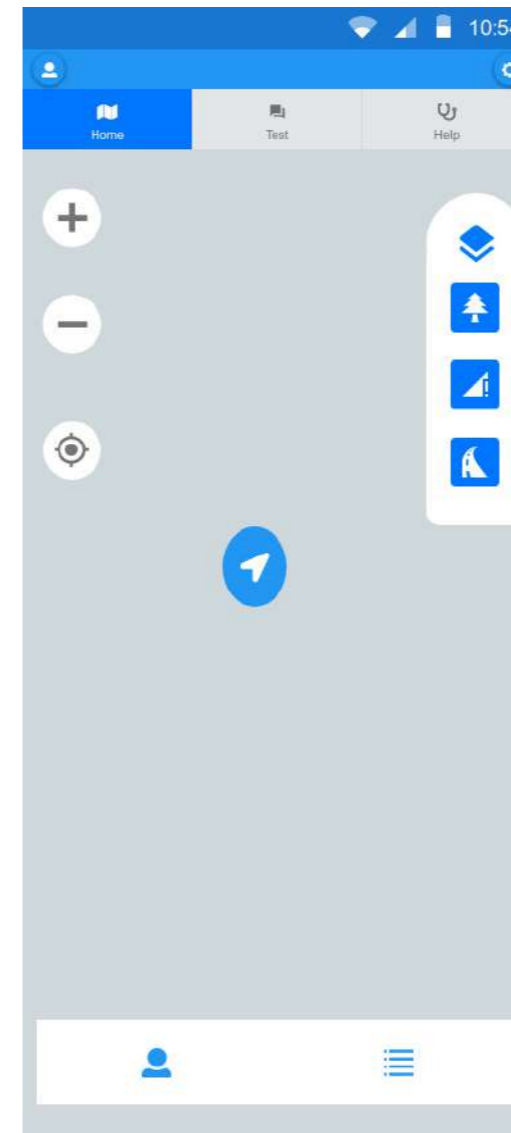
# Prototype 2



An activities page was added to the app to allow users to see other past activities



The questions were layed out in a simpler for allowing for easier reading and clearer answering



The filters section was increased for readability and the other user section was changed to the bottom row of actions

# Testing Methods

## How

The prototype was tested by 3 users, as there due to the restrictions brought on by the Covid 19 pandemic.

The processes of engaging with the social aspect, taking a test, requesting help and exploring one of auxiliary use of the app were tested.

### Tasks

- Request to join a fellow runner
- Take a test and follow the instructions
- Request help from a fellow app user
- Add a new shelter to the community shelters page

## What

The users were then asked a number of set questions in order to evaluate the usability of the concept and ways to improve the concept.

These questions were as followed

1. Were any of the tasks difficult to do?
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4. Did you find the app intuitive to use?
5. Is there anything you would change in the app?

## Why

- Were any of the tasks difficult to do?  
To determine the ease of use of the app
- Was the app east to navigate  
To determine the usability of the app and its UX components
- Could you take the test with ease  
To determine if the test could be completed by a user that may be compromised
- Did find the app intuitive to use  
To determine the devices inherent understandability
- Is there anything you would change in the app  
To determine changes the users want that my not be picked up during testing

# Prototype Testing

Male  
23

Ultra-marathon Runner

Female  
20

Mountain Biker

"the request to join a follow runner was a bit trickier this time"

"it looks a bit dull, is there any way to make it look nicer?"

"Maybe move the maps, test and help section to see if its easier to navigate"

[Design History File - 2. Verification - Testing Results - App Prototype Test 2](#)

## Key changes to be made

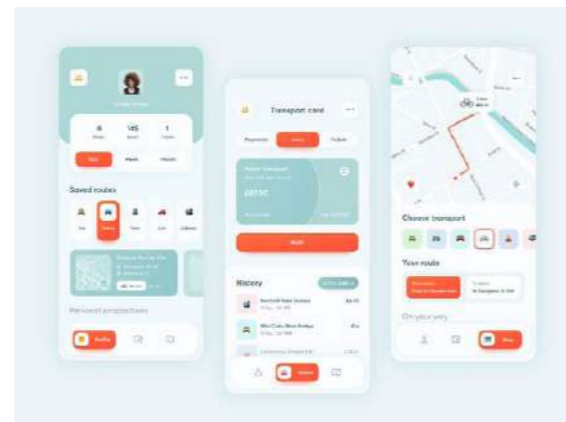
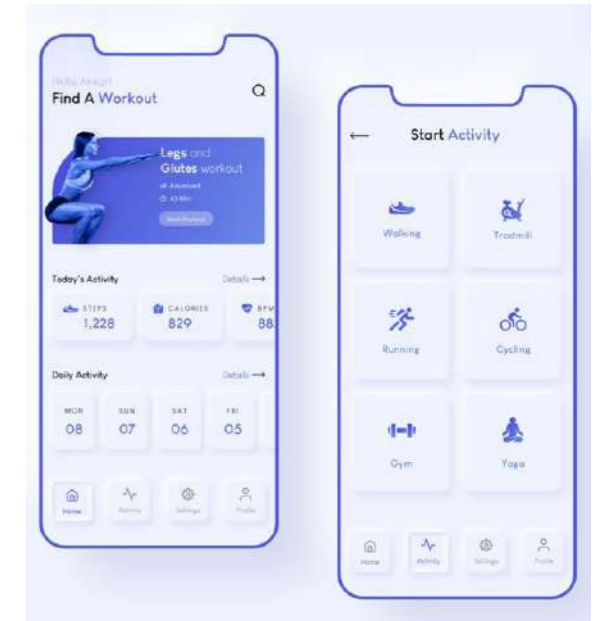
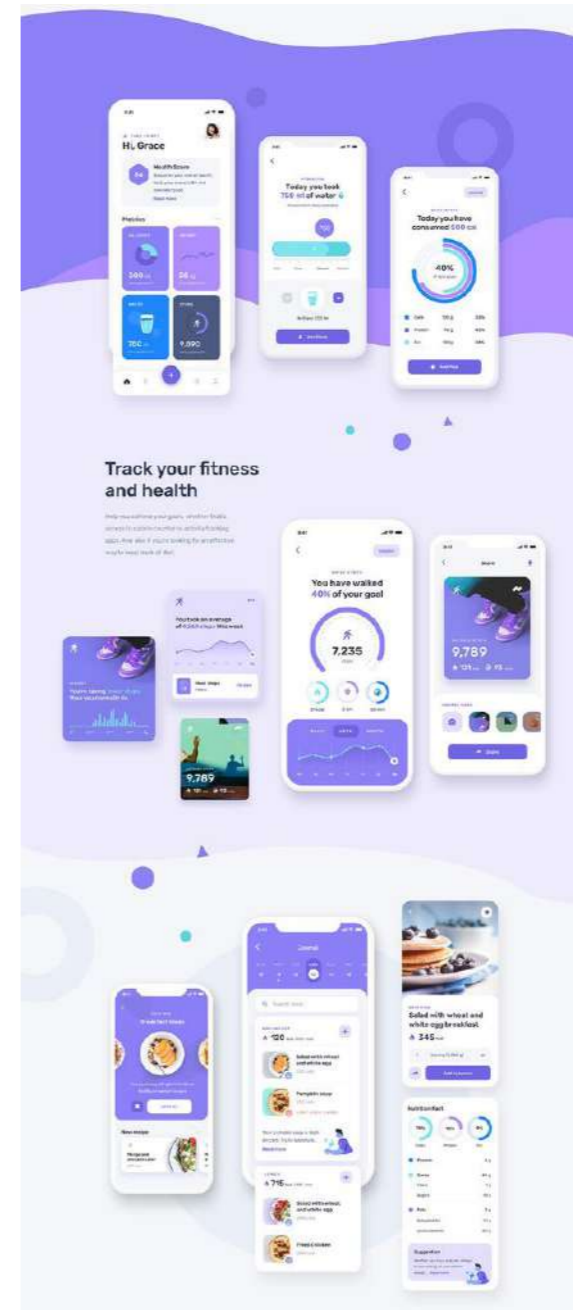
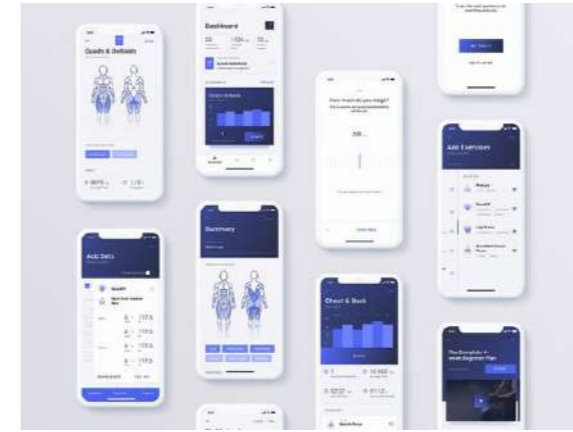
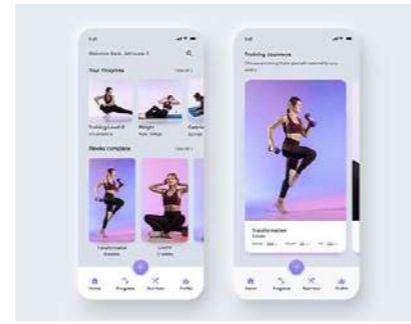
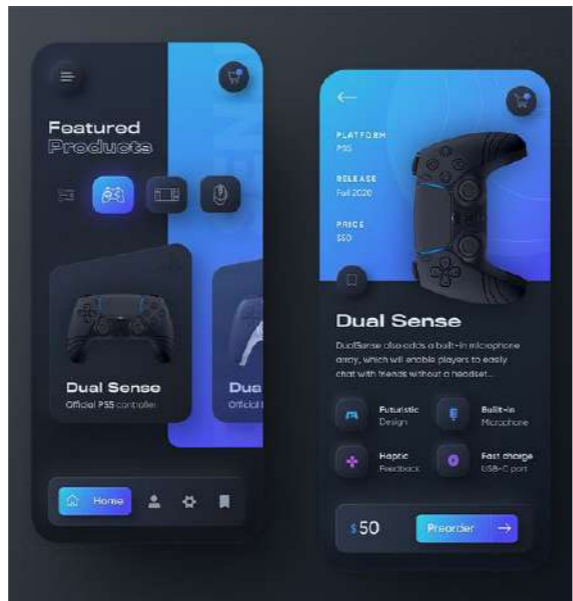
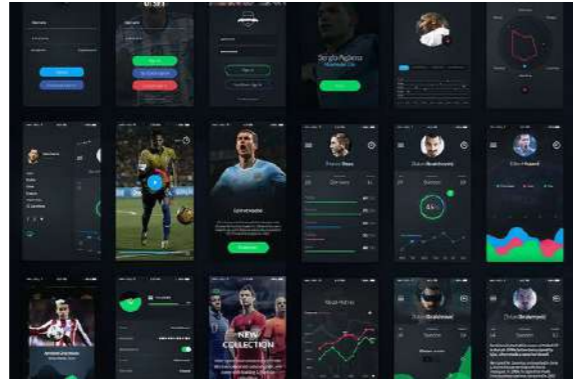
Change up the appearance of the app to something a bit more modern

but still easy to use

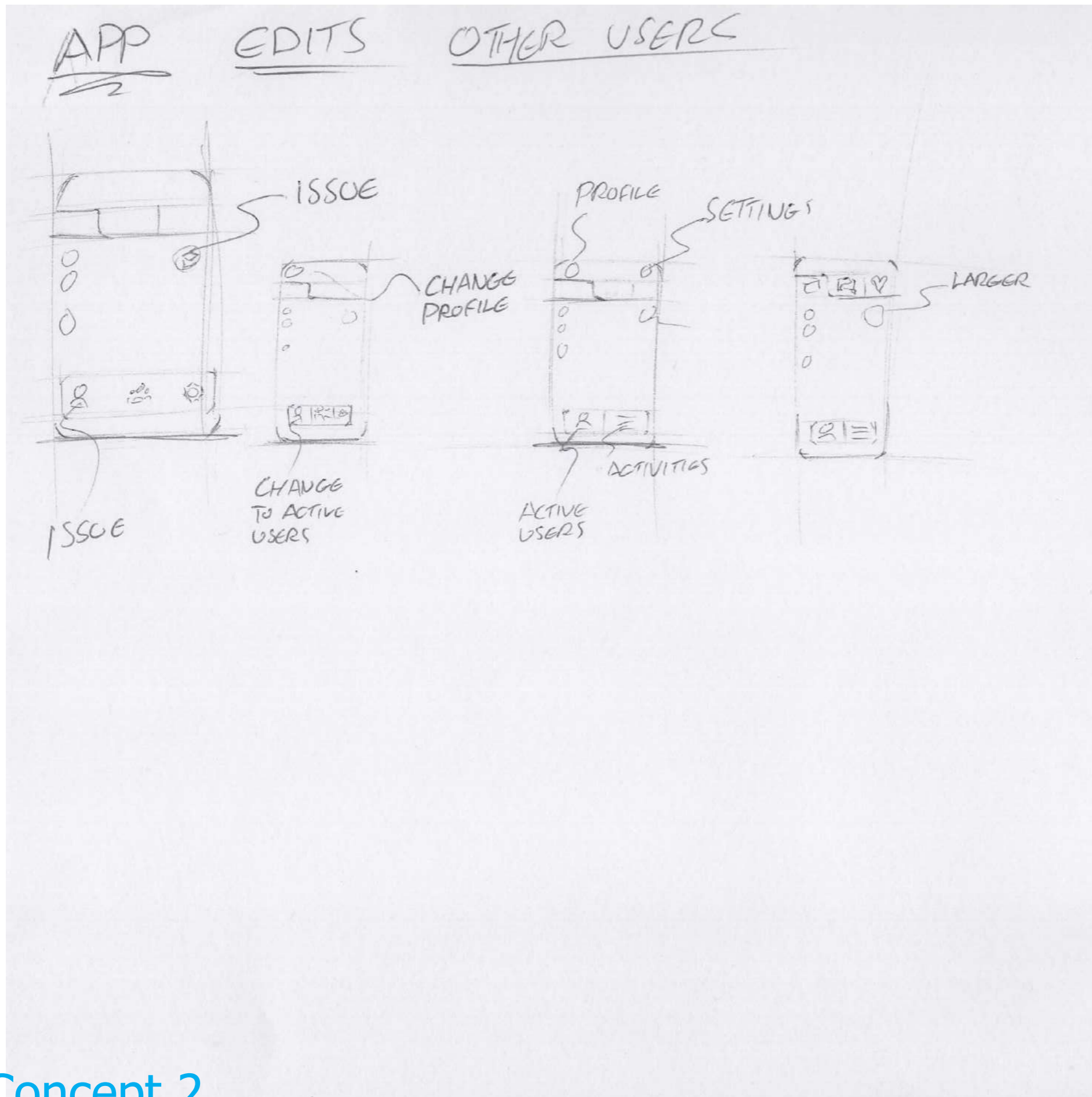
Explore the navigation menu placement



# Style Board

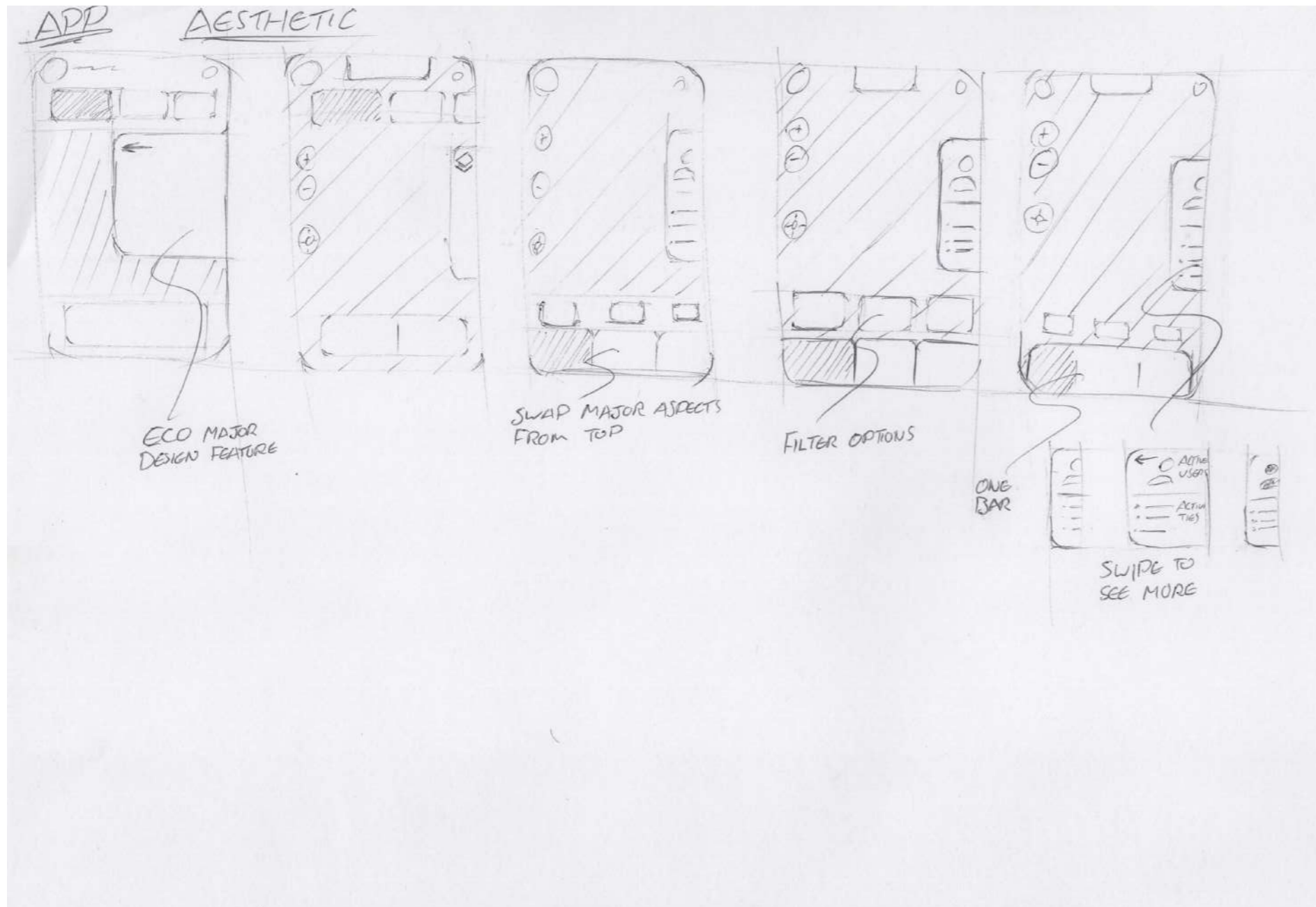


# Test Results



Changes needed from the last round of testing

Edits to be made were larger icons, moving the active user section from the map layers to its own section. This then move the options and setting section to the top of the app



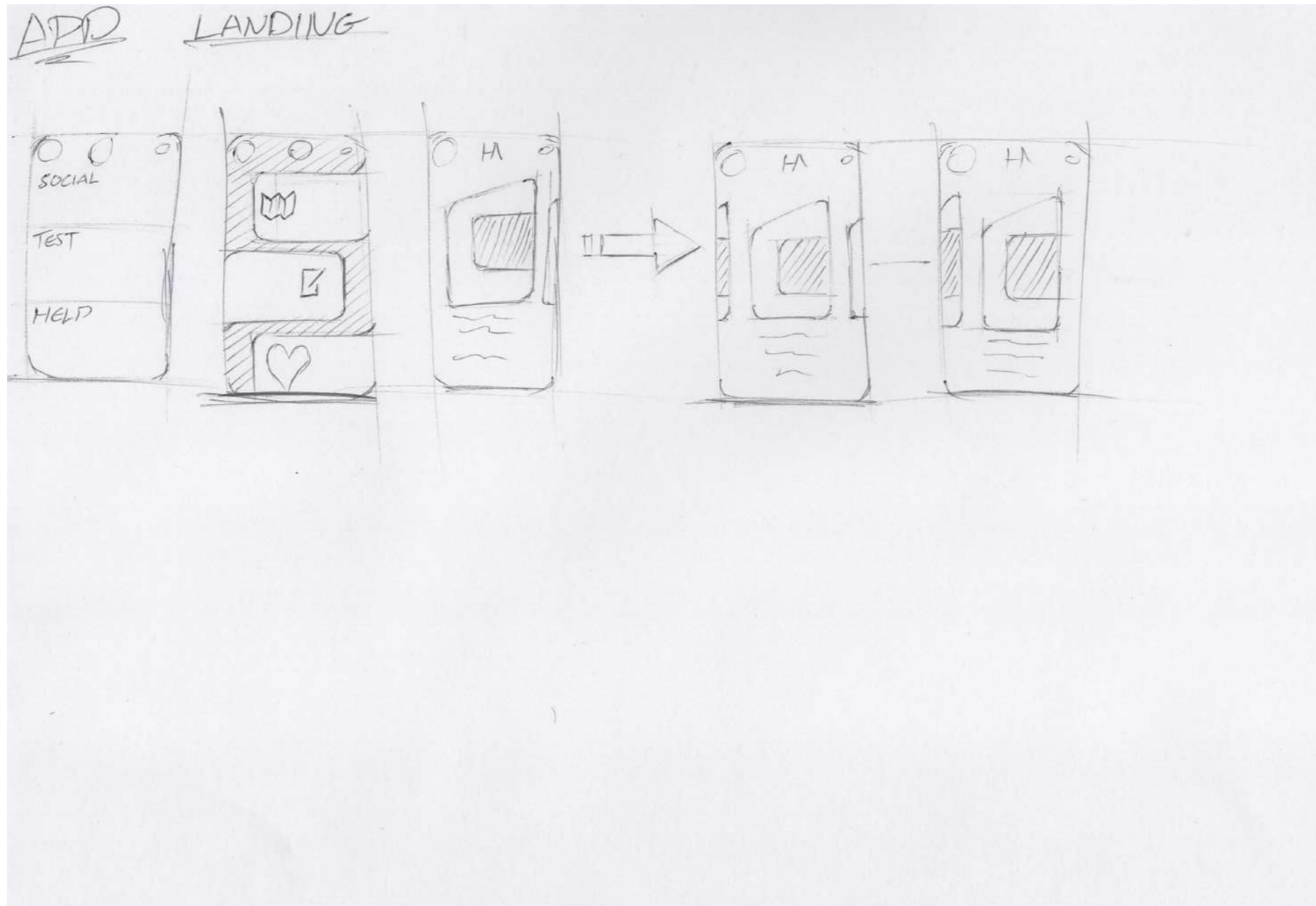
## Developing the aesthetic

Developing different interfaces that and aesthetics that better fit the new layout of the main screen.

Developing the interactions and where the map filters are placed for better integration.

Moving where the major app aspects such as testing and help requesting are located on screen from top to bottom

# Aesthetic



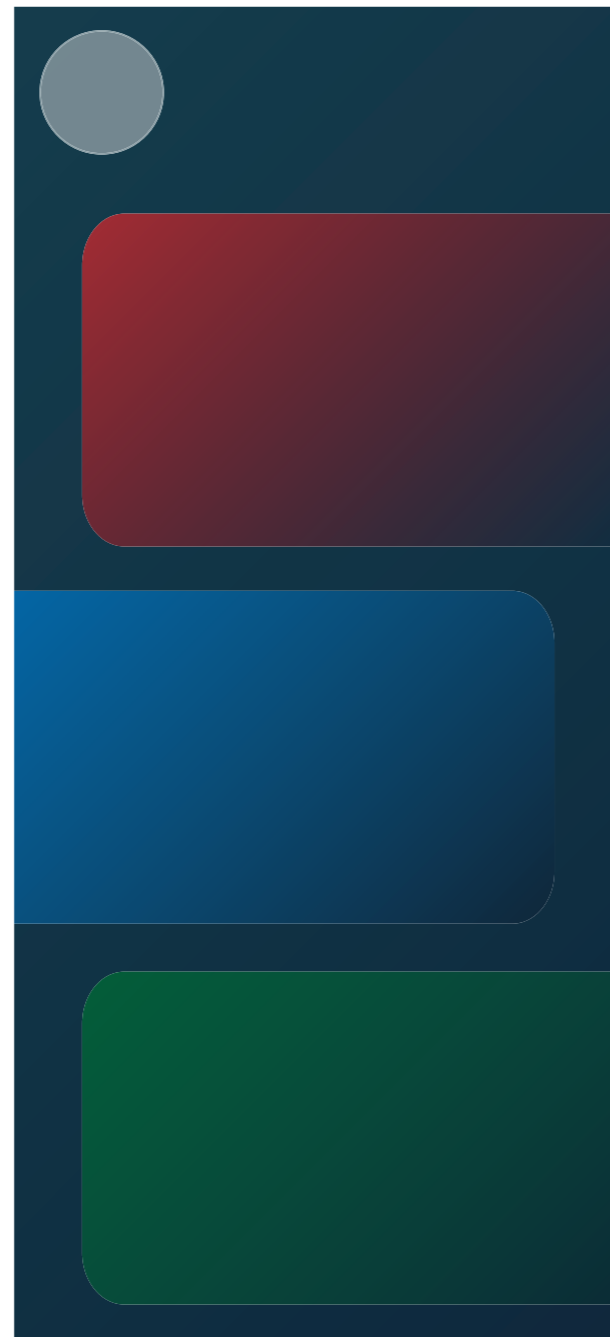
## Developing the aesthetic

Creating a landing page for when users first open the app, giving them the option of going straight to a test, to help or to the social aspect

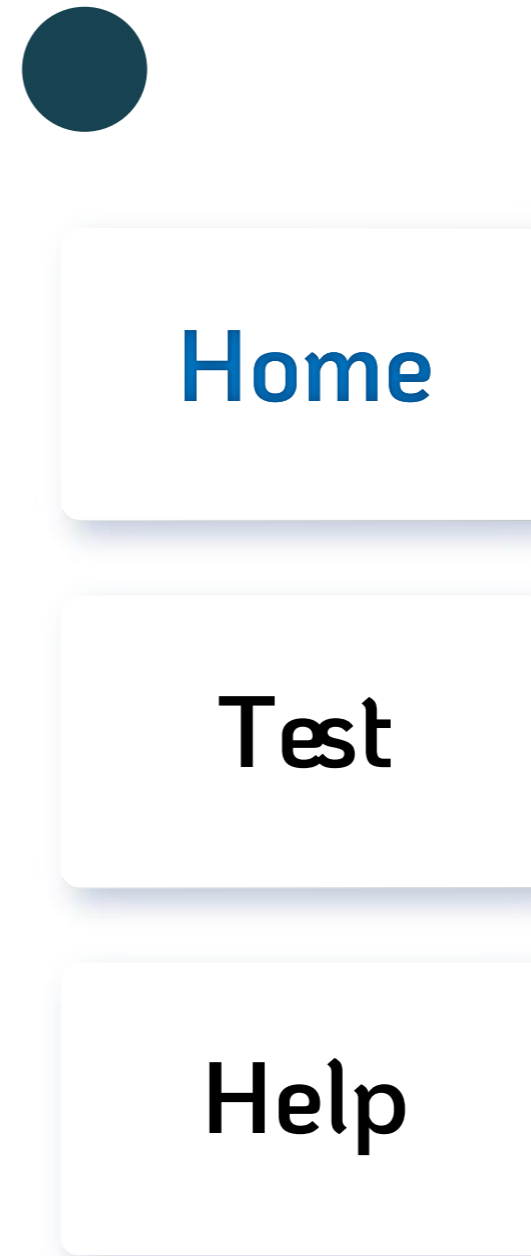
A-6, A-7



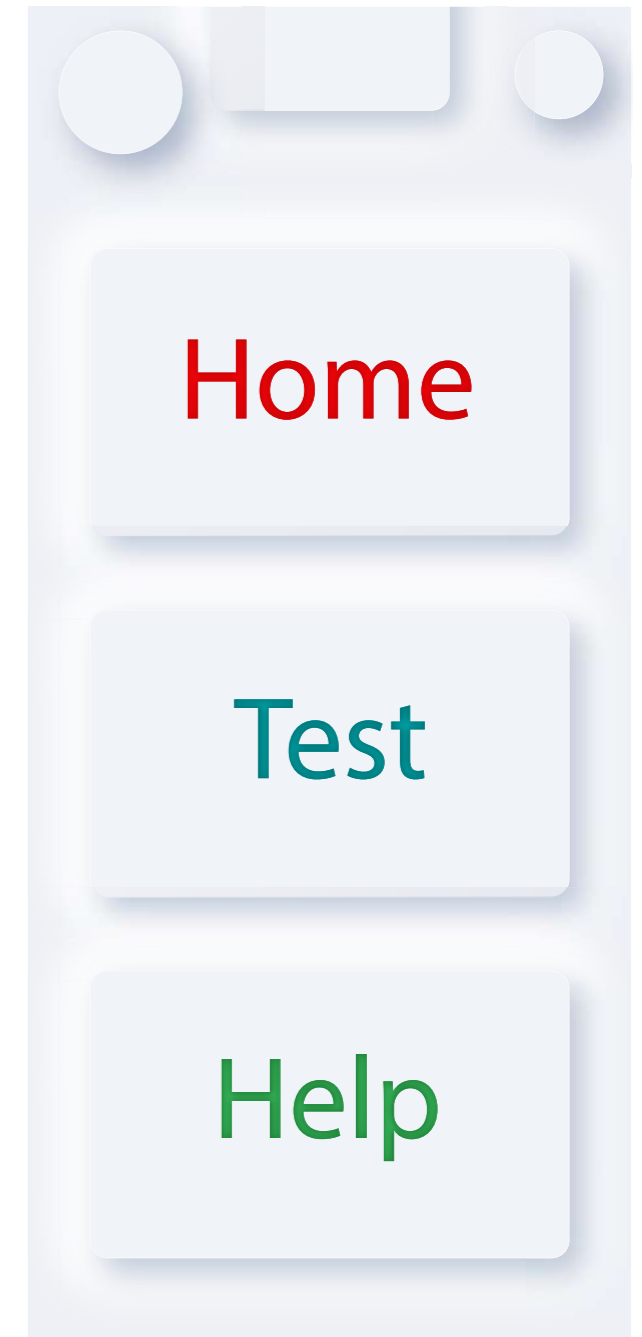
Blocked options and simple interface



Using colour to further differentiate the sections of the app

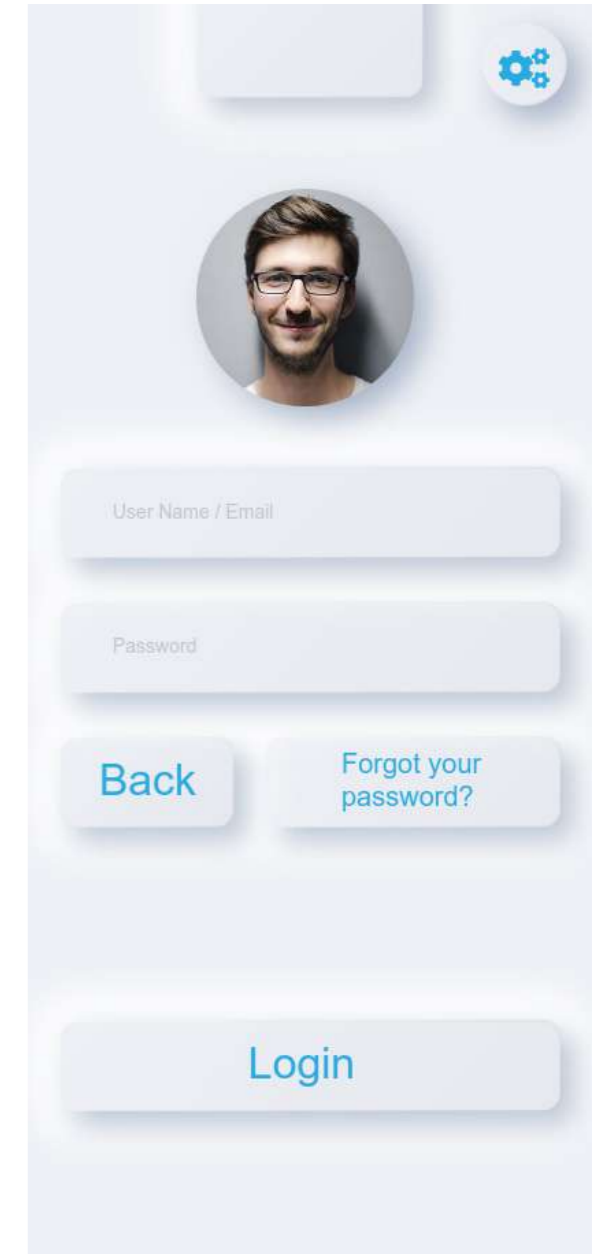
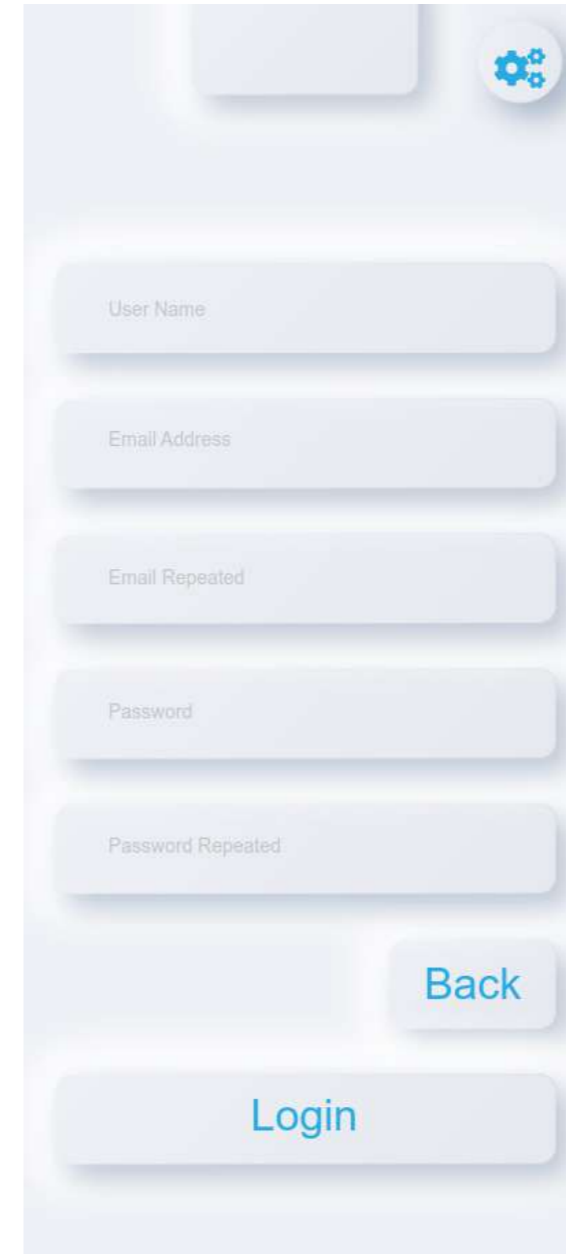
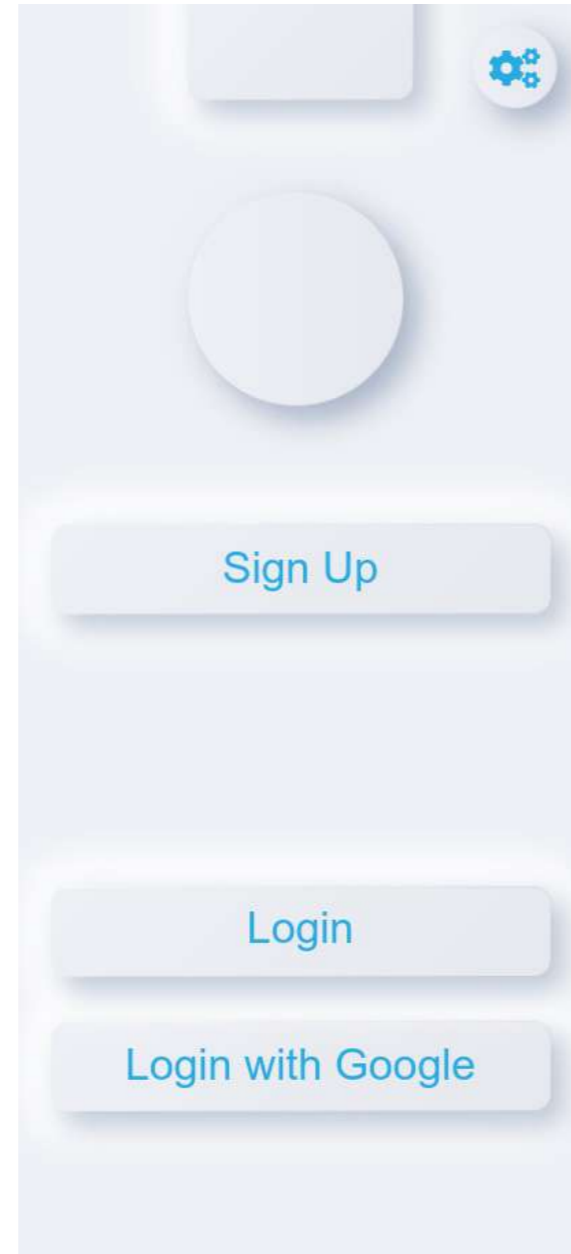
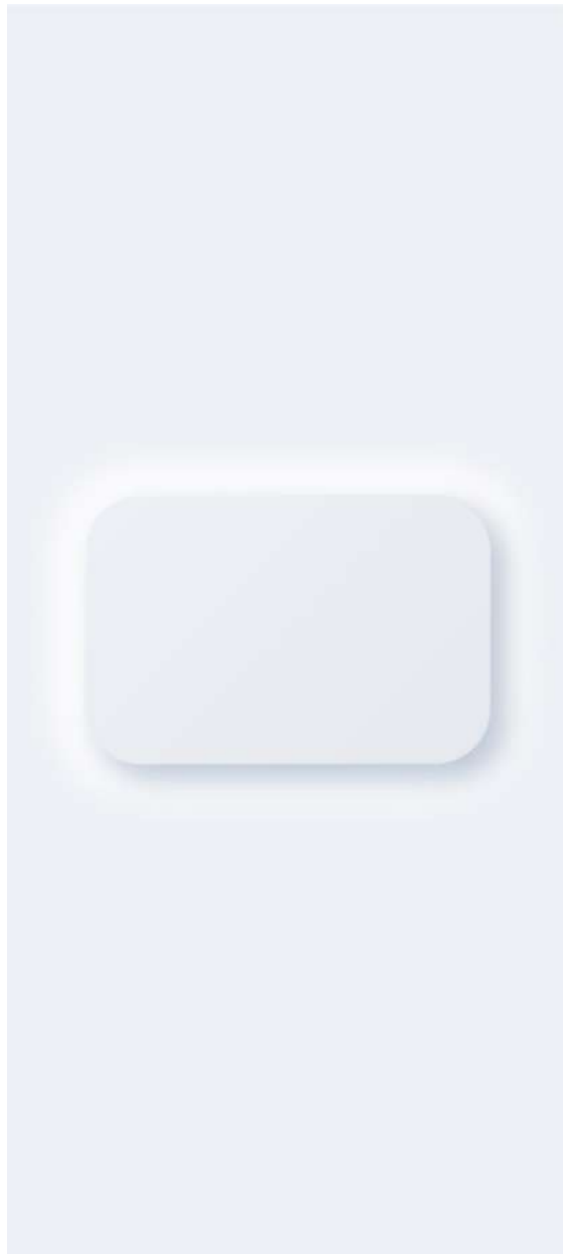


Incorporating a clean and simple interface



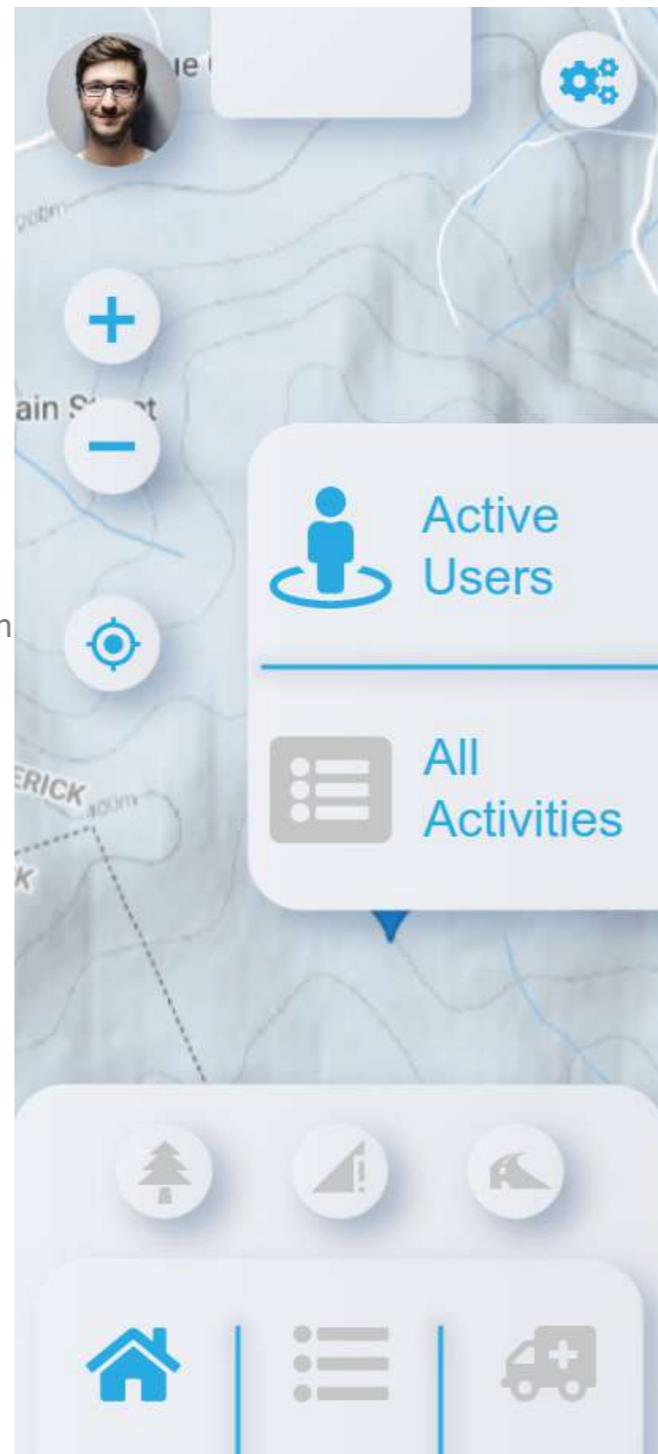
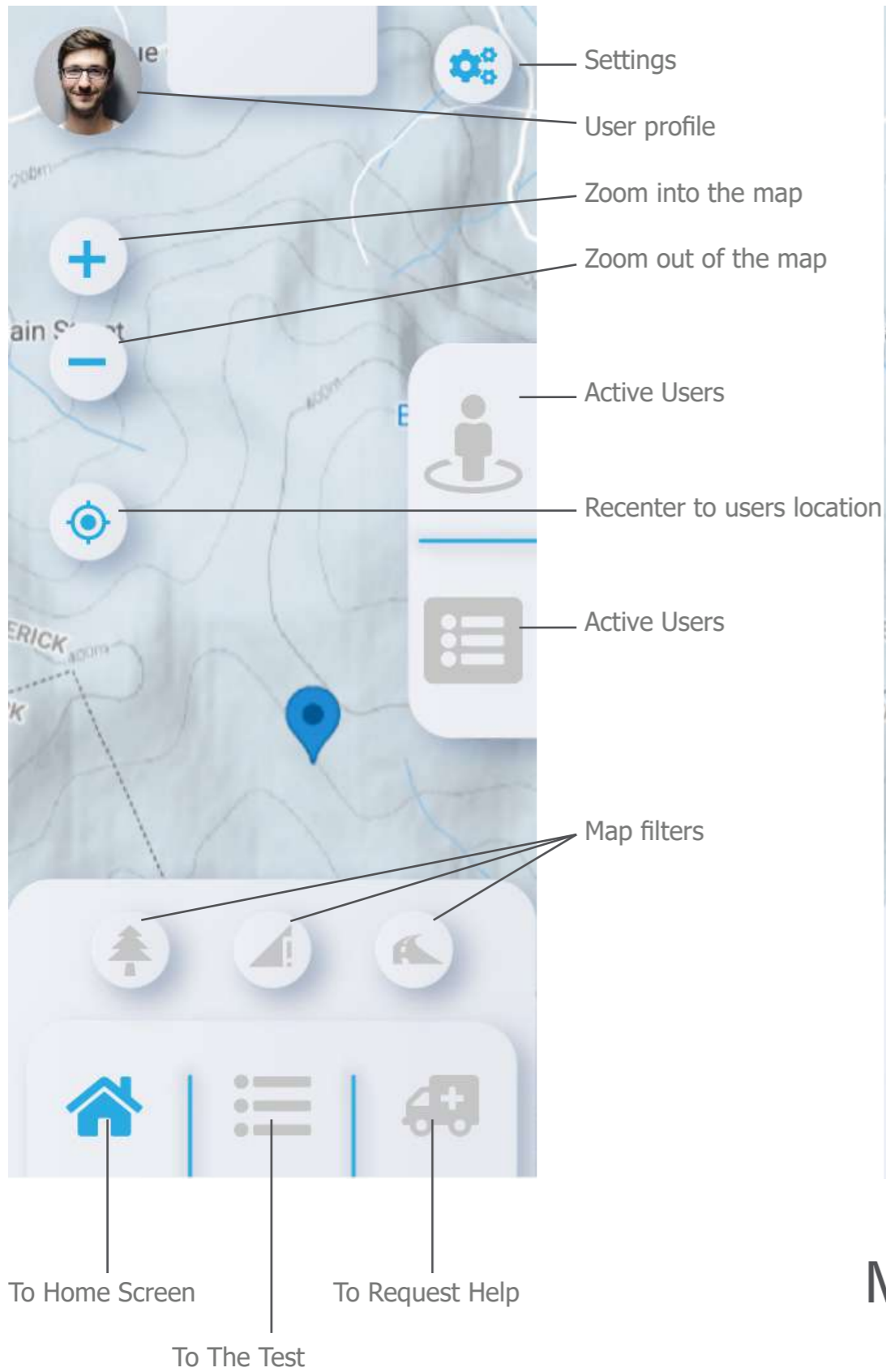
Adding design features to each page and designing a neumorphism style interface that is simple and clean

# Prototype 3



First time/one time use  
pages

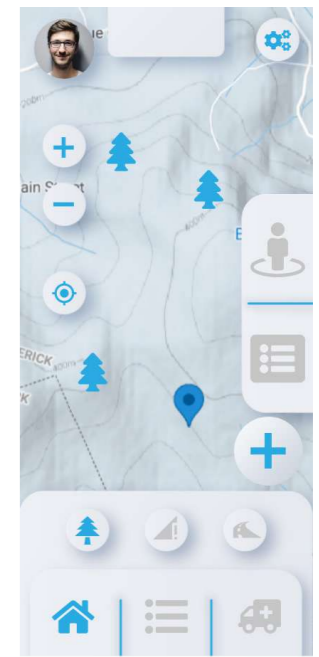
# Prototype 3



Main/Home page and options available



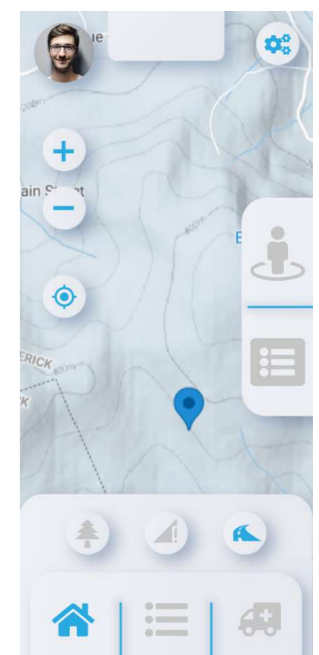
Active users



Nearest shelters



Network deadzones

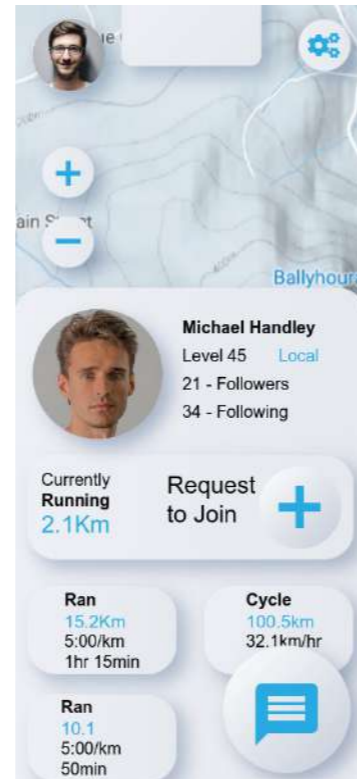


Nearest main road

# Prototype 3



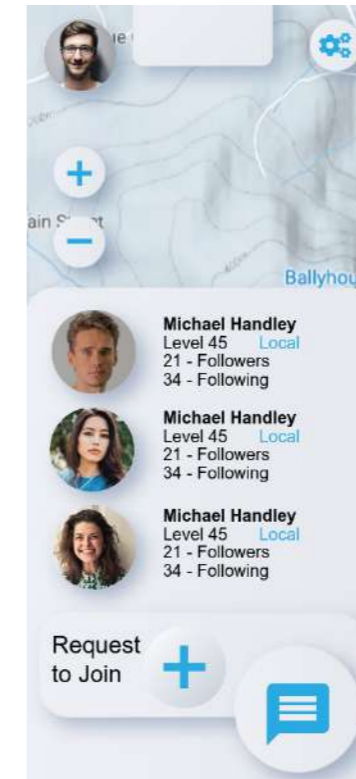
Active users



Simplified interface with enlarged icons for easy access



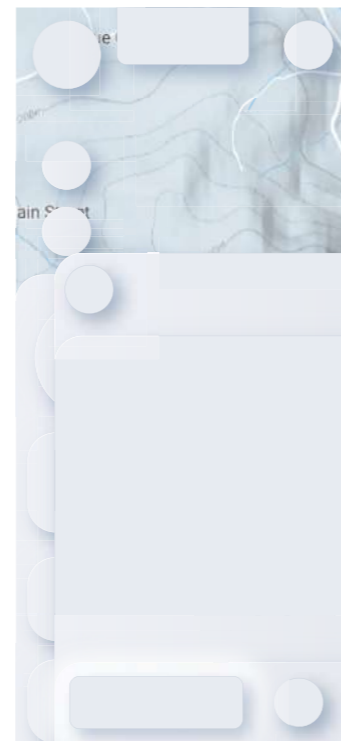
Clicking on the Join button opens the map and route to the user



Simplified interface with enlarged icons for easy access



Clicking on the Join button opens the map and route to the group



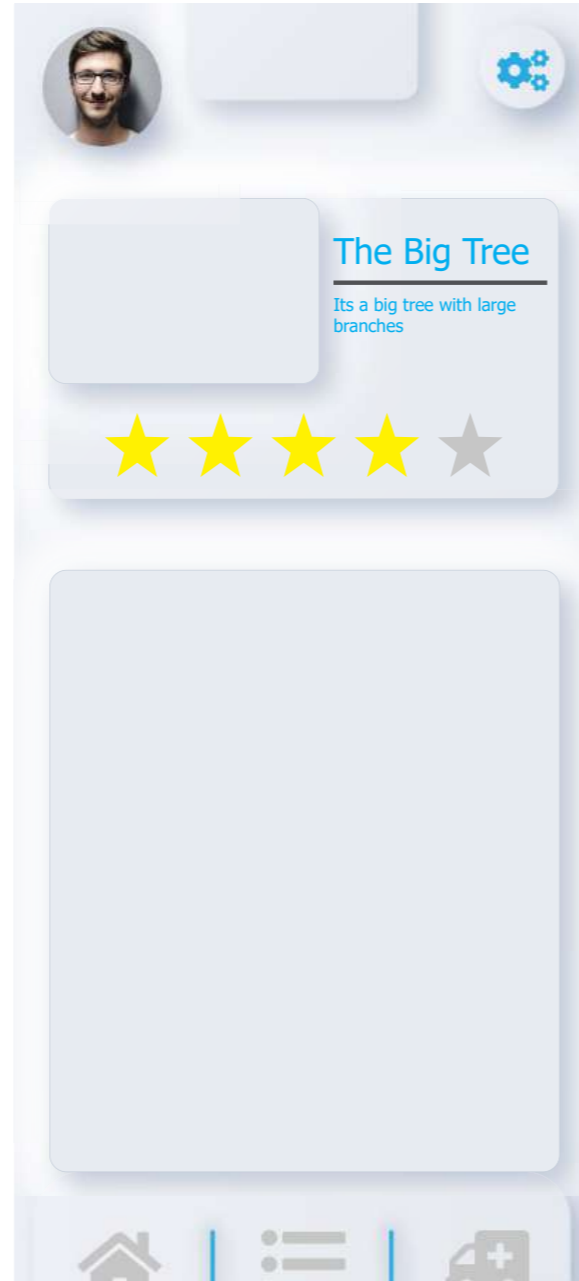
Clicking on the message button allows for contact between users

The active use page allows for users to engage with other users, befriend them and request help in times of need.

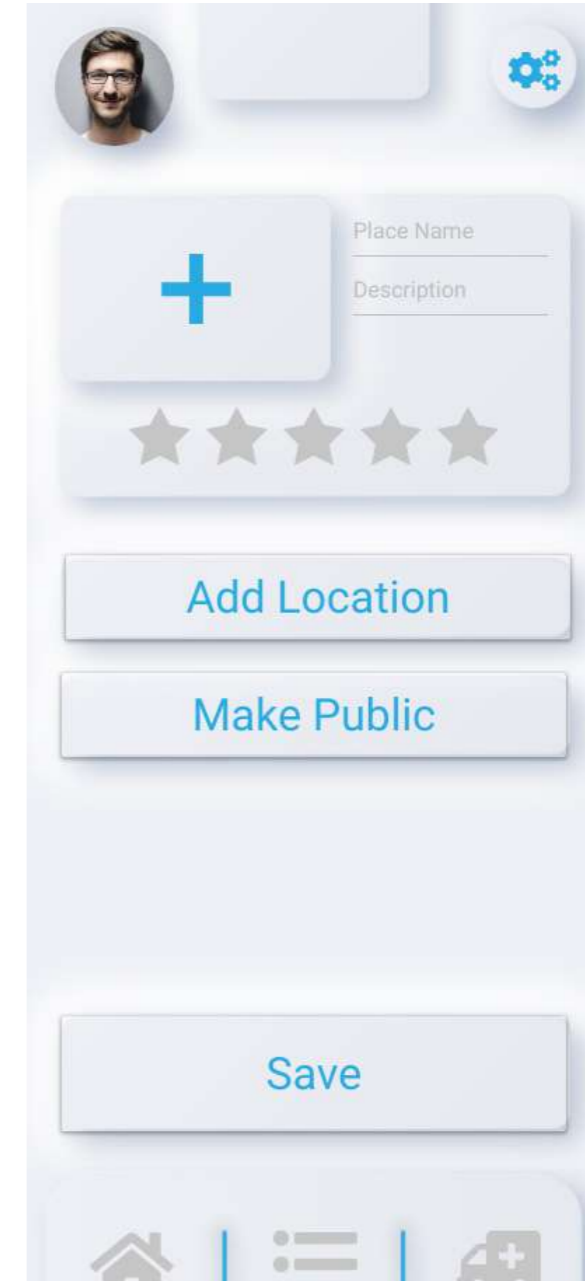
It also allows for people to request to join them on their activity as it is underway



# Prototype 3

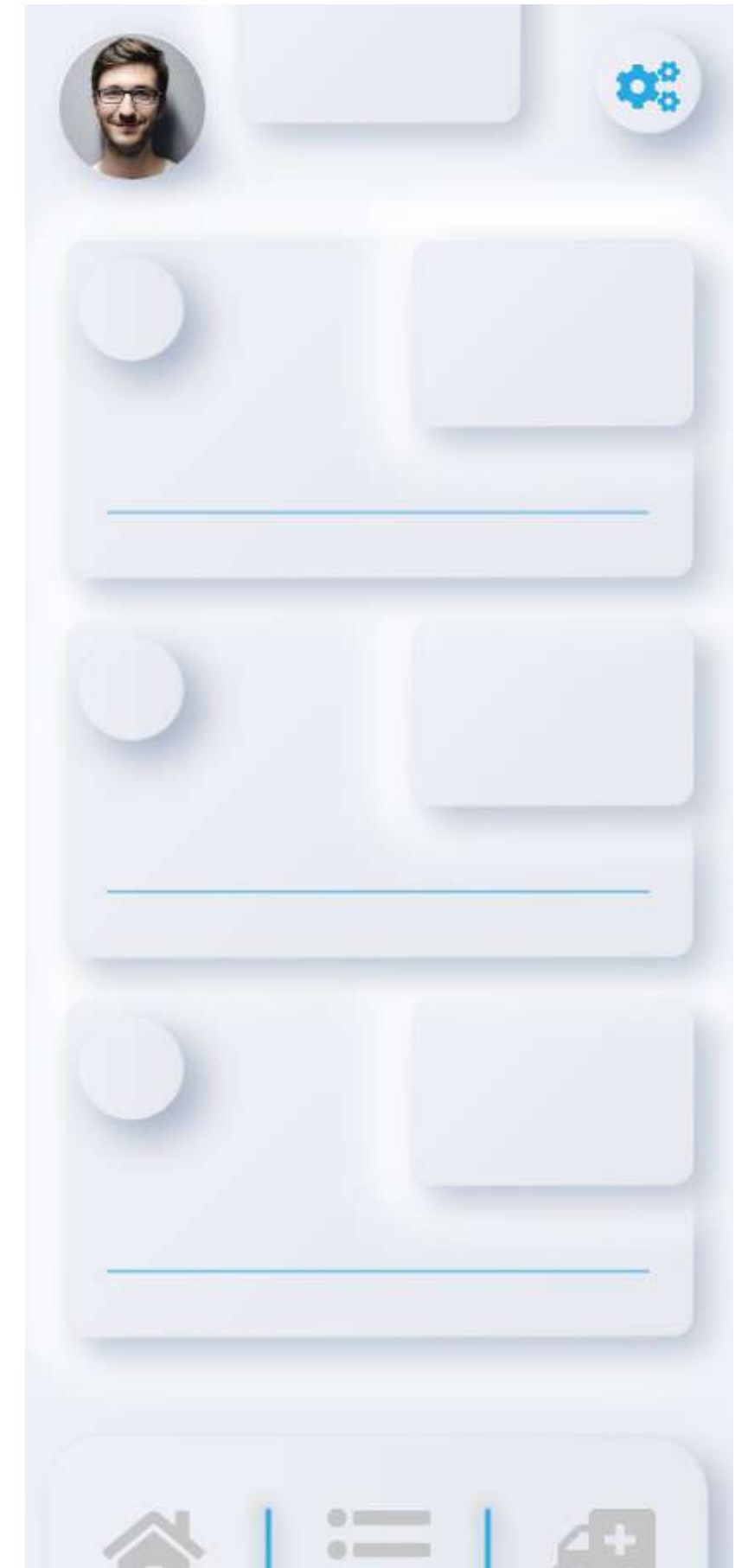
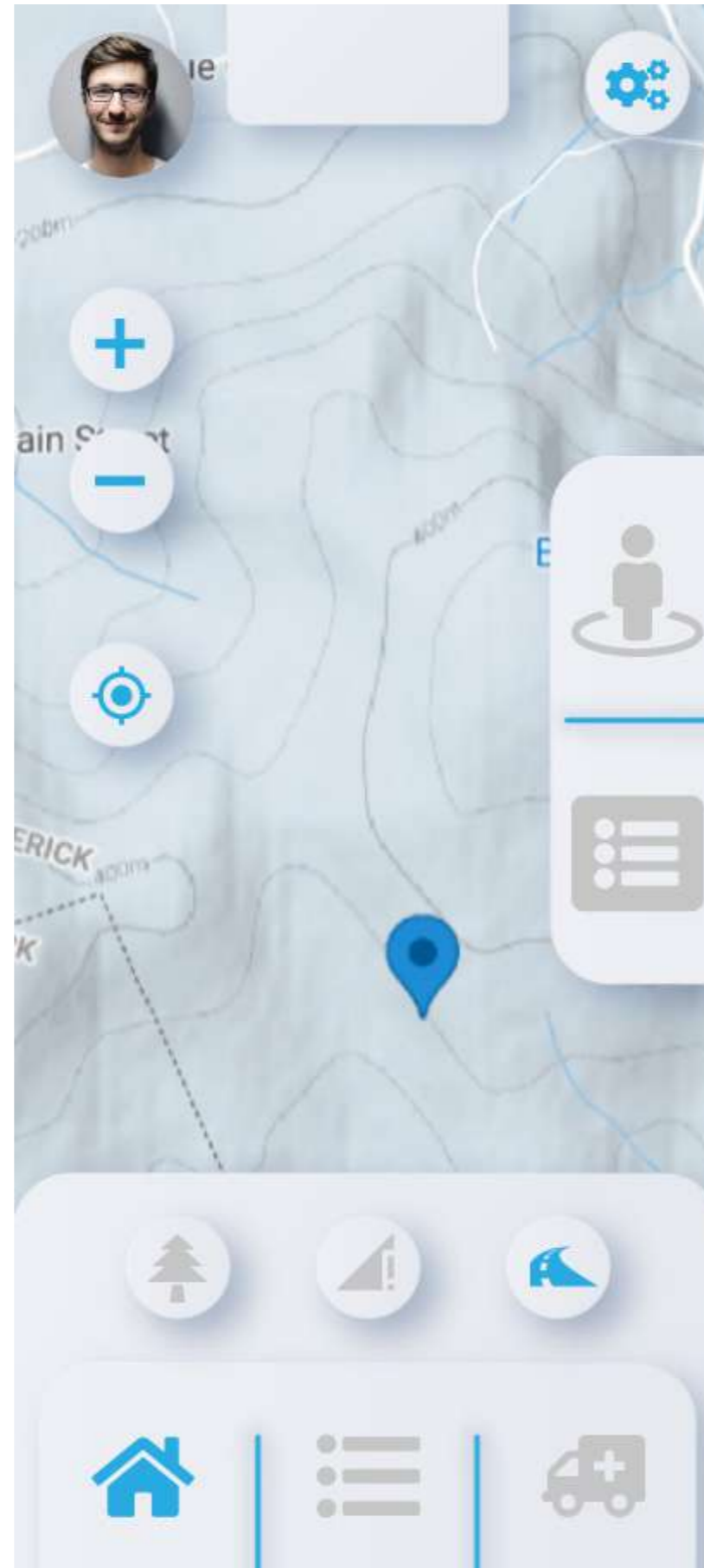
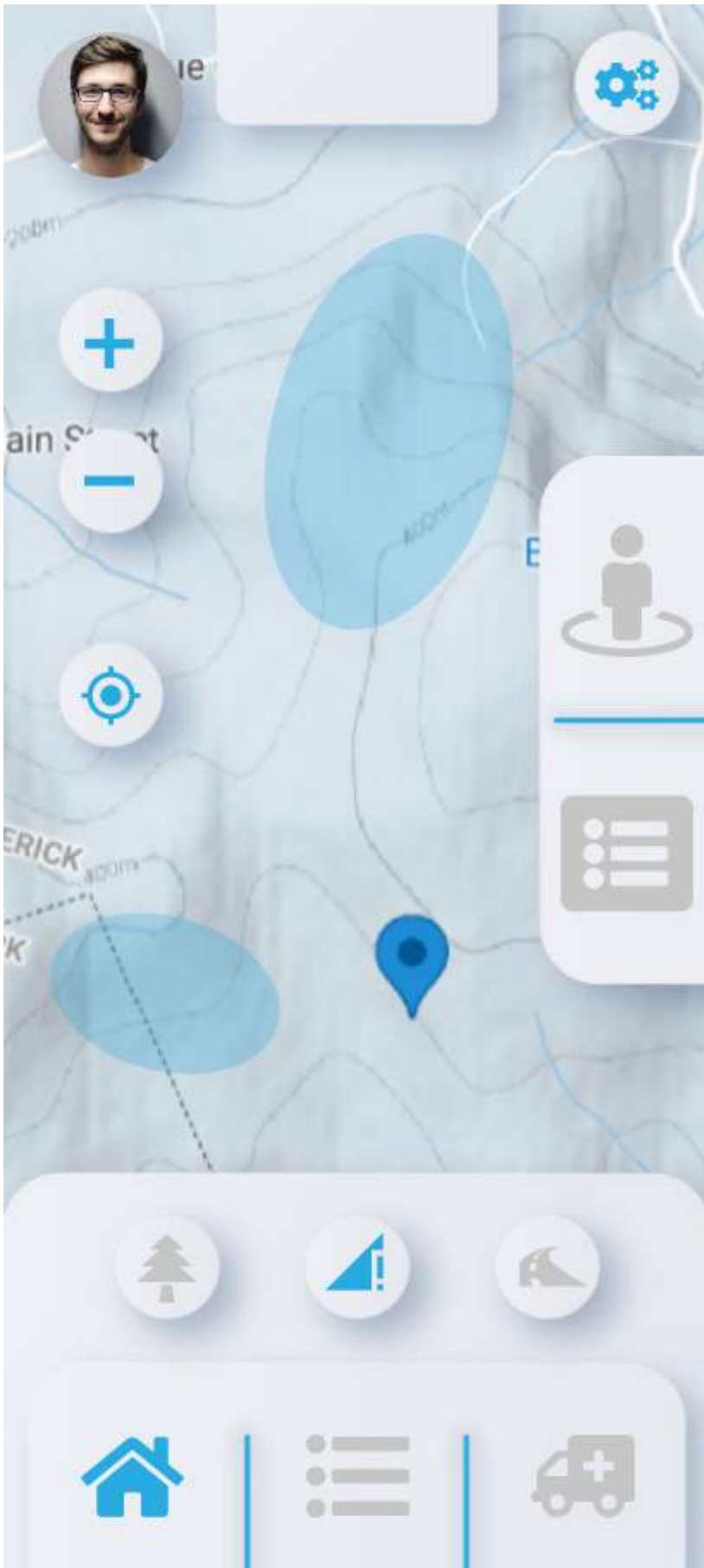


Clicking on a symbol will bring up its review page



Clicking on the "+" button will bring you to a page where you can add a shelter

# Prototype 3

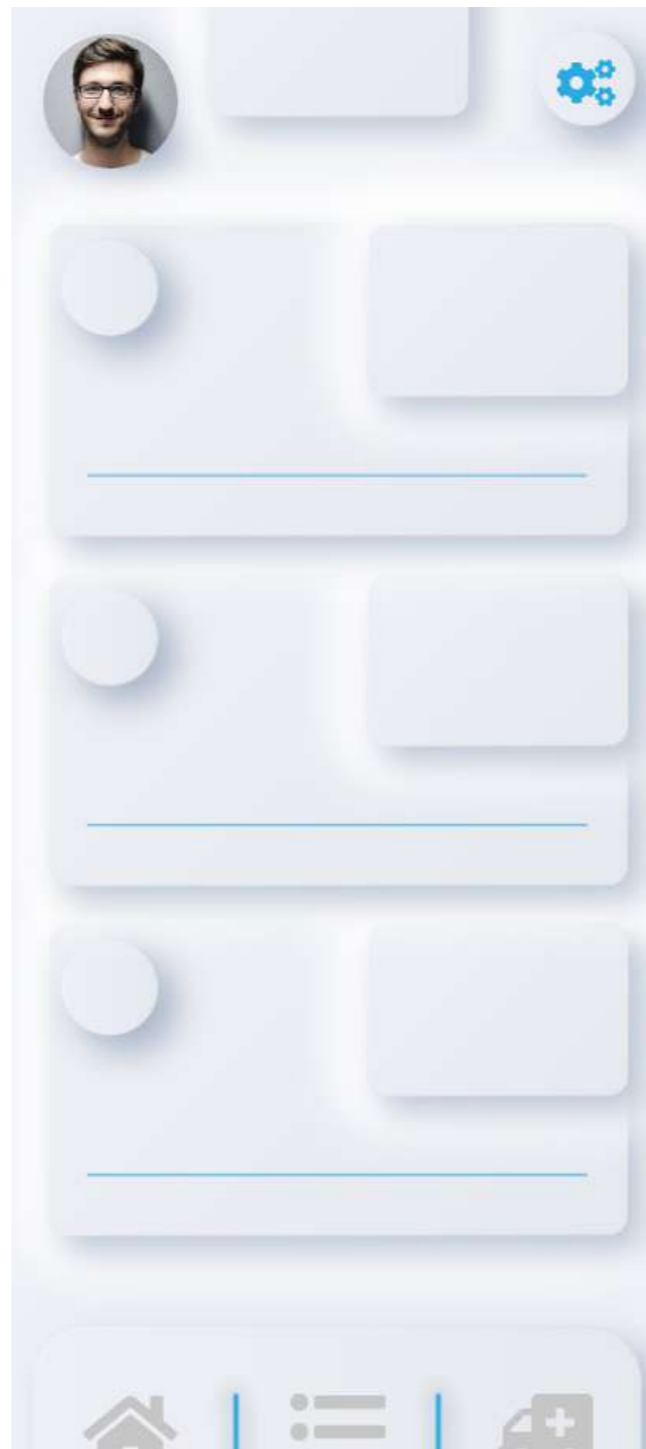


Concept 2

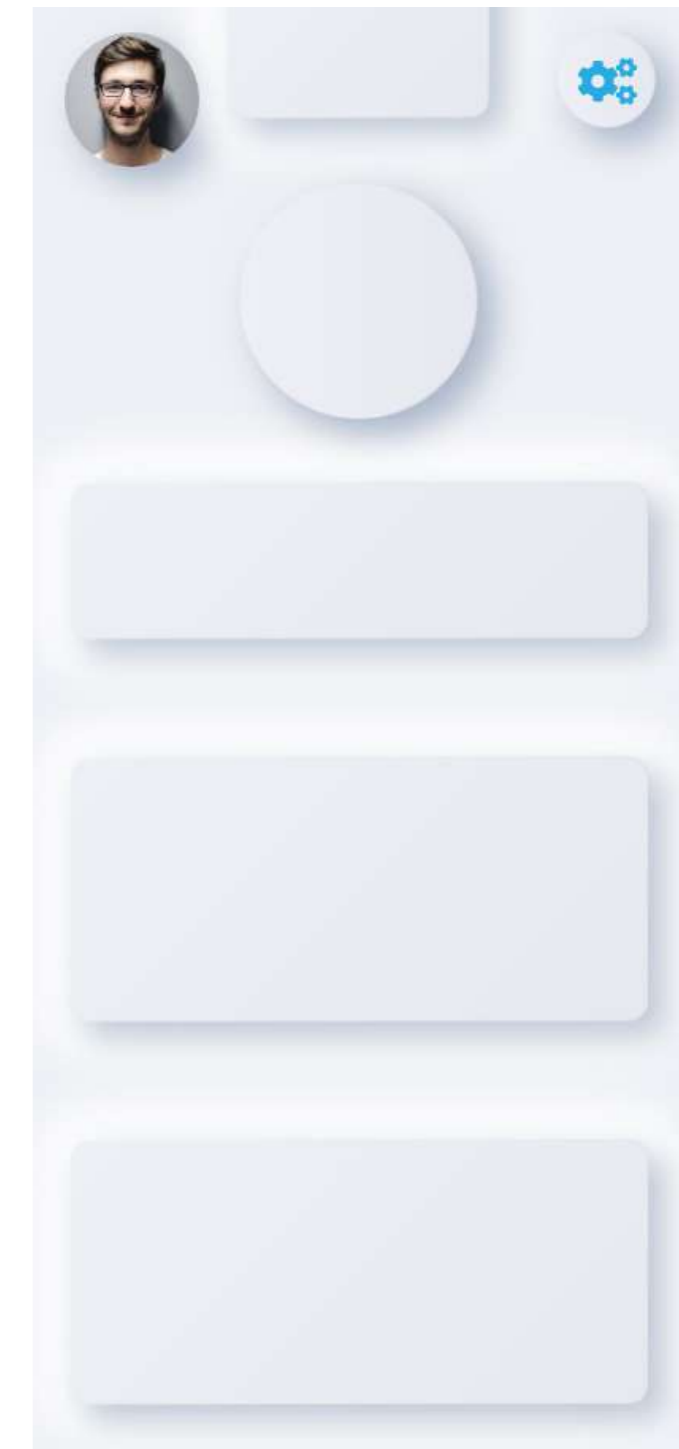
# Prototype 3



The user profile allows the user to track their own progress

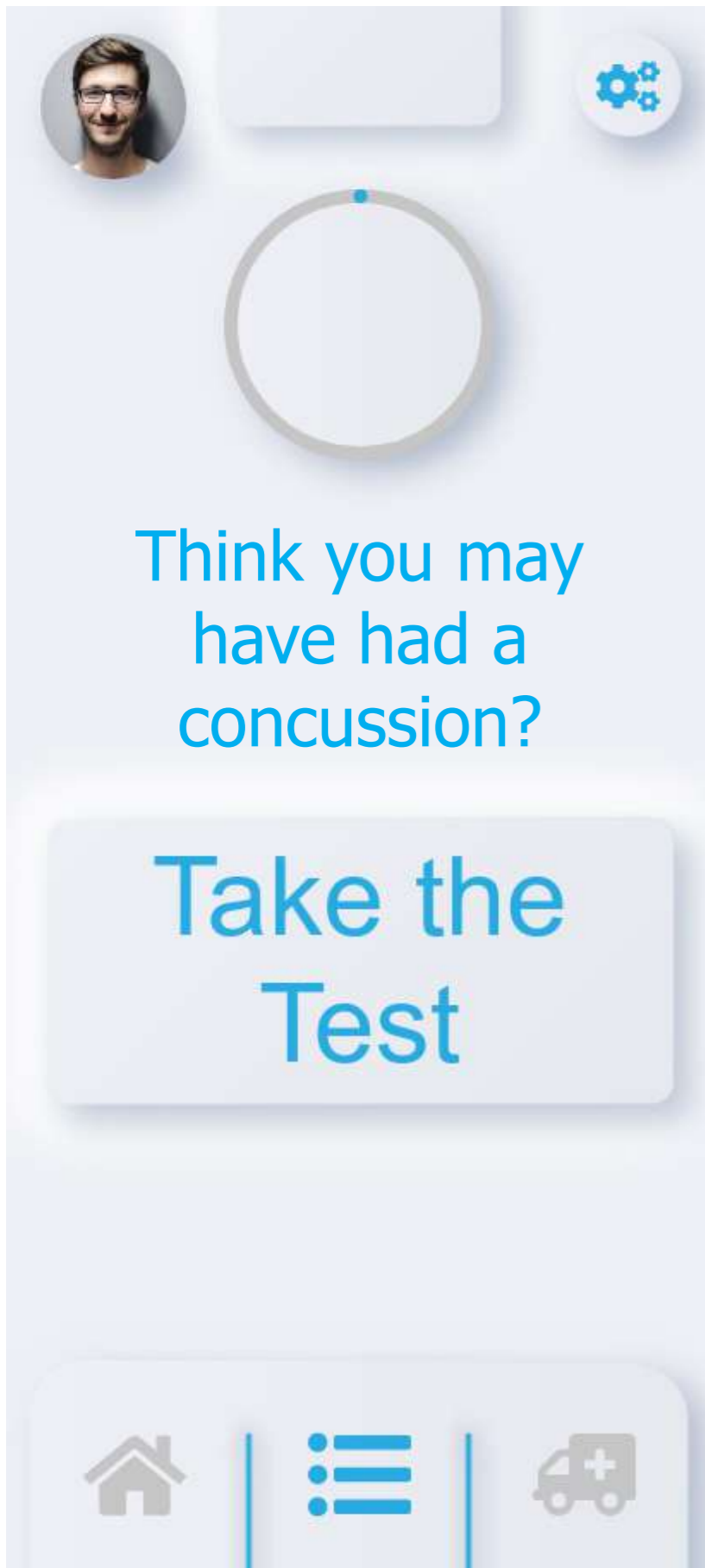


The user also has their own activities page that show their previous athletic endeavors

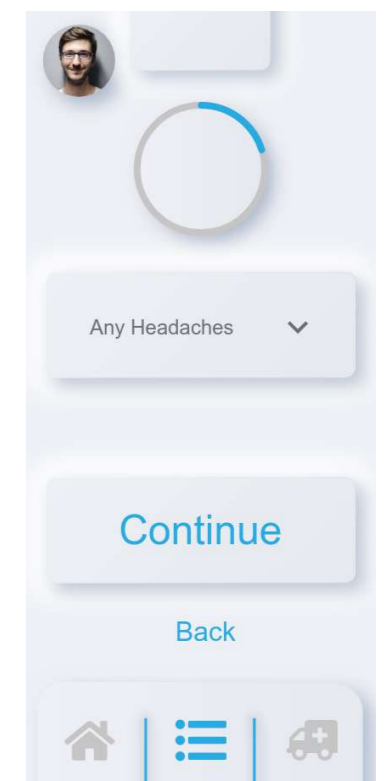
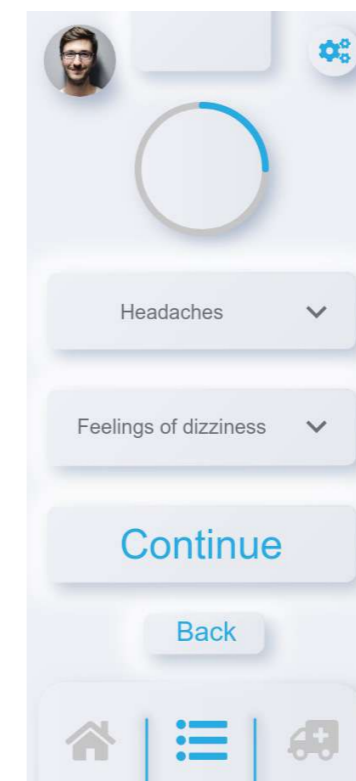
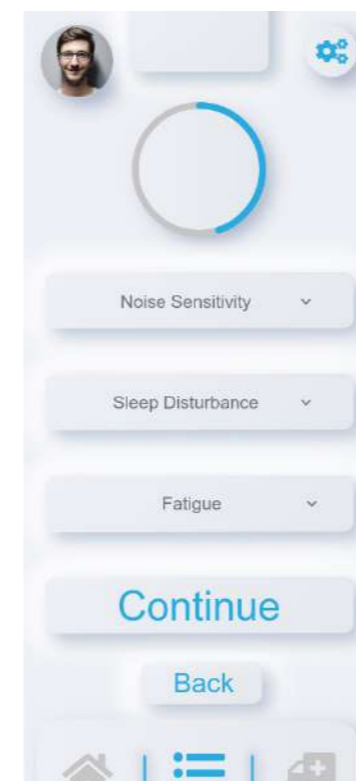
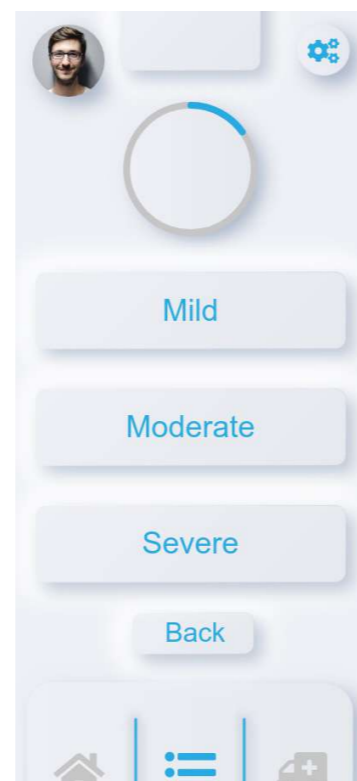
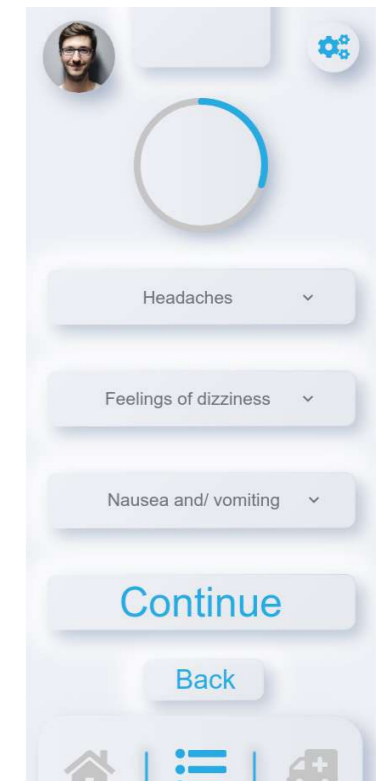
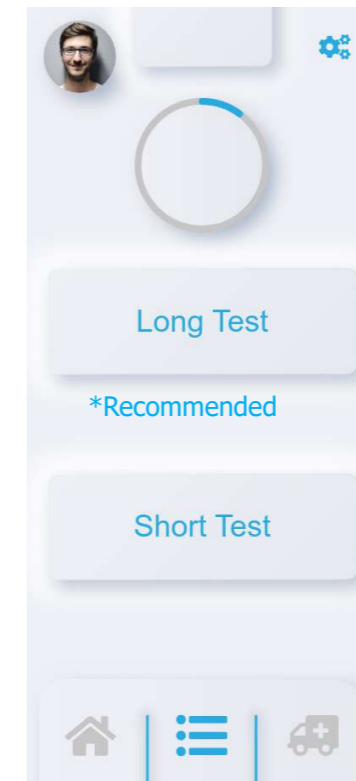
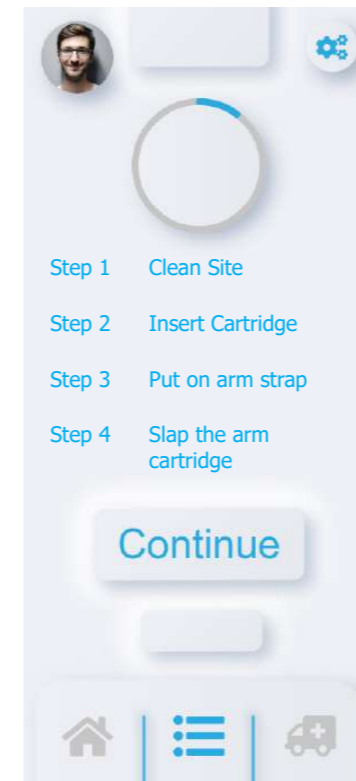


Clicking on the groups page would also take the user to their active group memberships and recommend potential groups to join

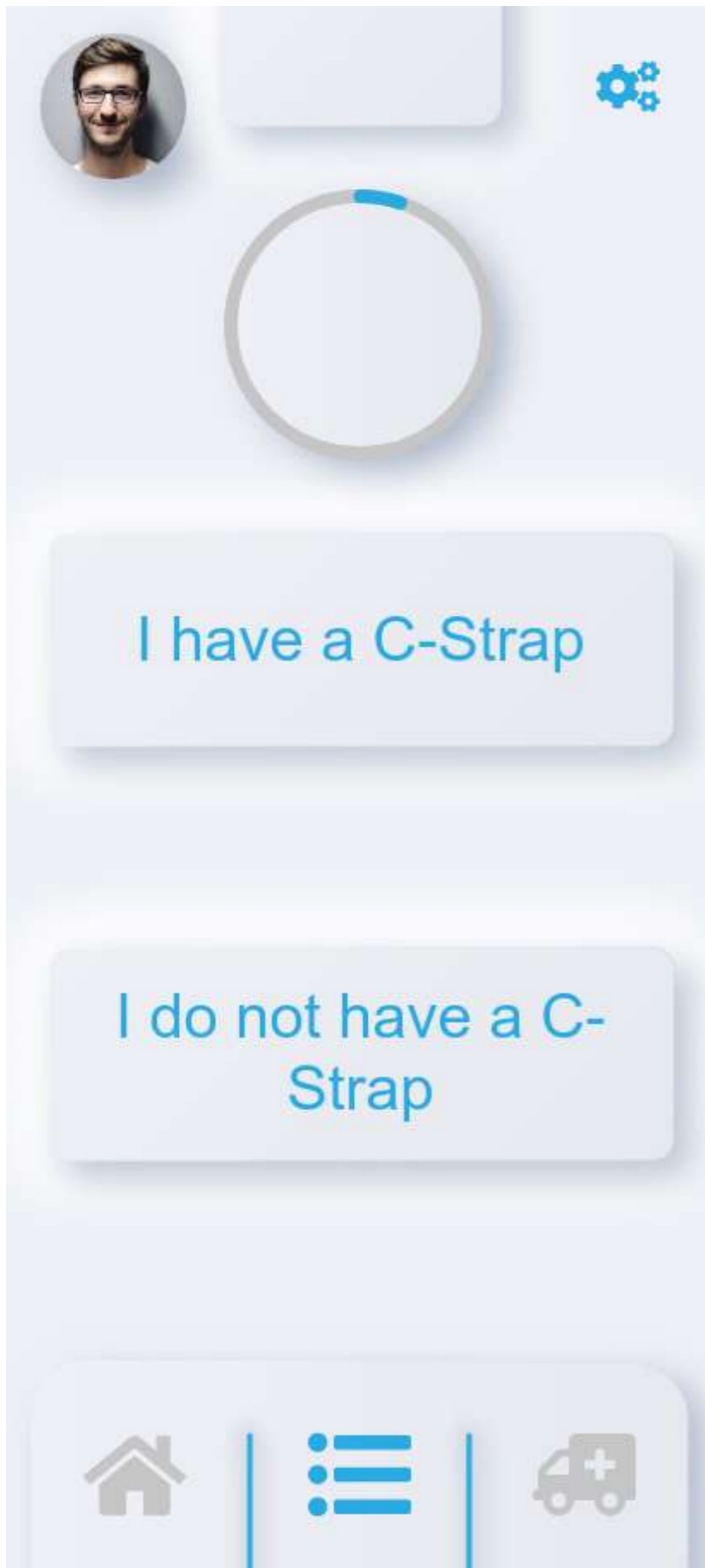
# Prototype 3



## Concept 2



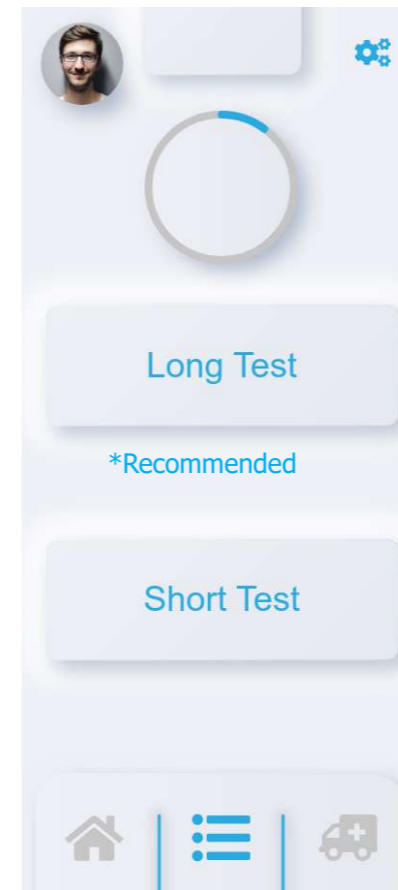
# Prototype 3



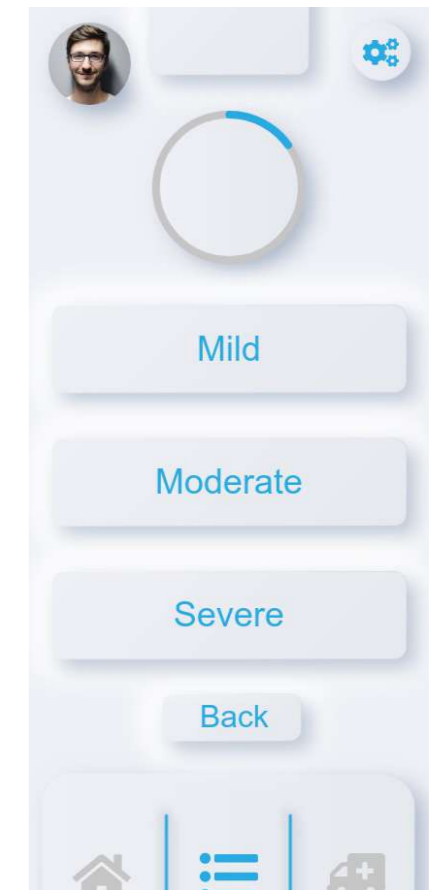
## Concept 2



If the user has a physical detection kit, they are advised and instructed to use it

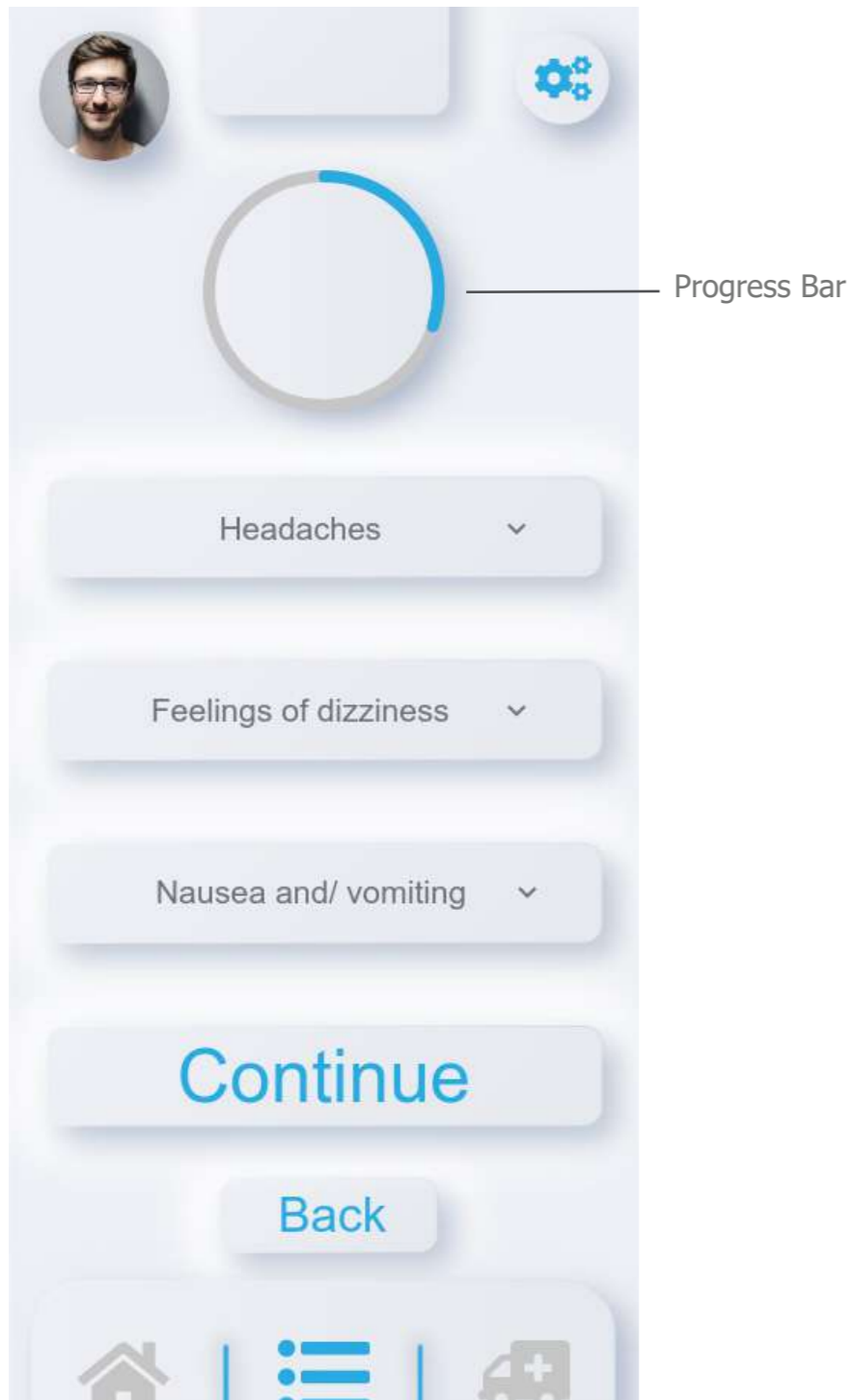


The results give you the option to take the long or short test

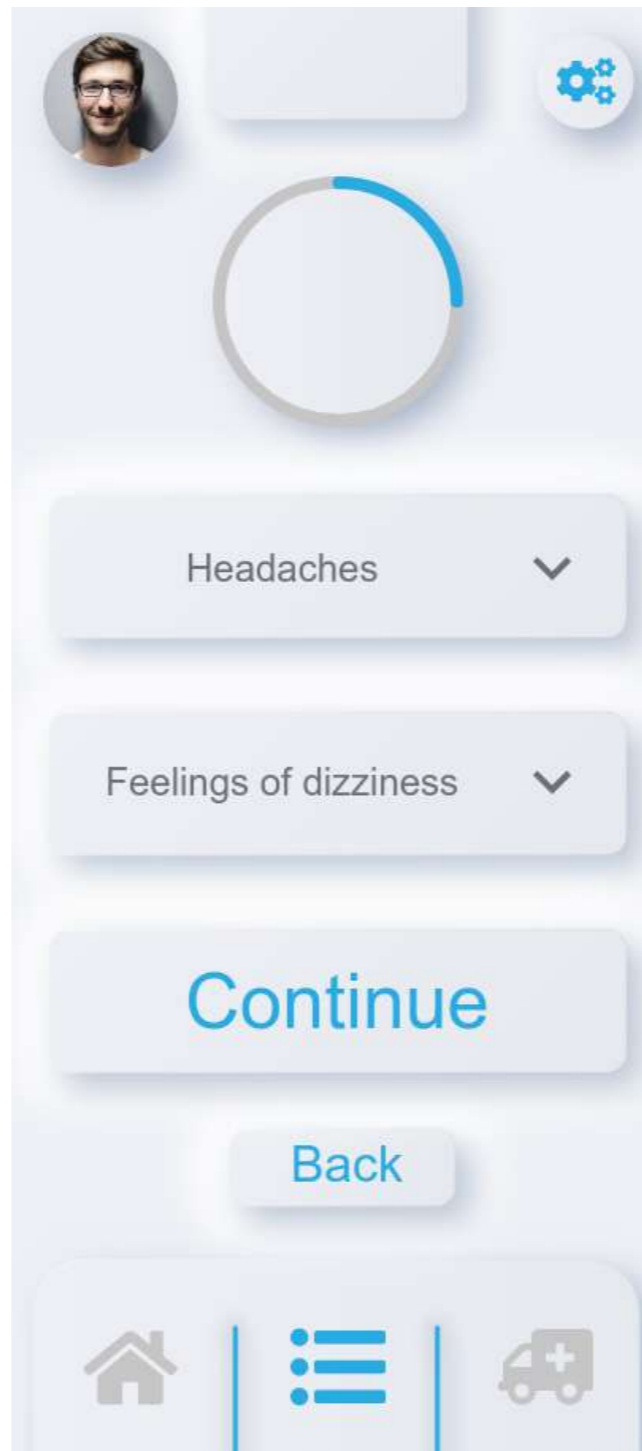


Once the test has been chosen, the severity of the concussion as displayed by the device will determine the test given

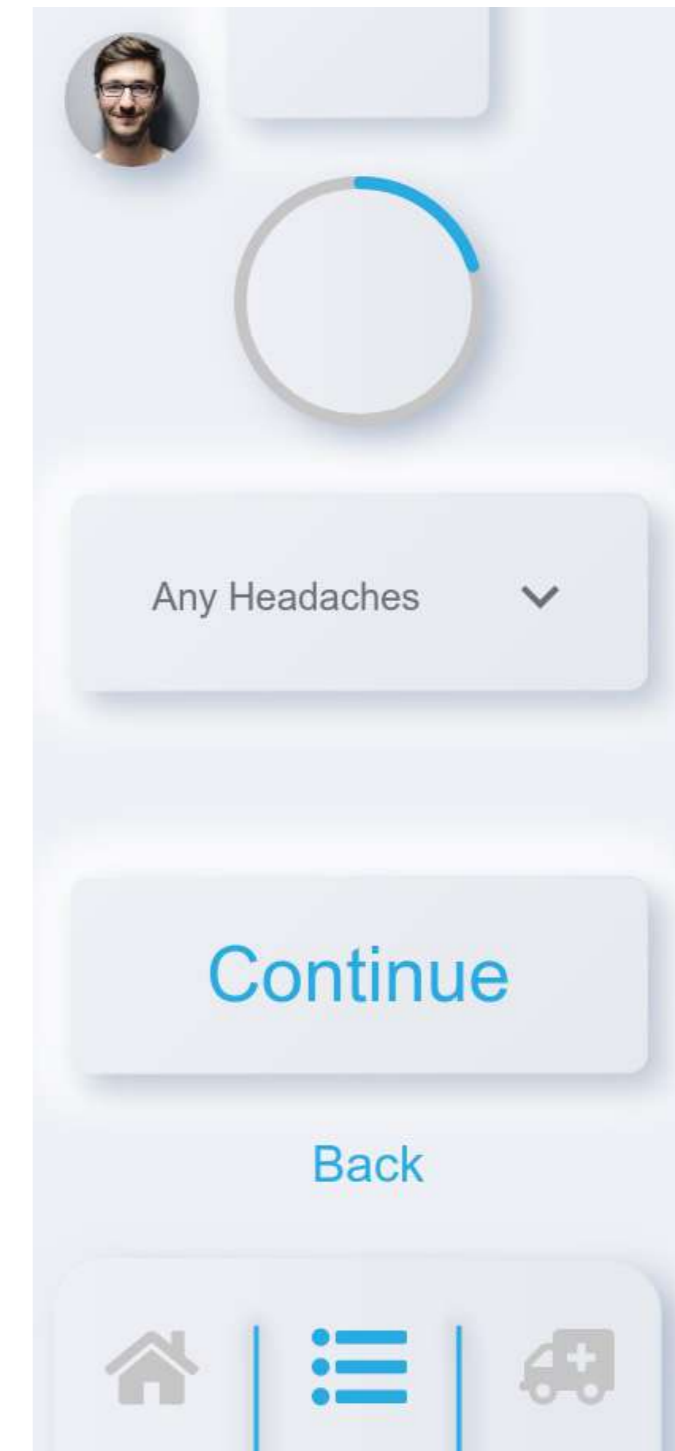
# Prototype 3



The different levels of severity also determine the ease of which the user can answer the questionnaire, Mild concussions will give the most advanced test when it comes to language and number of questions per page

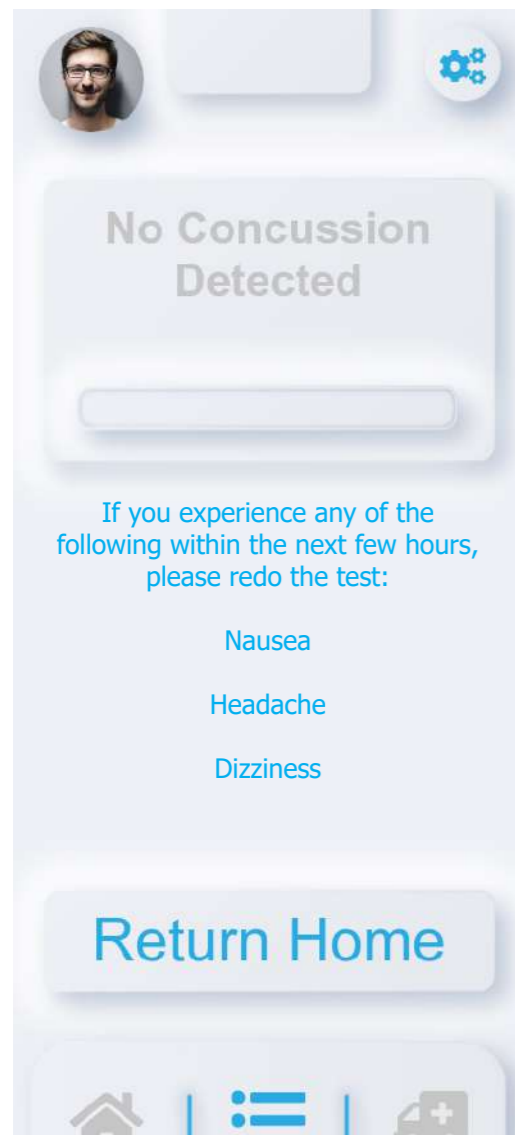


A Moderate concussion keeps the original questions but reduces the number of questions per page



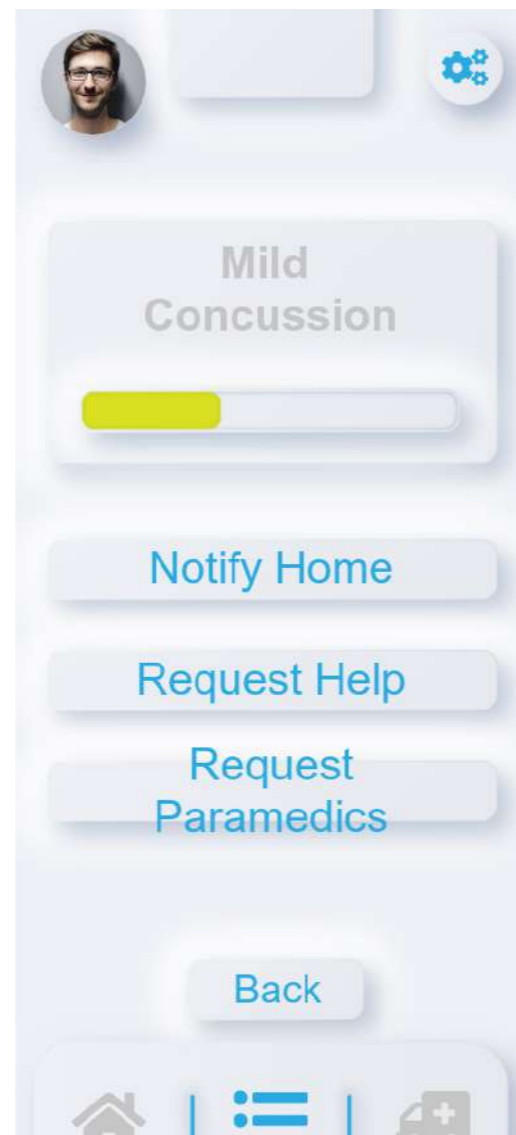
A Severe concussion results in simpler language and even less questions per page

# Prototype 3



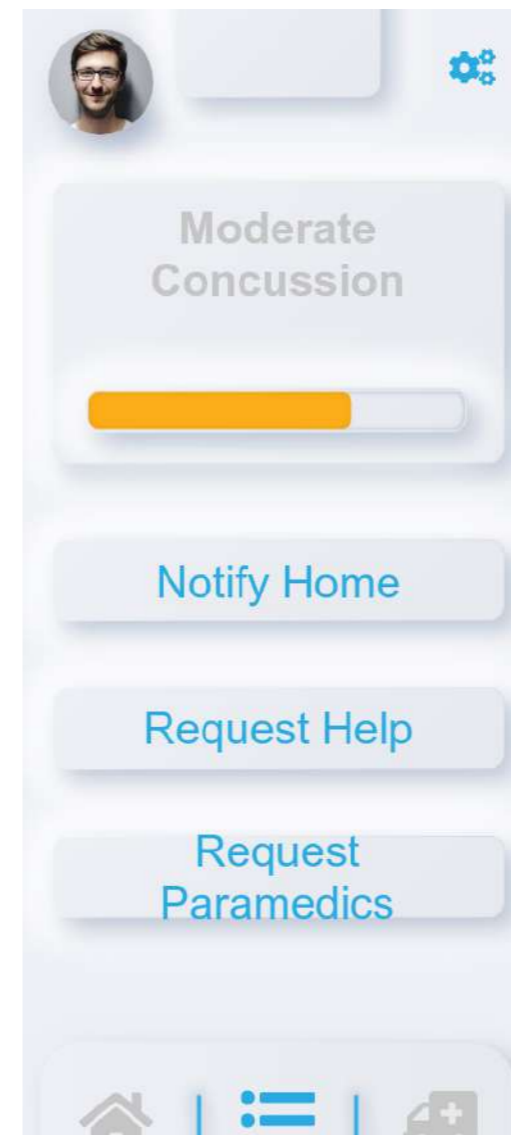
No detection

The user is advised to redo the test if they have the following symptoms but otherwise return to home



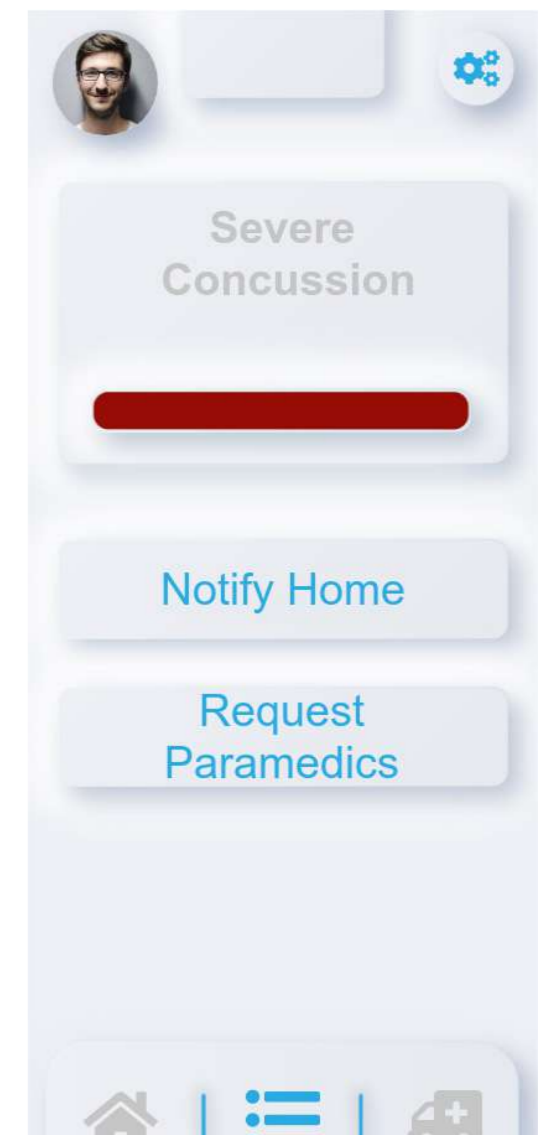
Mild Concussion

The user is advised to notify home, stop their activities and return to a safe space



Moderate Concussion

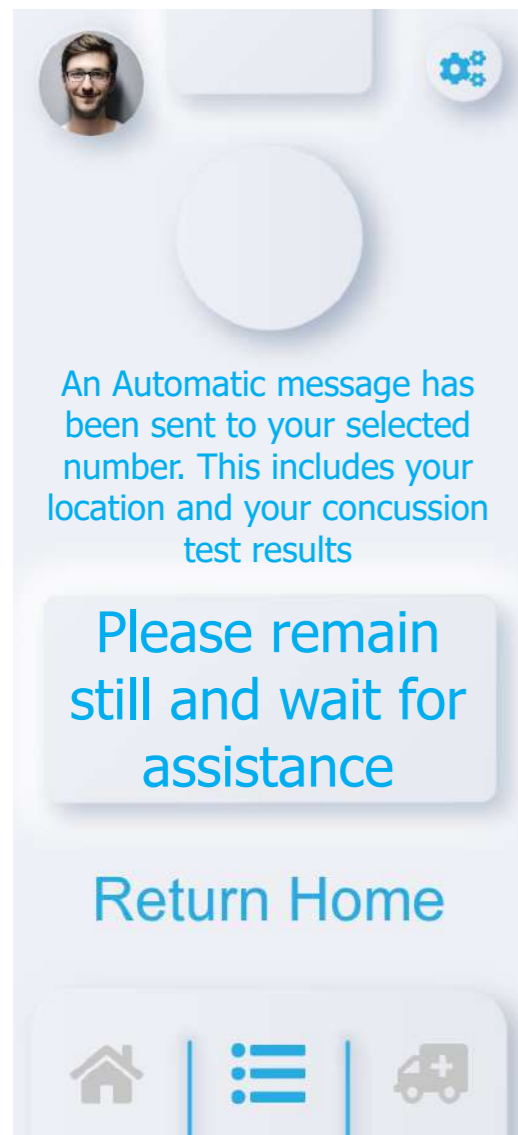
The user is advised to remain where they are and notify paramedics of their condition



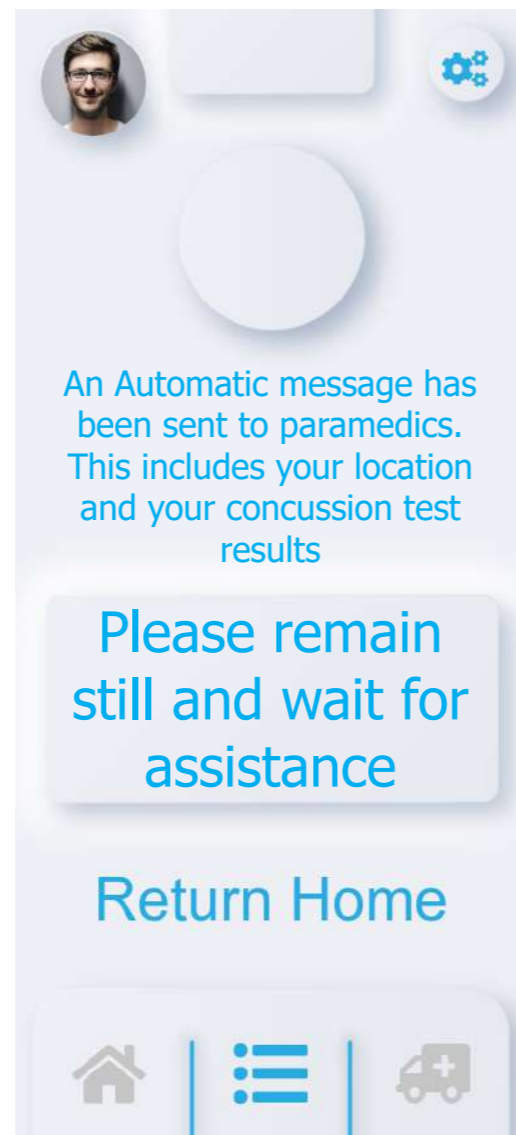
Severe Concussion

The paramedics and the users emergency contact are notified of their condition and location

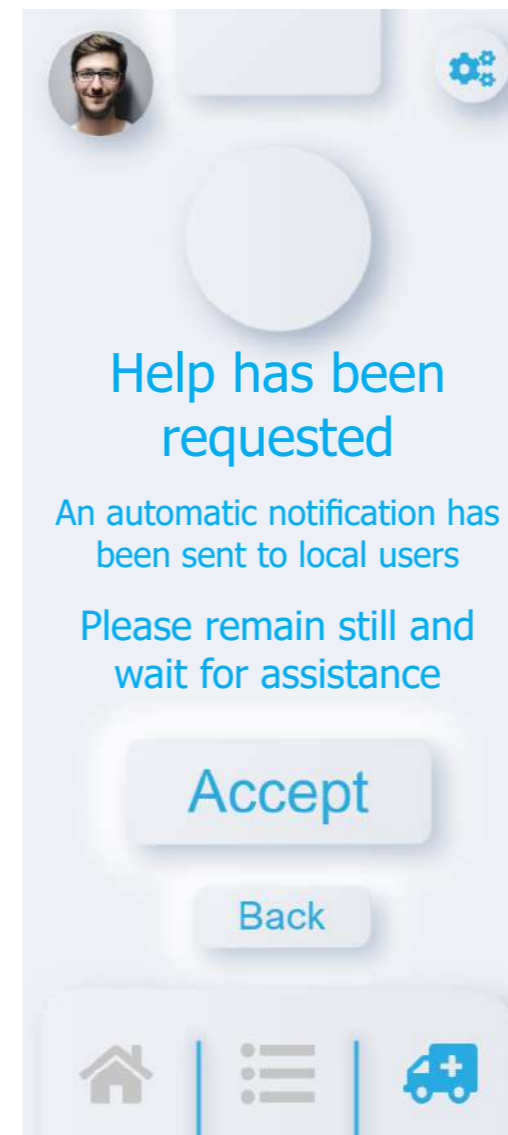
# Prototype 3



Notifying Home



Notify Paramedics



Request Help



# Validation.

# Physical Detection.

# Validation

## Theranos

### How it Works

The device uses a micro needle and capillary action to draw the blood into the collection tubes "Nanotainers", this functionality was approved by the FDA.

Unfortunately other aspects of the company were not as successful in successful delivery

## NanoDx

### How it Functions

The device first collects a blood sample and then runs it through an electrical nanosensor that is FDA awarded as a breakthrough technology but not yet approved by the FDA. The device measures the severity of TBI through the concentration of biomarker proteins within the blood of a concussed patient.



## Capillary Action

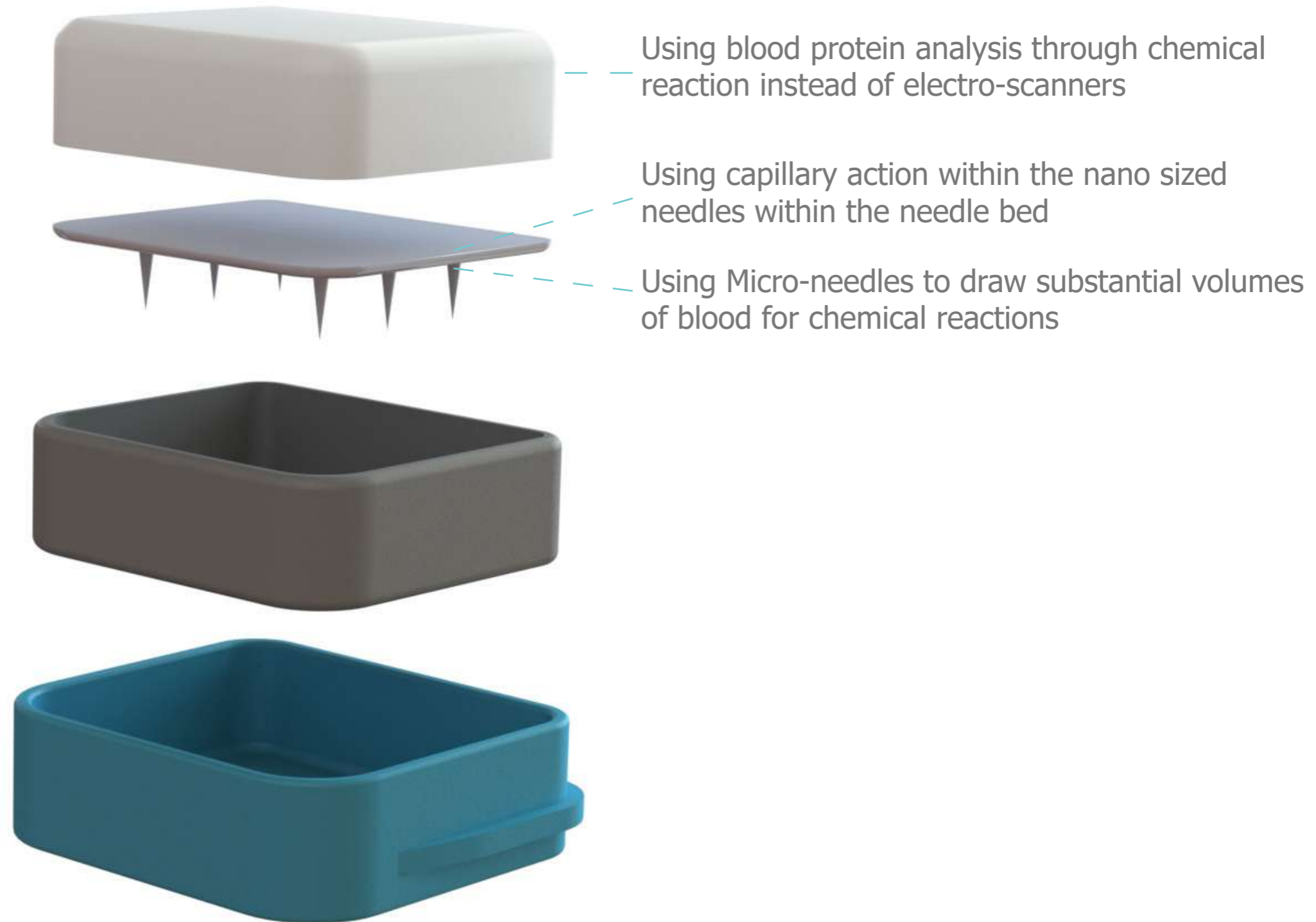
### How it Works

This process uses two physical forces — surface tension and adhesion — to counter the effects of gravity and draw a sample up. Surface tension is the forming of a barrier at the surface of a fluid created by the force that it takes to separate individual molecules of the fluid from one another whilst the adhesion aides in capillary action by creating a mutually attractive force between the liquid and the tube itself (Poulos, n.d.) This is a common mode of fluid collection, including bloods within medical practices via the use of a capillary tube.



## The Design

The design incorporates all 3 of the listed and proven concepts but due to the global scars-19 pandemic and the limitations of the time and scope of the project, these aspects could not be tested and thus examples have been show above, demonstrating the viability of the concepts in both FDA approved devices and real world situations



# Cognitive Detection.

# Validation

## mRPQ

### Clinical Data

A number of studies have proven the validity and reliability of the mRPQ including (Balalla, et al., 2020) and (Barker-Collo, et al., 2018).

## MPAI-4

### Clinical Data

A number of studies have proven the validity and reliability of the MPAI-4 including (Kean, et al., 2011) and (Guerrette & McKerral, 2020).



# Design Refinement.



## Breakdown

Final Design	pg 237
Material Requirements	pg 242
DFM	pg 249
Regulatory Specifications	pg 258
Market Analysis	pg 261
Branding and Packaging	pg 263
Storyboards	pg 266
Regulatory Pathways	pg 271
Essential Requirements Checklist	pg 272

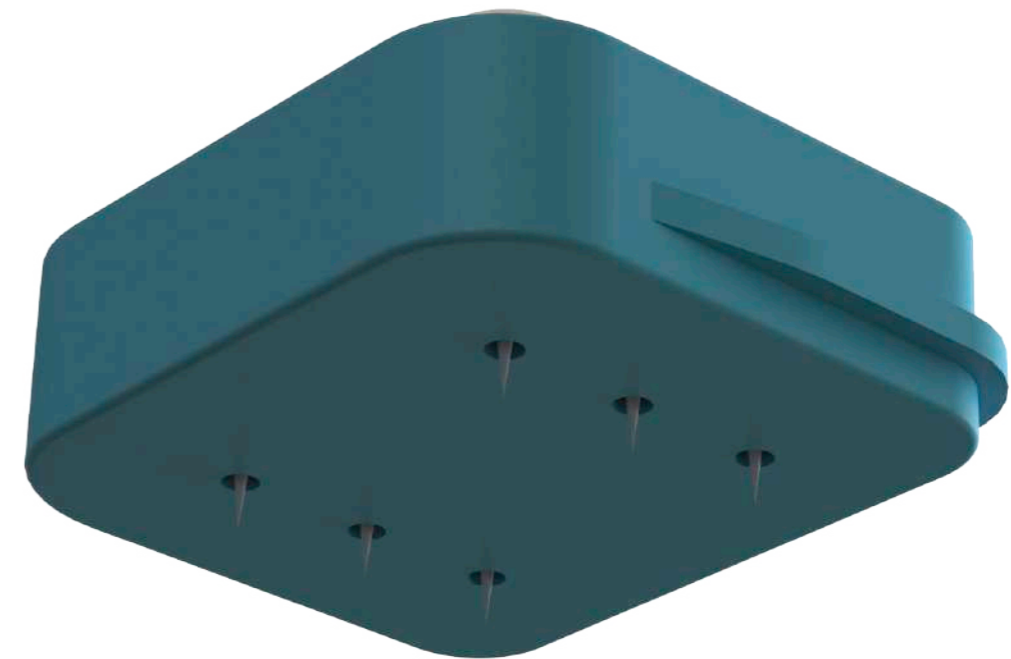
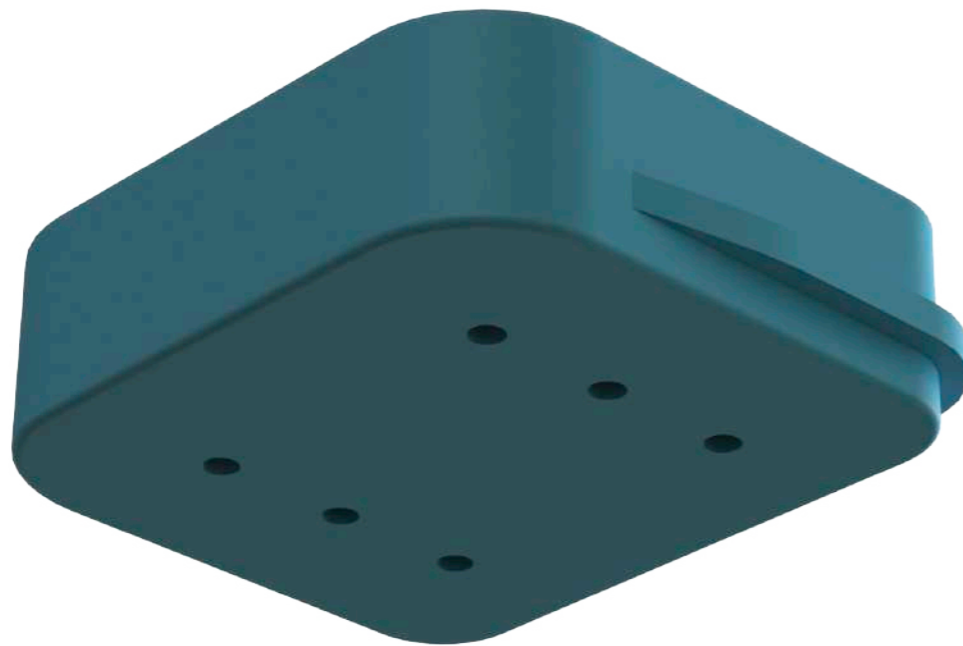
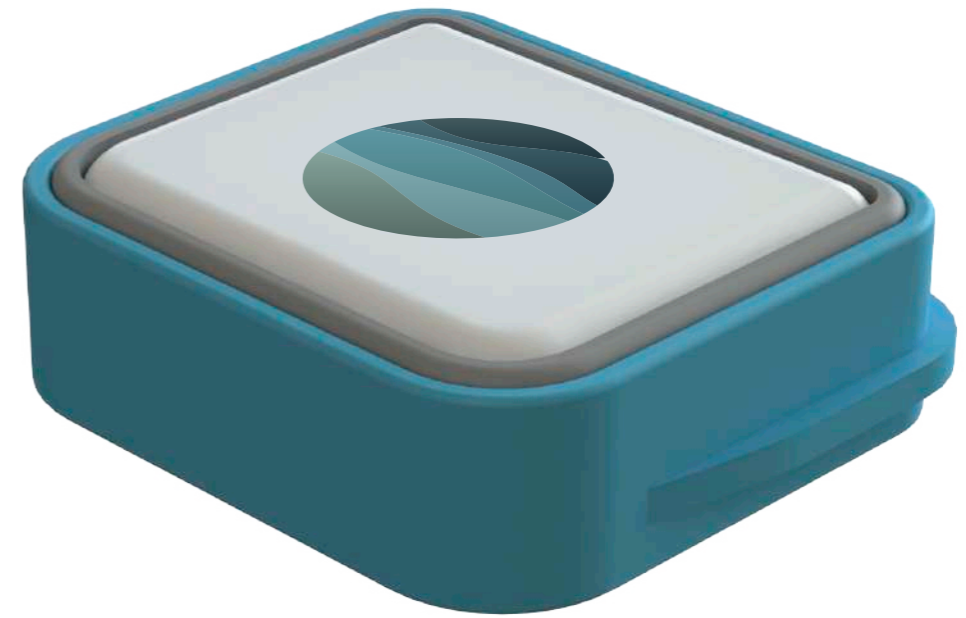
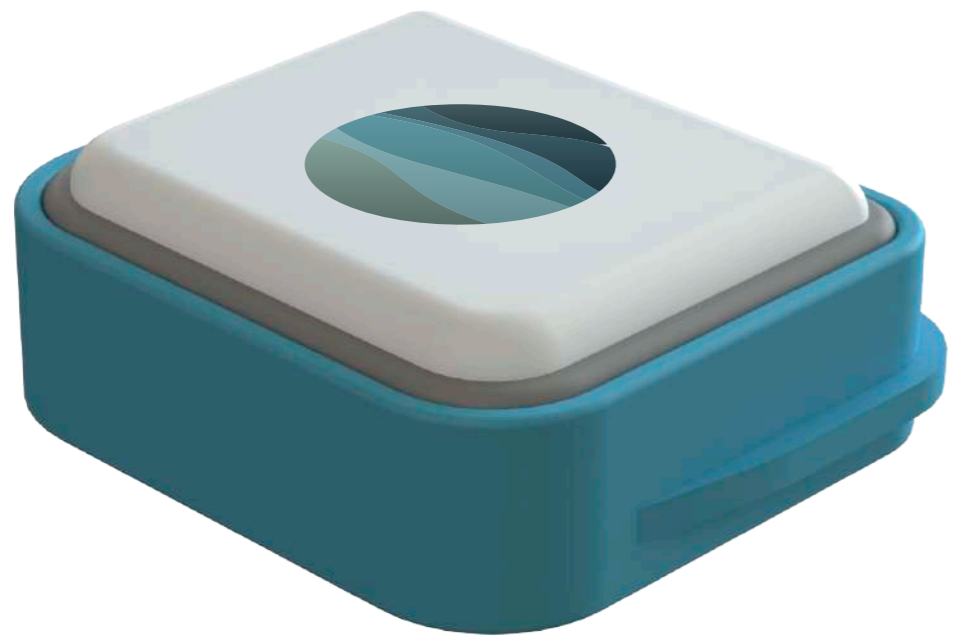
# Final Design



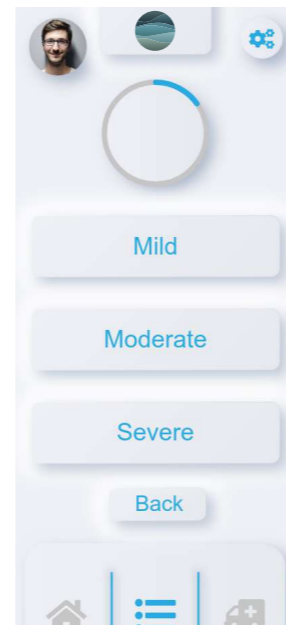
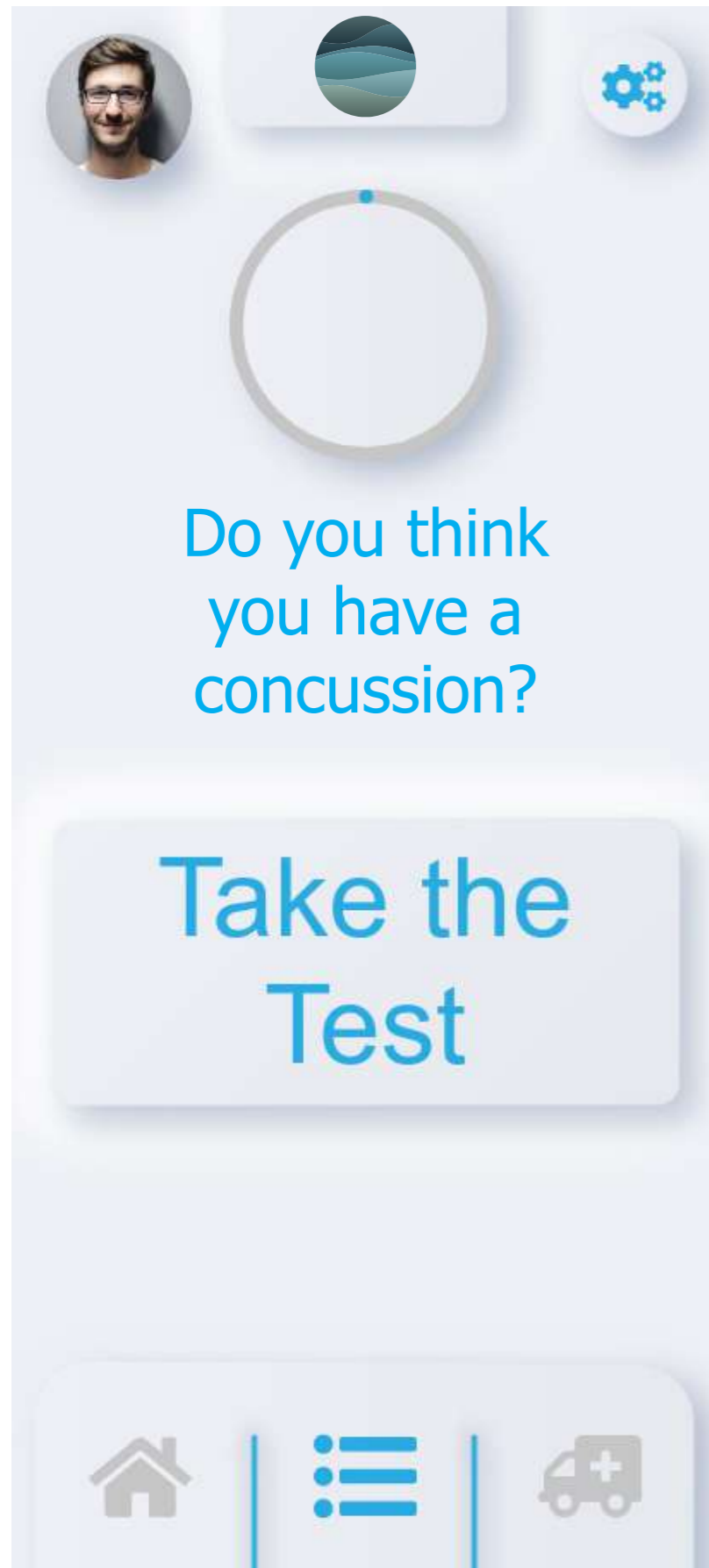
# Final Design



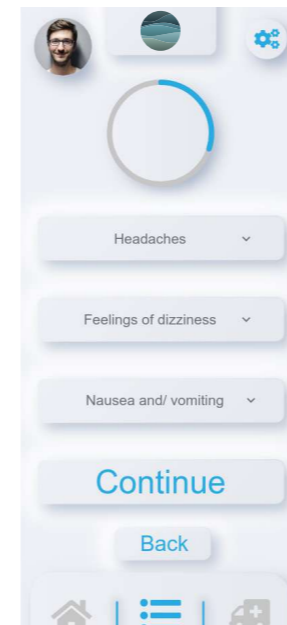
# Final Design



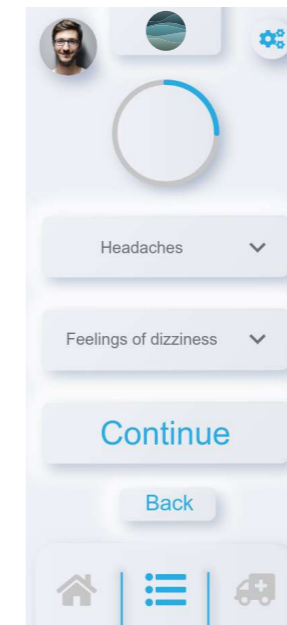
# Final Design



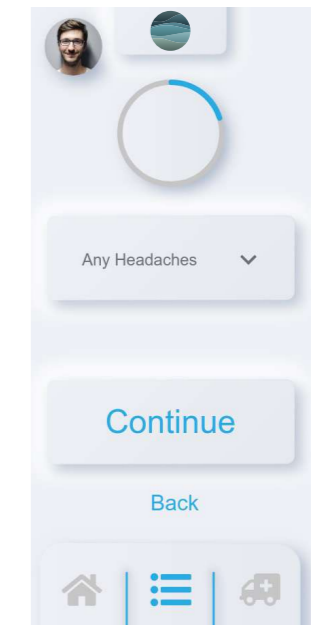
Input from the BCT device gives multiple option paths for users depending on the severity of the concussion



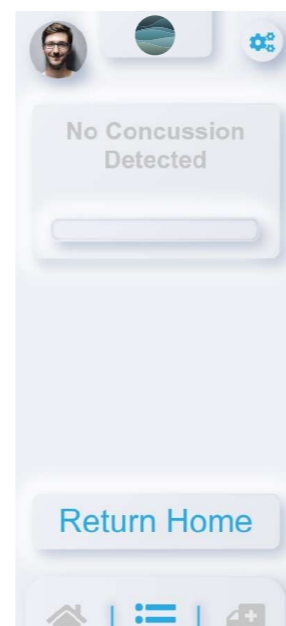
The Mild concussion option give the user the full gambit of questions required for the mRPQ cognitive test



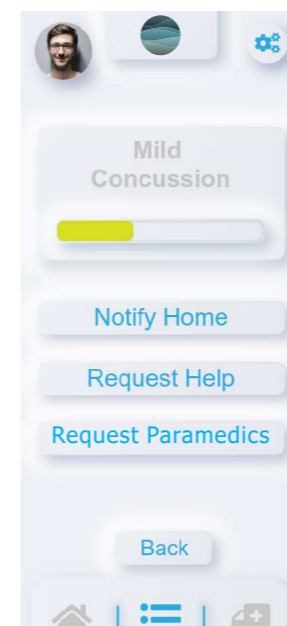
The Moderate concussion option give the user a simplified layout of the mRPQ cognitive questionnaire test



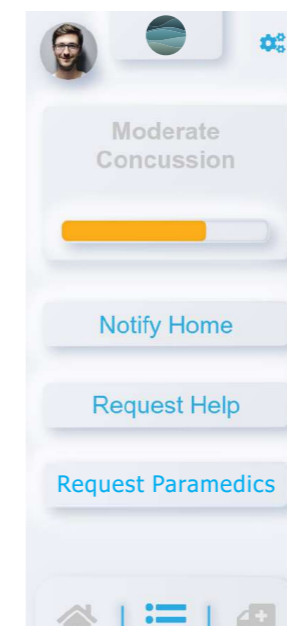
The Severe concussion option gives the user a much simpler version of the mRPQ test which is also only 10 questions long



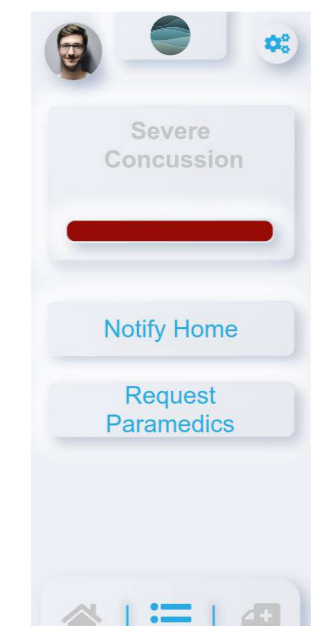
Each Result gives the user a number of options depending on whether a concussion was detected, in the case of non-detection then the user is free to continue with caution



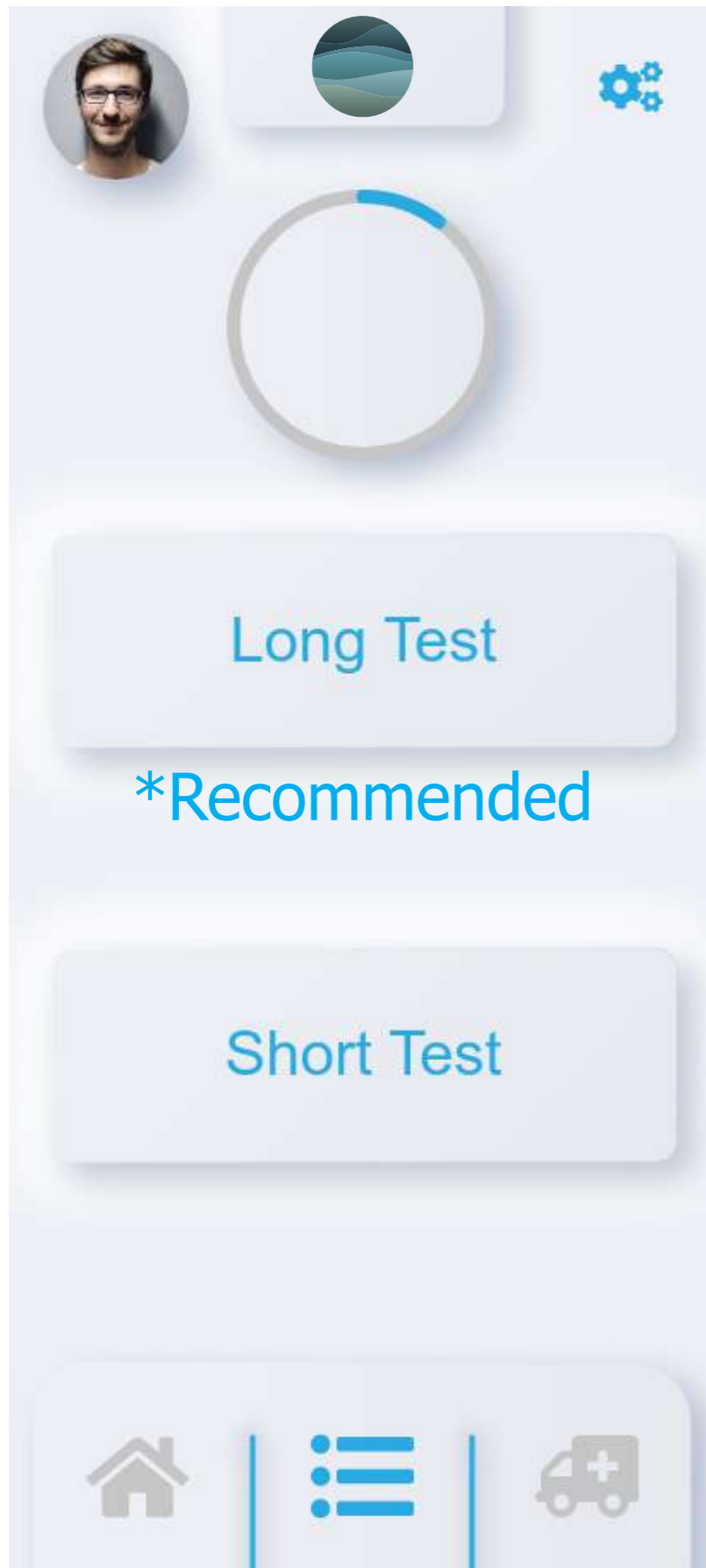
In the case of a mild concussion, the user is given 3 option for assistance but is allowed to also return with extreme caution



In the case of a moderate concussion, the user is given 3 choices that they must make, either notify home, request help from another app user or request paramedic help



In the case of a severe concussion, the user is given no choice and both the paramedics and home is notified in order to get the user to safety



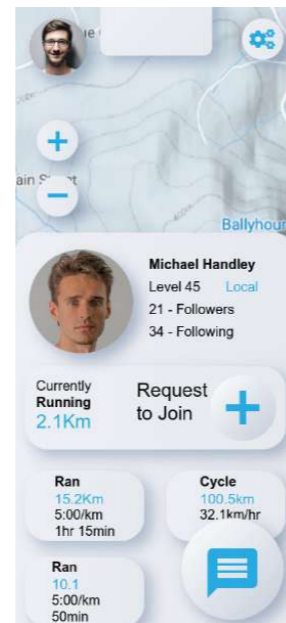
The app has allows the user to chose between a shorter less accurate test and a longer and more in-depth test.

The longer test being the **mRPQ** test

The shorter test being the **MPAI-4** test

This is to give the user the option to take a shorter test if their battery is low or there are other environmental factors or the longer test if they have the available time or want a more in-depth test.

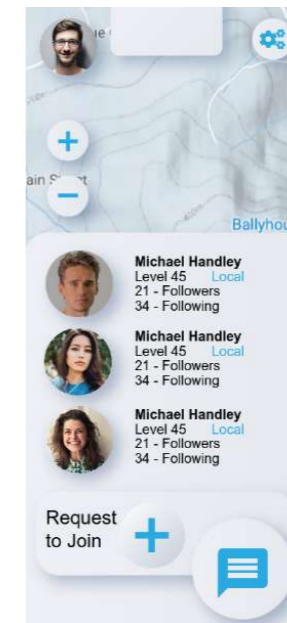
# Final Design



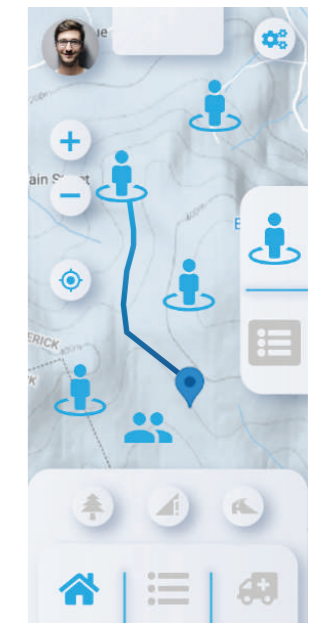
Simplified interface with enlarged icons for easy access



Clicking on the Join button opens the map and route to the user



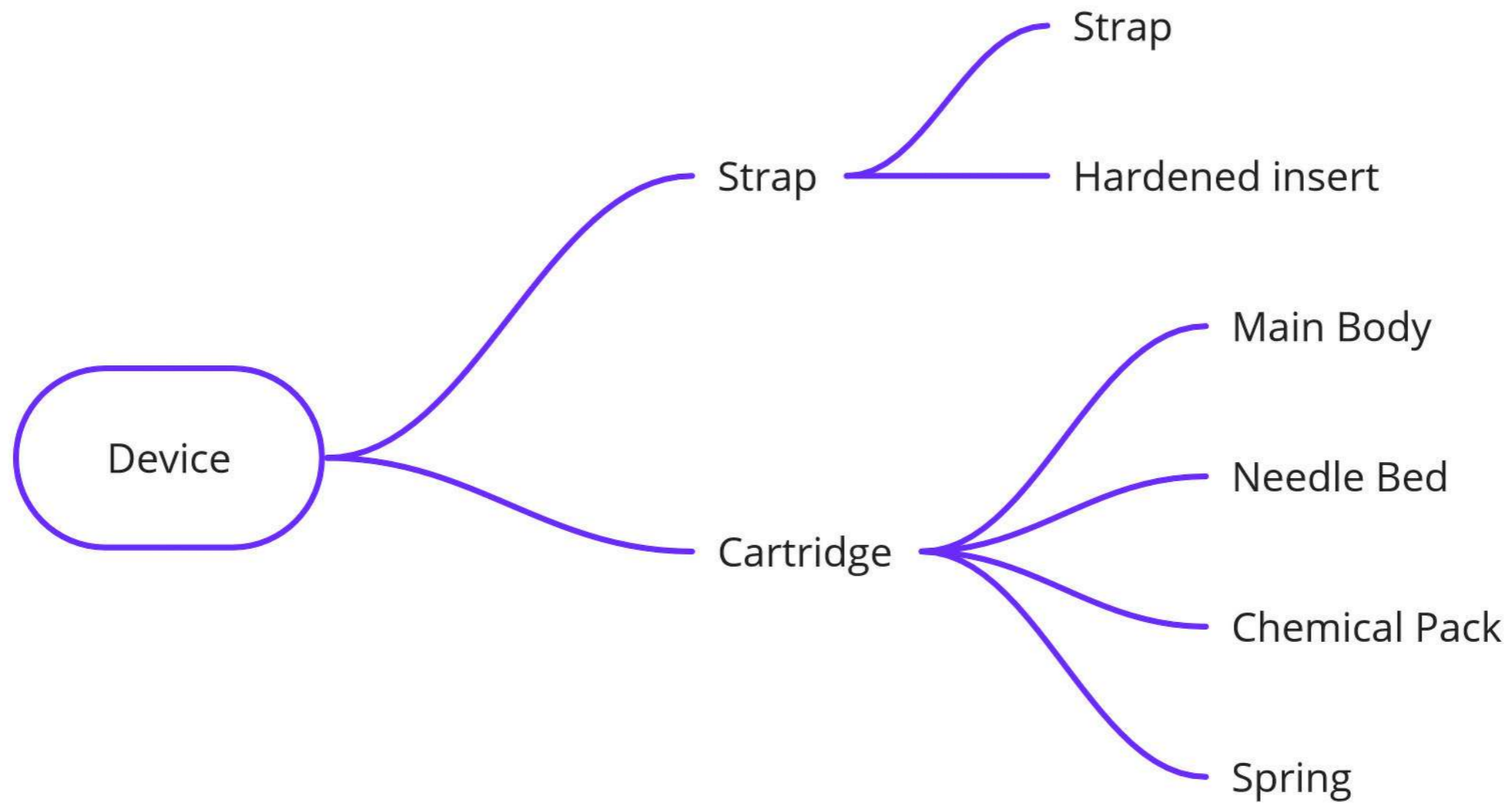
Simplified interface with enlarged icons for easy access



Clicking on the Join button opens the map and route to the group

The app has a social aspect that allows users to connect with each other to participate in group activities or to join current activities

It also allows for the user to request assistance if they get into trouble.





## Strap

### Requirements

Bio Compatible  
Elastic  
Durable  
Moldable  
Durable  
Overmoldable

Must Pass

ISO 10993  
EN ISO 13485

### Options

Medical-Grade Silicone  
Natural Rubber  
Polypropylene Oxide (PPO)  
Polypropylene glycol (PEO)  
Polysiloxane

### Choice

**Polysiloxane**  
(Silicone Rubber)

### Reason

Elasticity  
Flexibility  
Moldable  
Biocompatible  
Colourable  
Eco-Friendly

Resistant to:

Extreme Temperatures  
Fire  
Ozone  
Ultraviolet Radiation

## Insert

### Requirements

Durable  
Moldable  
Ridged

Must Pass

ISO 10993  
EN ISO 13485

### Options

Polypropylene (PP)

Acrylonitrile butadiene styrene  
(ABS)

Polystyrene (PS)

Polyethylene (PE-HD)

### Choice

Acrylonitrile  
Butadiene Styrene  
(ABS)

### Reason

Rigid  
Tough  
Stable  
Durable

Resistant to:  
Extreme Temperatures  
Chemical  
Abrasion  
Impact

## Main Body

### Requirements

Durable  
Bio-inert  
Anti Allergenic  
Moldable

Must Pass

ISO 10993  
EN ISO 13485

### Options

Polypropylene (PP)

Acrylonitrile butadiene styrene  
(ABS)

Polystyrene (PS)

Polyethylene (PE-HD)

### Choice

**Polyethylene**  
(PE-HD)

### Reason

Ease of Production  
Low Cost  
Durable  
Colourable  
Recyclable

Resistant to:

Extreme Temperatures  
Chemical  
Fatigue

# Needle Bed

## Requirements

Durable  
Bio-inert  
Anti Allergenic  
Moldable  
Ridged

Must Pass

ISO 10993  
EN ISO 13485

## Options

Polypropylene (PP)

Acrylonitrile butadiene styrene  
(ABS)

Polystyrene (PS)

Polyethylene (PE-HD)

Aluminum

Stainless Steel (440)

Stainless Steel (316L)

Stainless Steel (420)

Stainless Steel (17-4)

Stainless Steel (304)

## Choice

**Stainless Steel**  
(316L)

## Reason

Ease of Production  
Low Cost  
Durable  
High Tensile Strength  
Recyclable

Resistant to:

Extreme Temperatures  
Chemical  
Fatigue  
Corrosion

## Chemical Pack

### Requirements

Durable  
Bio-inert  
Anti Allergenic  
Moldable  
Semi-Ridged

Must Pass

ISO 10993  
EN ISO 13485

### Options

Polypropylene (PP)

Acrylonitrile butadiene styrene  
(ABS)

Polystyrene (PS)

Polyethylene (PE-HD)

### Choice

Polypropylene  
(PP)

### Reason

Ease of Production  
Low Cost  
Semi-Flexible  
Light Weight  
Tough

Resistant to:  
Temperatures  
Chemical  
Fatigue

## Spring

### Requirements

Elastic  
Light  
Low Cost  
Easily Produced

### Options

Pre-hardened Steel  
Polypropylene (PP)  
Acrylonitrile butadiene styrene (ABS)  
Polystyrene (PS)  
Polyethylene (PE)  
Polyester  
Nylon  
Acetal  
Polyphenylene Sulfide

### Choice

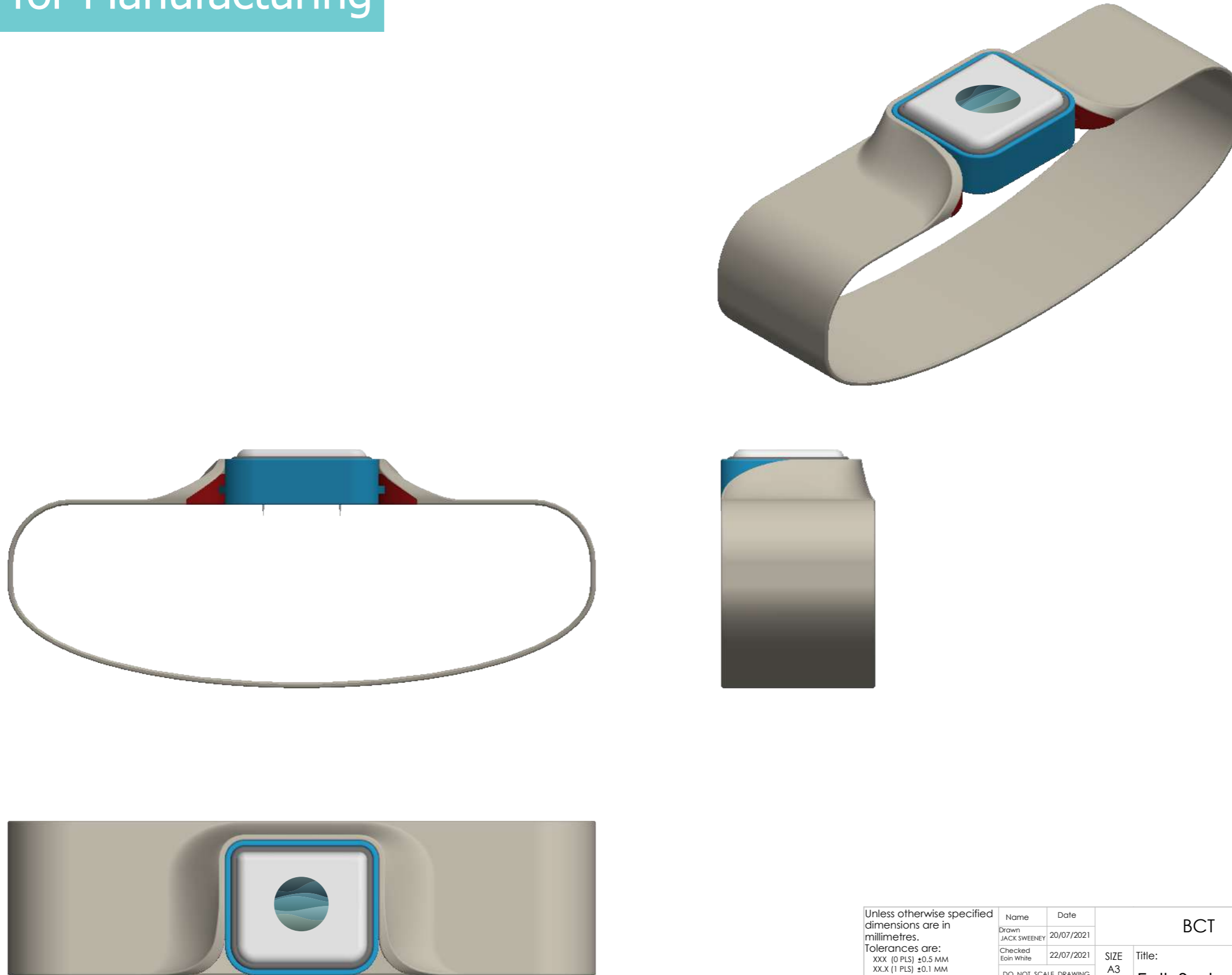
Polyethylene  
(PE)

### Reason

Ease of Production  
Low Cost  
Elastic

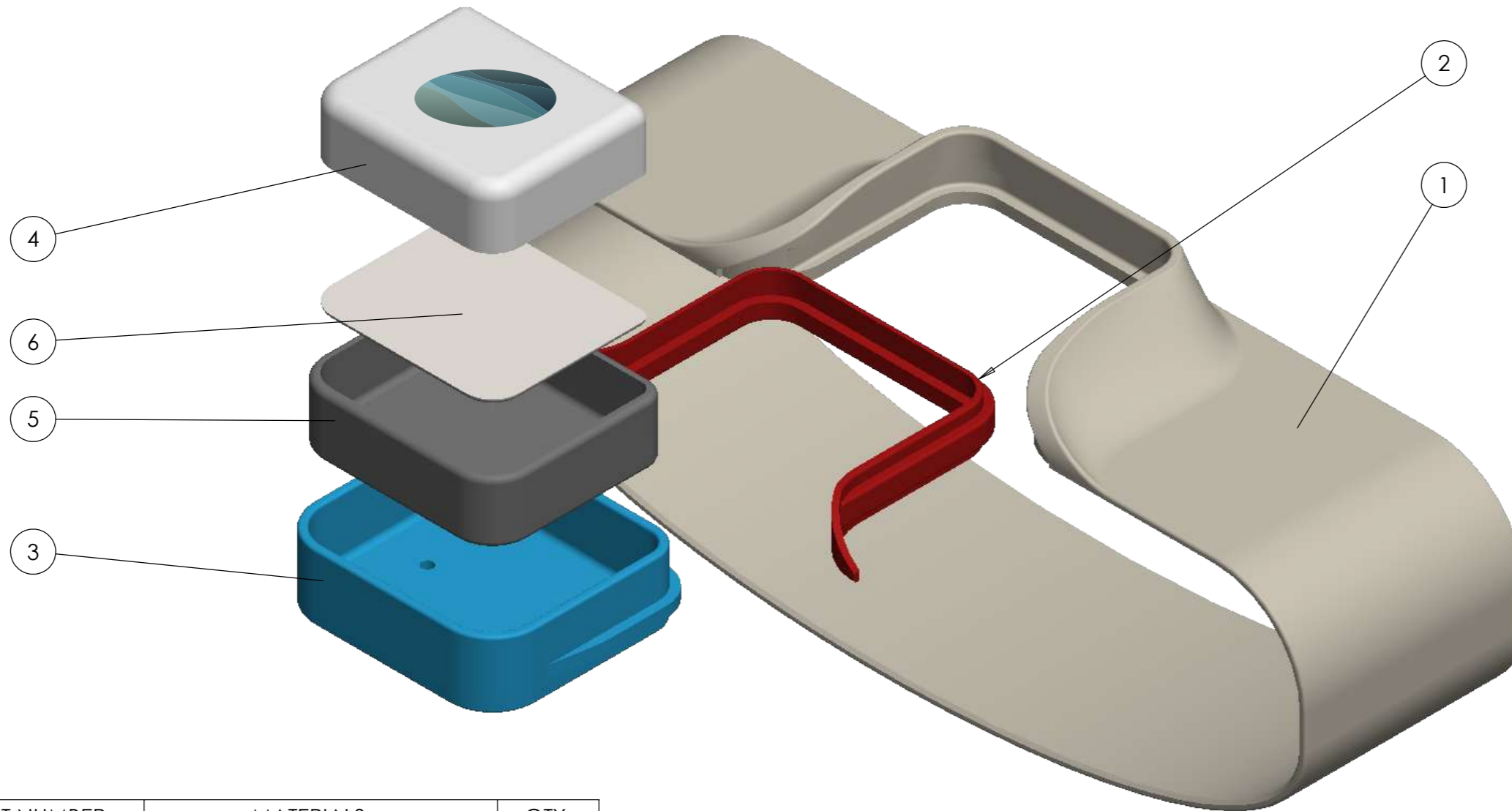
Resistant to:  
Temperatures  
Chemicals  
Fatigue

# Design for Manufacturing



Unless otherwise specified dimensions are in millimetres. Tolerances are: .XXX (0 PLS) ±0.5 MM XX.X (1 PLS) ±0.1 MM X.XX (2 PLS) ±0.03 MM .XXX (3 PLS) ±0.007 MM UNLESS OTHERWISE NOTED ANGLE TOLERANCE ±0°30', UNLESS NOTED Sheet Name: Full Build	Name	Date	BCT	
	Drawn JACK SWEENEY	20/07/2021	SIZE A3 DO NOT SCALE DRAWING	Title: Full_System_JS
	Checked Eoin White	22/07/2021		
	THIRD ANGLE PROJECTION 		DWG. NO.	Material: Rubber
		REV.	Scale: 1:1	Sheet 1 of 9

# Design for Manufacturing

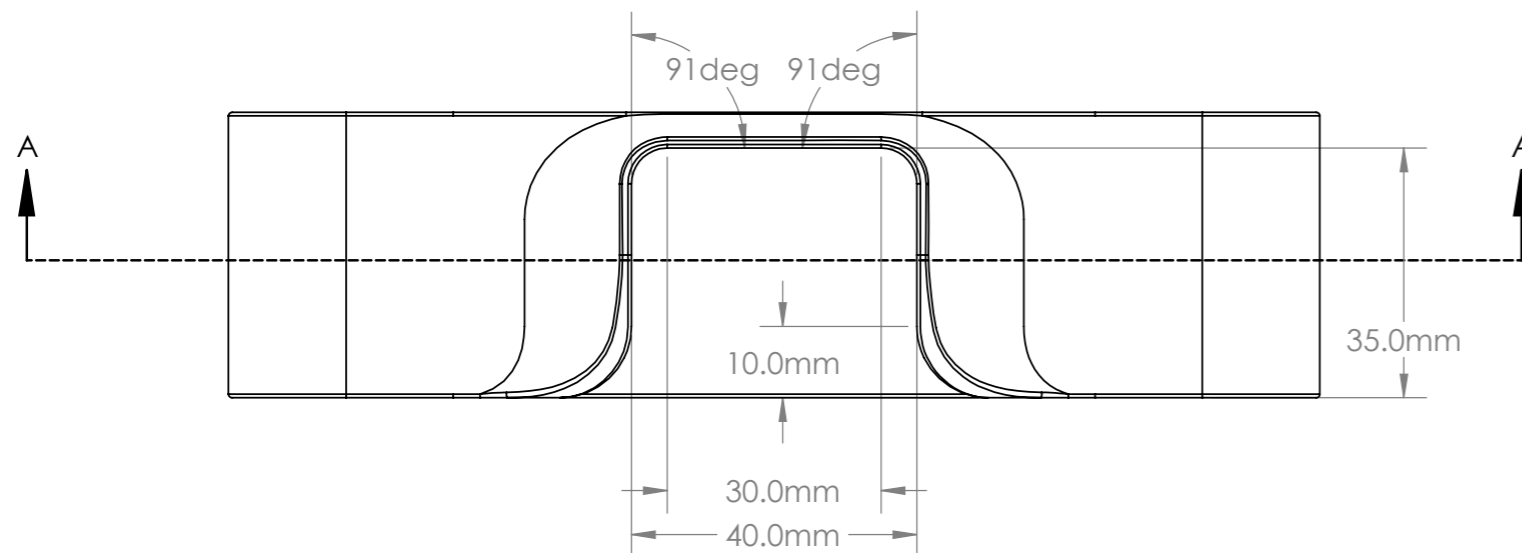
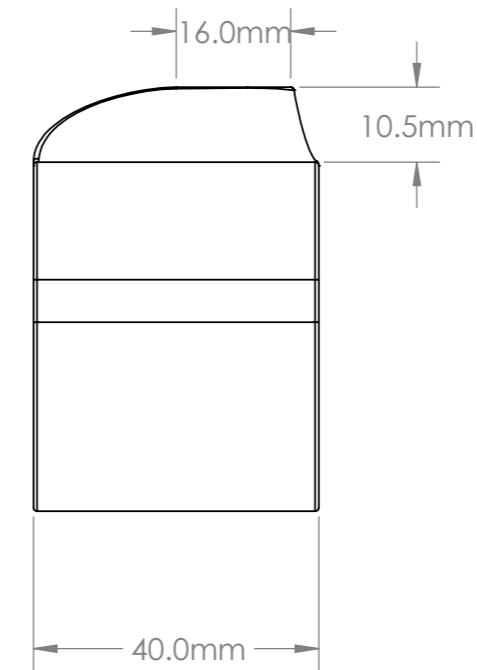
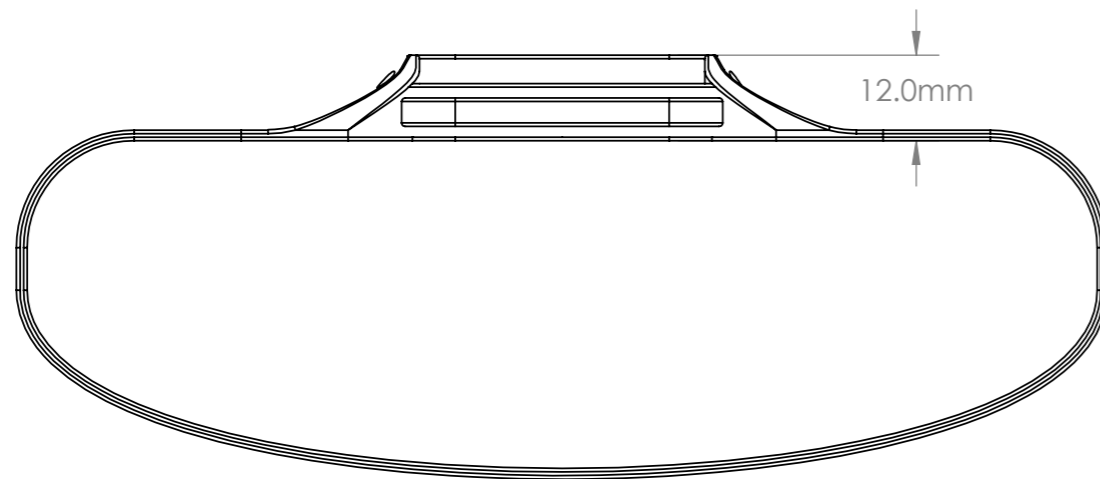
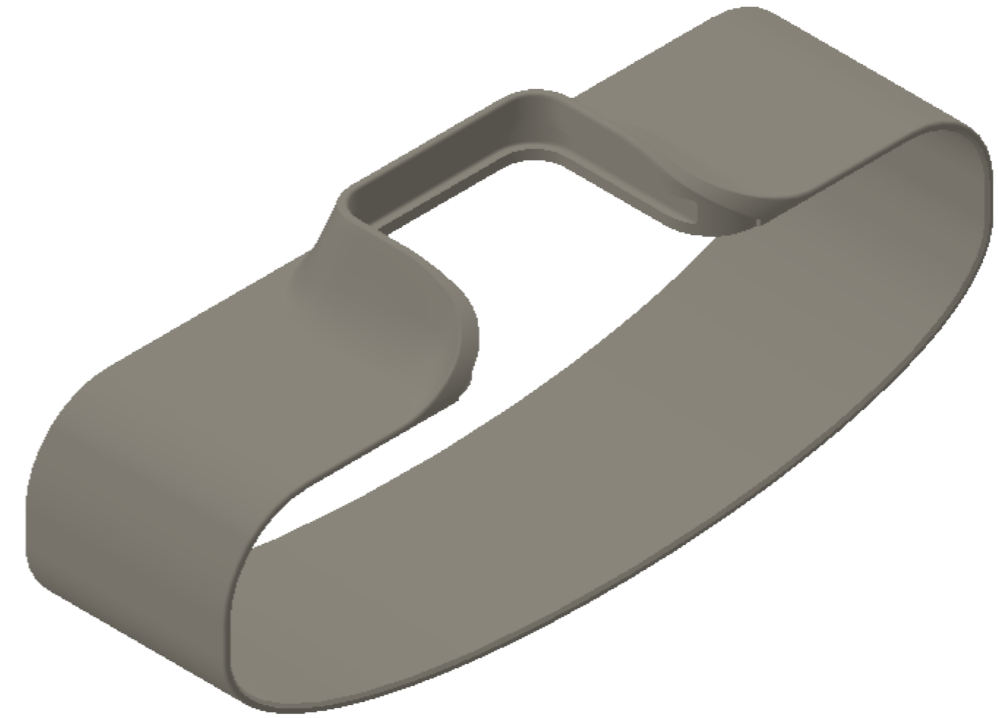
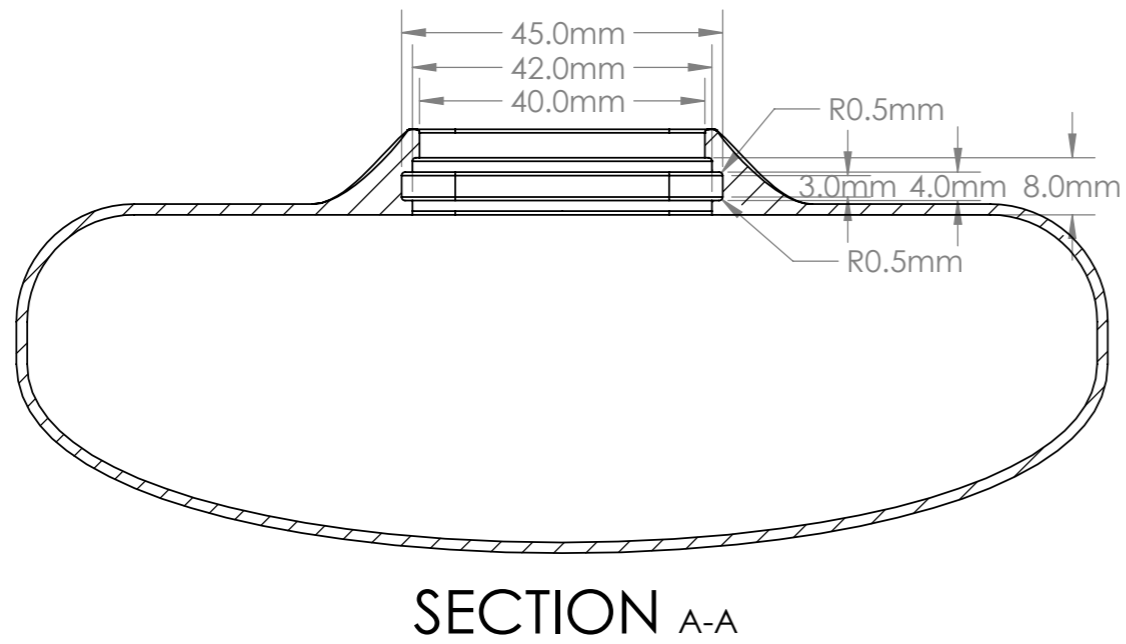


ITEM NO.	PART NUMBER	MATERIALS	QTY.
1	Strap	Polysiloxane	1
2	Strap insert	Acrylonitrile Butadiene Styrene (ABS)	1
3	Capsule body	Polyethylene (PE-HD)	1
4	Chemical pack	Polypropylene (PP)	1
5	Capsule body inner	Polyethylene (PE-HD)	1
6	Needle bed	Stainless Steel (316L)	1
7	Retainer/retraction spring	Polyethylene (PE)	1

Unless otherwise specified dimensions are in millimetres. Tolerances are: .XXX (0 PLS) ±0.5 MM XX.X (1 PLS) ±0.1 MM X.XX (2 PLS) ±0.03 MM .XXX (3 PLS) ±0.007 MM UNLESS OTHERWISE NOTED ANGLE TOLERANCE ±0°30', UNLESS NOTED Sheet Name: BOM	Name JACK SWEENEY	Date 20/07/2021	BCT	
	Checked Eoin White	Date 22/07/2021	SIZE A3	Title: BOM_JS
	DO NOT SCALE DRAWING		THIRD ANGLE PROJECTION	
	DWG. NO.		Material: Rubber	Weight: g
REV.		Scale: 1:1		Sheet 2 of 9

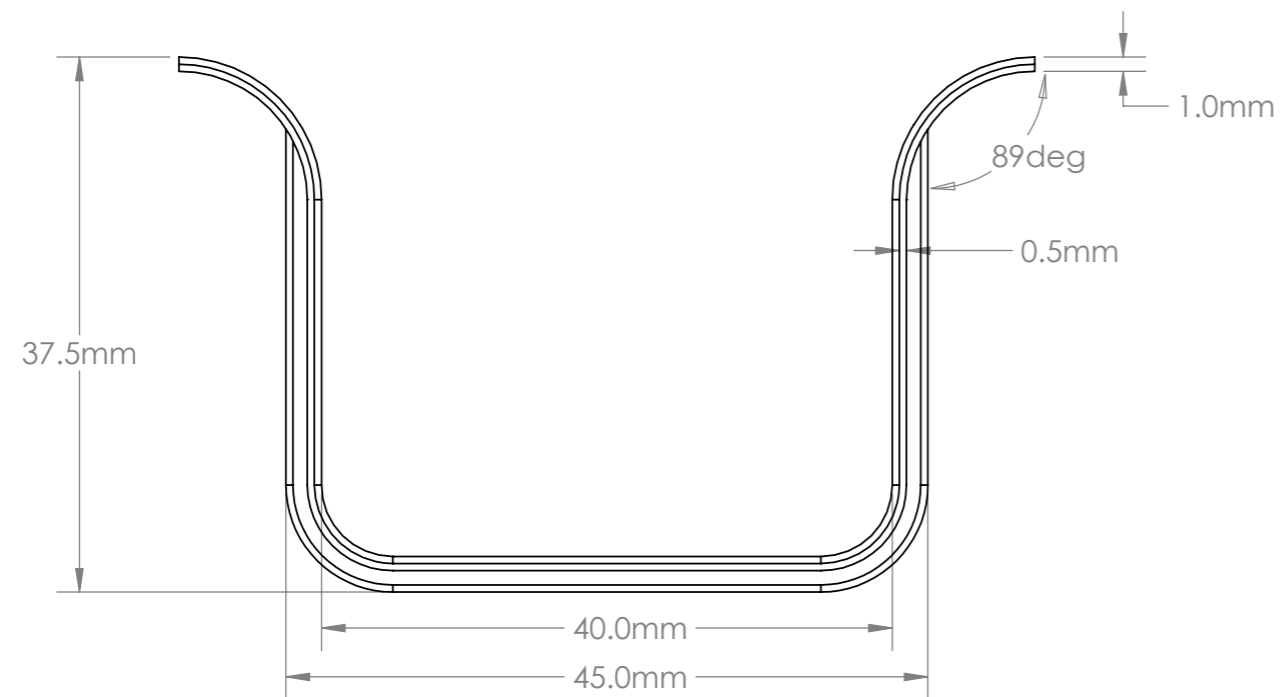
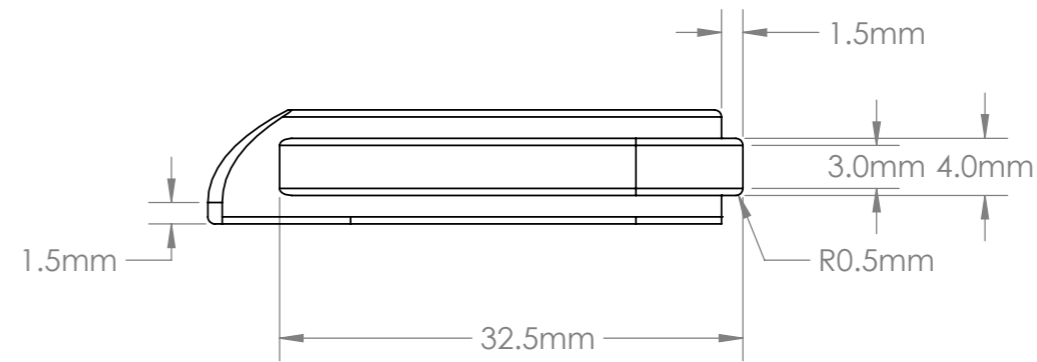
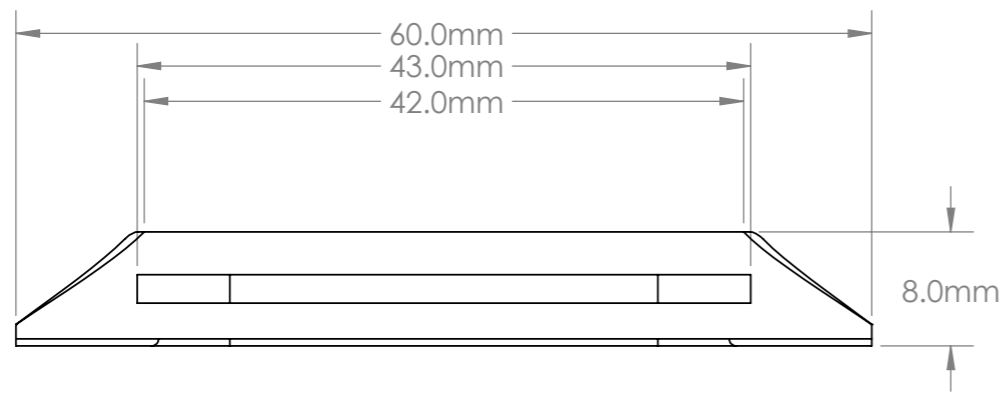
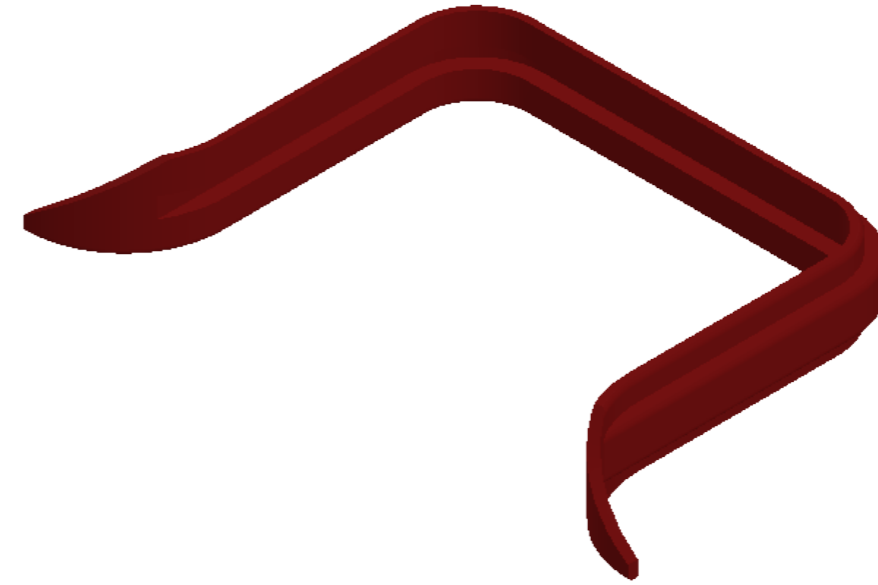


# Design for Manufacturing



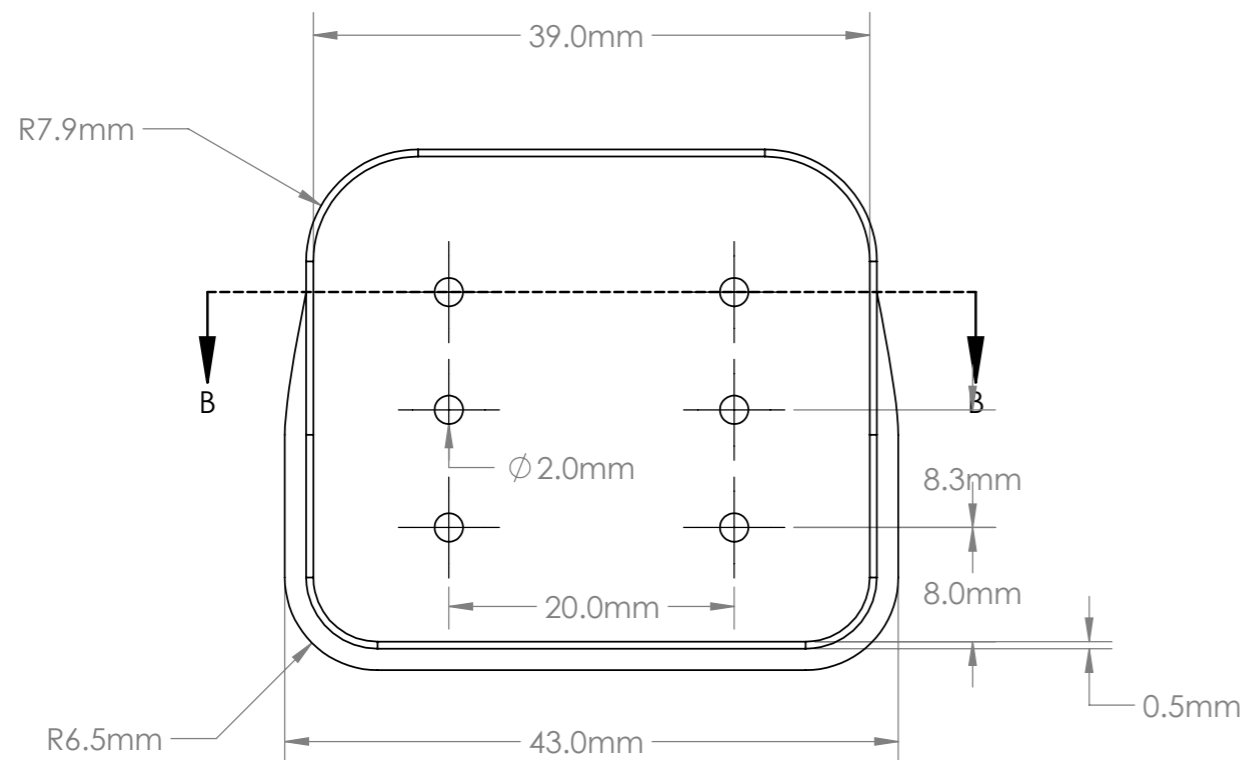
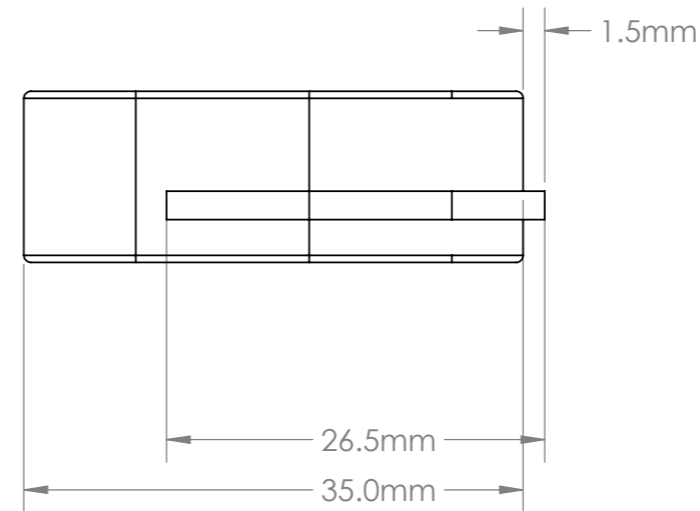
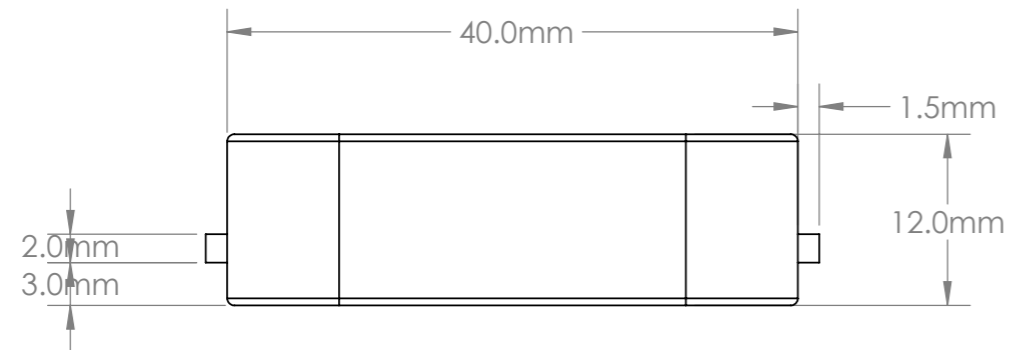
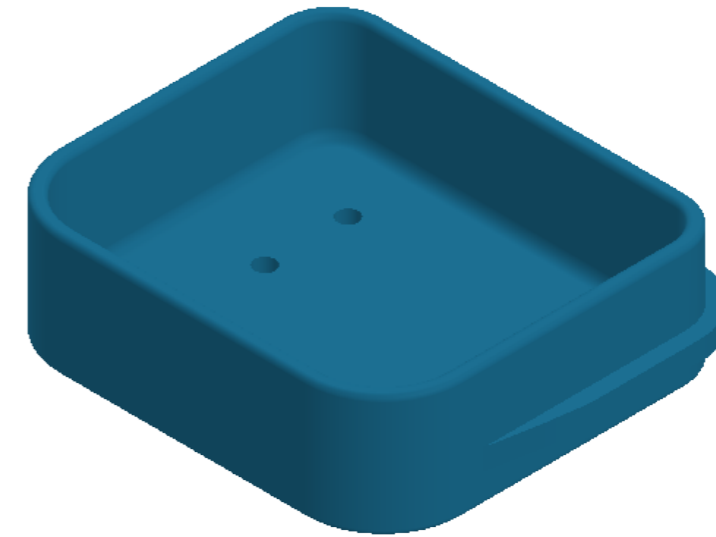
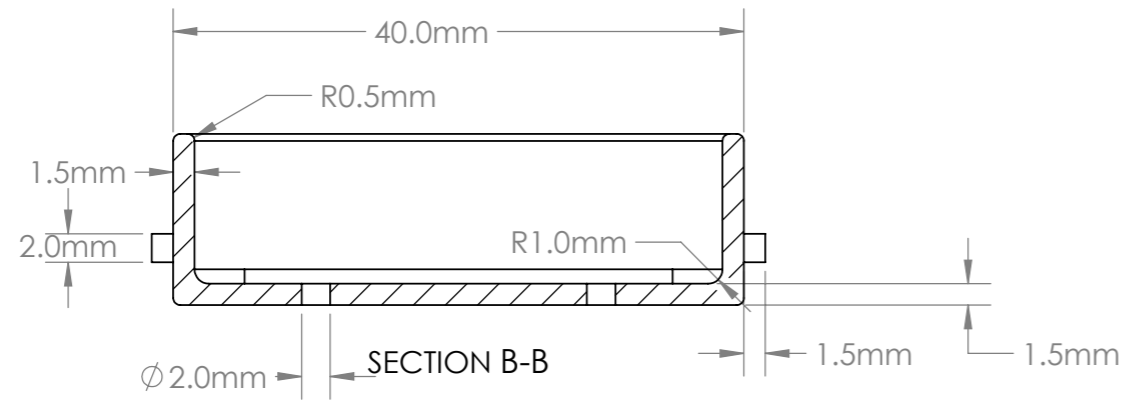
Unless otherwise specified dimensions are in millimetres. Tolerances are: .XXX (0 PLS) ±0.5 MM XX.X (1 PLS) ±0.1 MM X.XX (2 PLS) ±0.03 MM .XXX (3 PLS) ±0.007 MM UNLESS OTHERWISE NOTED ANGLE TOLERANCE ±0°30', UNLESS NOTED Sheet Name: Main Strap	Name	Date	BCT	
	Drawn JACK SWEENEY	20/07/2021	Title: 01_Main_Body_Strap_JS	DWG. NO. REV.
	Checked Eoin White	22/07/2021		
	DO NOT SCALE DRAWING THIRD ANGLE PROJECTION	SIZE A3	Scale: 1:1	Sheet 3 of 9

# Design for Manufacturing



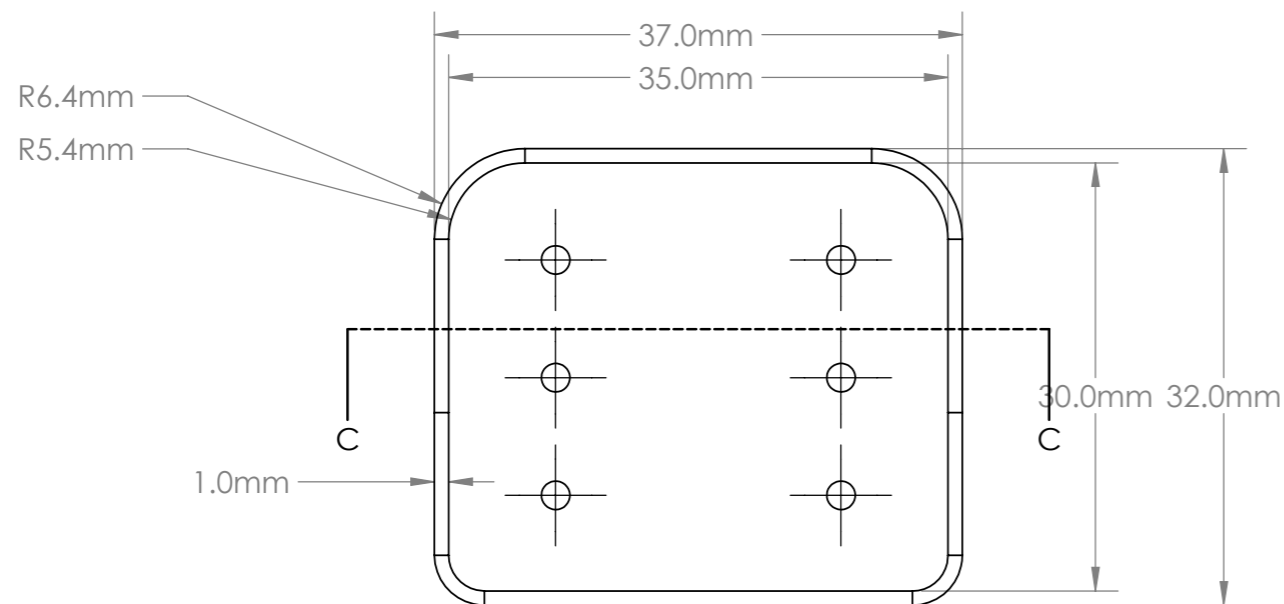
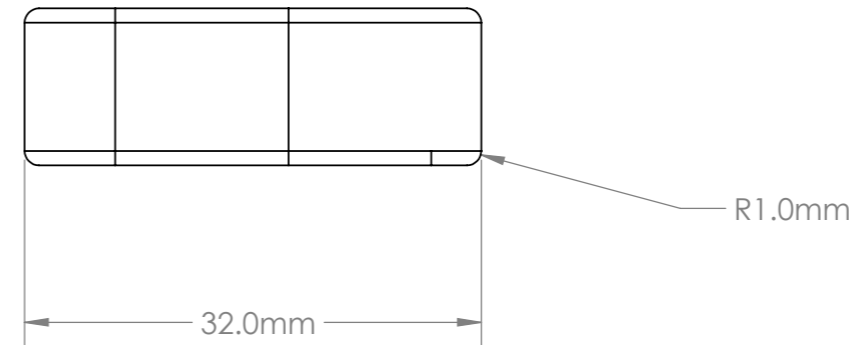
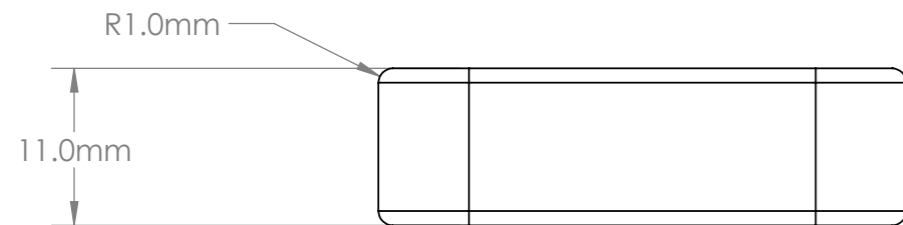
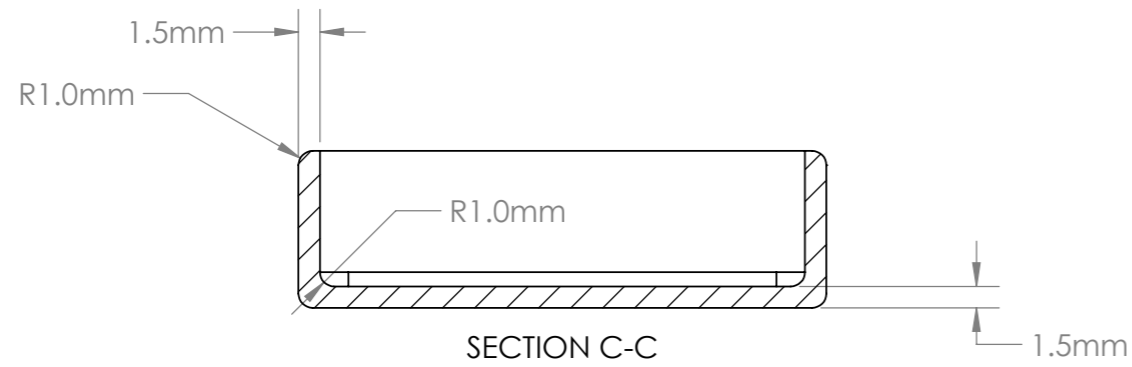
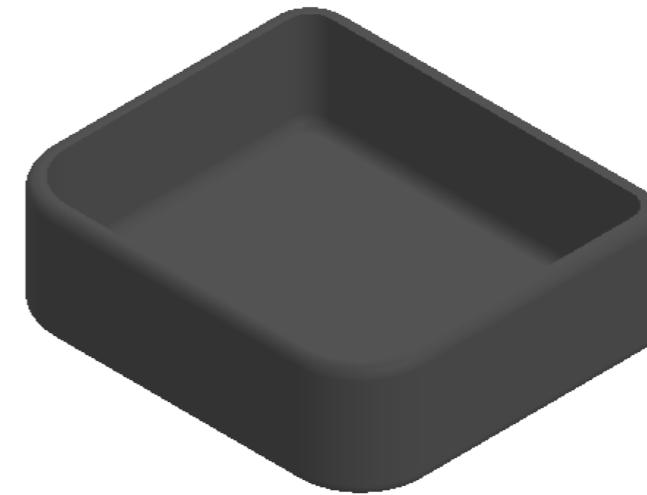
Unless otherwise specified dimensions are in millimetres. Tolerances are: .XXX (0 PLS) ±0.5 MM XX.X (1 PLS) ±0.1 MM X.XX (2 PLS) ±0.03 MM .XXX (3 PLS) ±0.007 MM UNLESS OTHERWISE NOTED ANGLE TOLERANCE ±0°30', UNLESS NOTED Sheet Name: Overmoulded Insert	Name JACK SWEENEY	Date 20/07/2021	BCT	
	Checked Eoin White	Date 22/07/2021	SIZE A3	Title: 02_Overmoulded_insert _JS
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			DWG. NO. REV.	Material: Rubber Scale: 1:1 Weight: g Sheet 4 of 9

# Design for Manufacturing

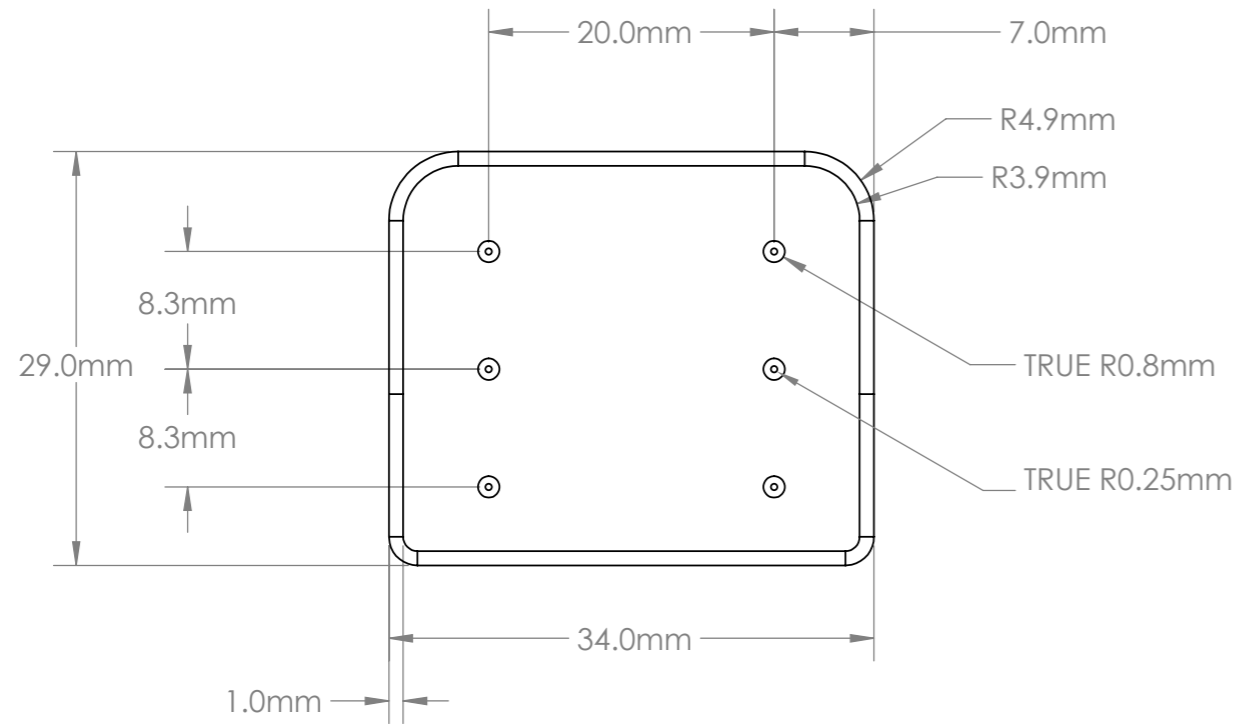
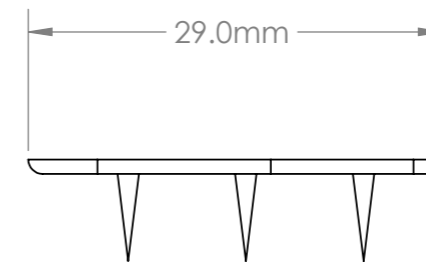
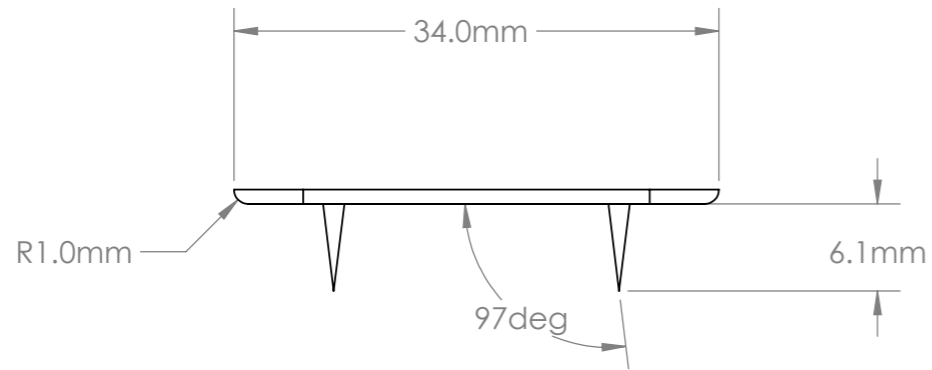
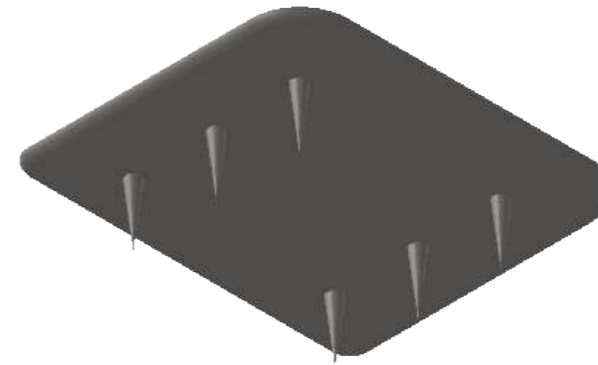


Unless otherwise specified dimensions are in millimetres. Tolerances are: .XXX (0 PLS) ±0.5 MM XX.X (1 PLS) ±0.1 MM X.XX (2 PLS) ±0.03 MM .XXX (3 PLS) ±0.007 MM UNLESS OTHERWISE NOTED ANGLE TOLERANCE ±0°30', UNLESS NOTED Sheet Name: Capsule Body	Name	Date	BCT	
	Drawn JACK SWEENEY	20/07/2021	SIZE A3	Title: 03_Capsule_Body_JS
	Checked Eoin White	22/07/2021		
	DO NOT SCALE DRAWING			DWG. NO.
THIRD ANGLE PROJECTION 			REV.	Weight: g
			Scale: 1:1	
			Sheet 5 of 9	

# Design for Manufacturing

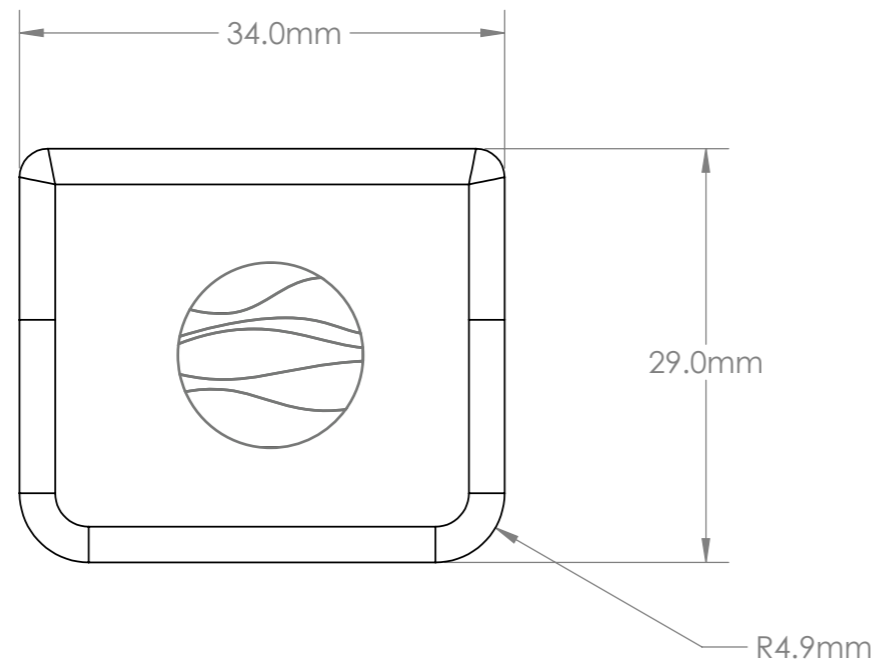
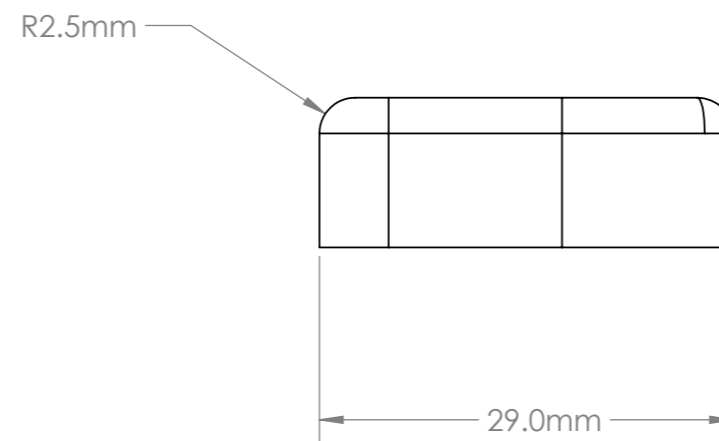
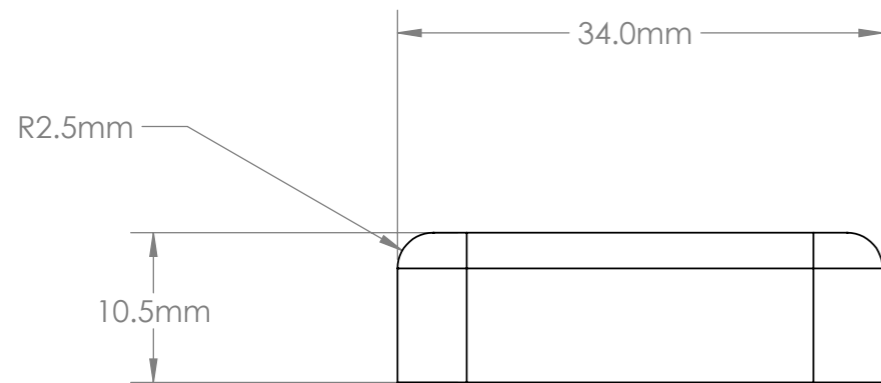
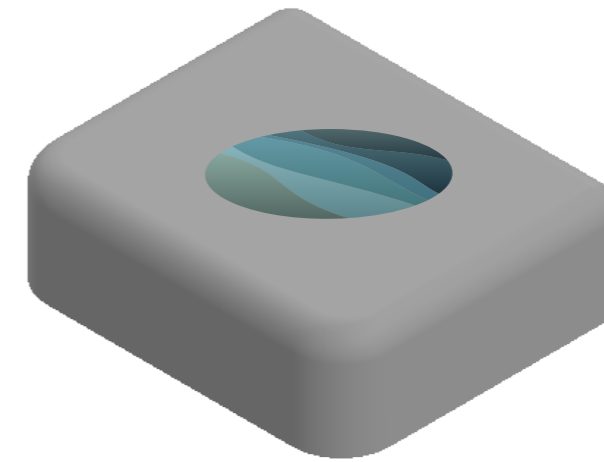


Unless otherwise specified dimensions are in millimetres. Tolerances are: .XXX (0 PLS) ±0.5 MM XX.X (1 PLS) ±0.1 MM X.XX (2 PLS) ±0.03 MM .XXX (3 PLS) ±0.007 MM UNLESS OTHERWISE NOTED ANGLE TOLERANCE ±0°30', UNLESS NOTED Sheet Name: Capsule Internals	Name	Date	BCT	
	Drawn JACK SWEENEY	20/07/2021	SIZE A3	Title: 04_Capsule_Internals_JS
	Checked Eoin White	22/07/2021		
	DO NOT SCALE DRAWING			DWG. NO.
THIRD ANGLE PROJECTION 			REV.	Scale: 1:1
			Weight: g	Sheet 6 of 9



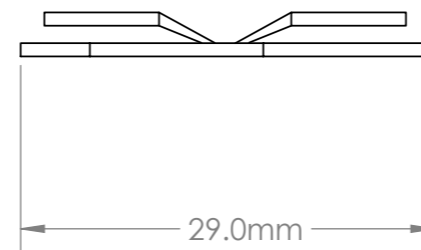
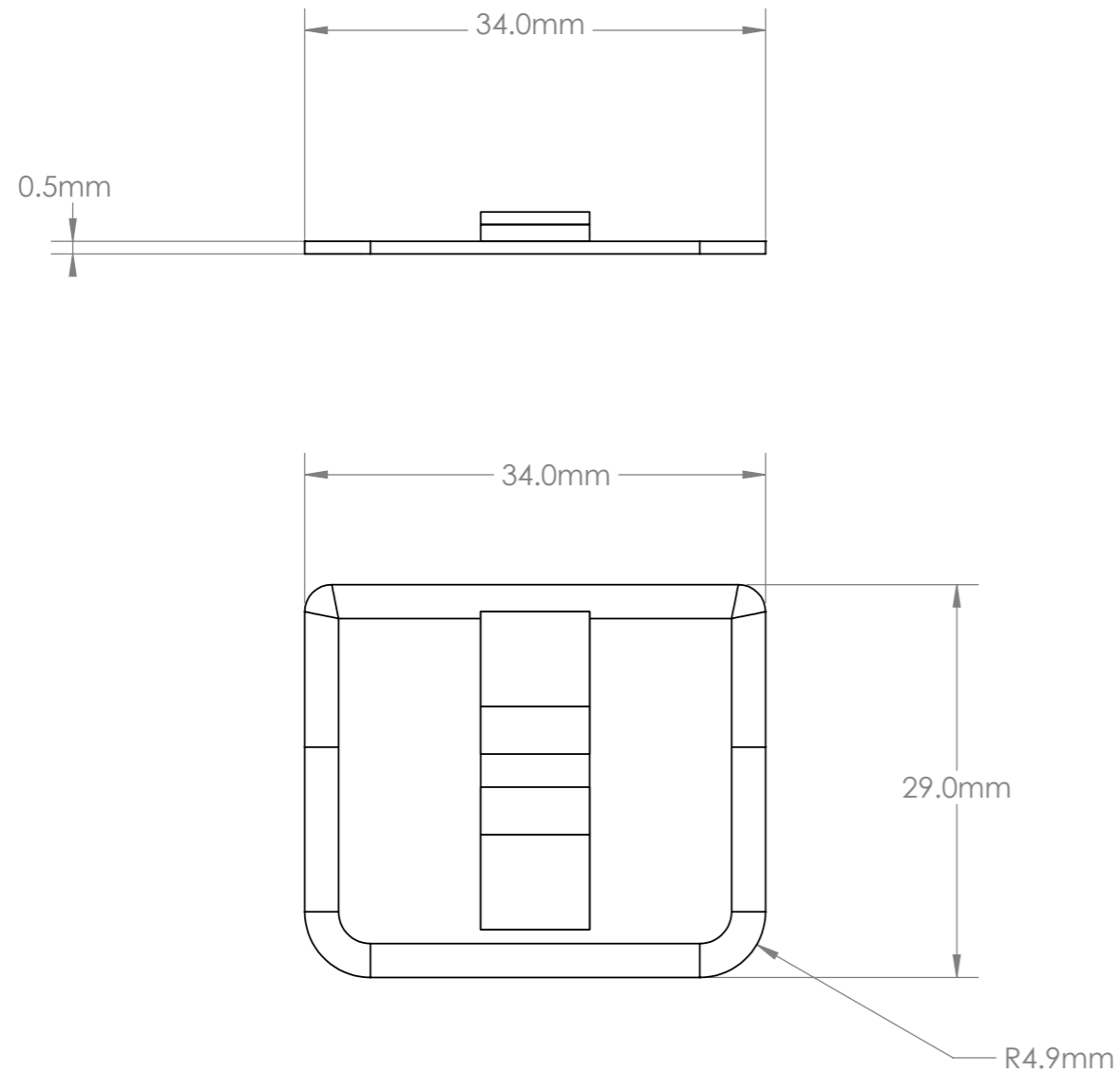
Unless otherwise specified dimensions are in millimetres. Tolerances are: .XXX (0 PLS) ±0.5 MM XX.X (1 PLS) ±0.1 MM X.XX (2 PLS) ±0.03 MM .XXX (3 PLS) ±0.007 MM UNLESS OTHERWISE NOTED ANGLE TOLERANCE ±0°30', UNLESS NOTED Sheet Name: Needle Bed	Name JACK SWEENEY	Date 20/07/2021	BCT	
	Checked Eoin White	Date 22/07/2021	SIZE A3	Title: 06_Needle_Bed_JS
	DO NOT SCALE DRAWING		THIRD ANGLE PROJECTION	
			DWG. NO.	Material: Rubber
		REV.	Scale: 1:1	Sheet 7 of 9

# Design for Manufacturing



Unless otherwise specified dimensions are in millimetres. Tolerances are: XXX (0 PLS) ±0.5 MM XX.X (1 PLS) ±0.1 MM X.XX (2 PLS) ±0.03 MM .XXX (3 PLS) ±0.007 MM UNLESS OTHERWISE NOTED ANGLE TOLERANCE ±0°30', UNLESS NOTED Sheet Name: Chemical Pack	Name	Date	BCT	
	Drawn JACK SWEENEY	20/07/2021	SIZE A3	Title: 07_Chemical_Pack_JS
	Checked Eoin White	22/07/2021		
	DO NOT SCALE DRAWING			DWG. NO.
THIRD ANGLE PROJECTION 			REV.	Scale: 1:1
			Weight: g	Sheet 8 of 9

# Design for Manufacturing



Unless otherwise specified dimensions are in millimetres. Tolerances are: .XXX (0 PLS) ±0.5 MM XX.X (1 PLS) ±0.1 MM X.XX (2 PLS) ±0.03 MM .XXX (3 PLS) ±0.007 MM UNLESS OTHERWISE NOTED ANGLE TOLERANCE ±0°30', UNLESS NOTED Sheet Name: Retaining Spring	Name	Date	BCT		
	Drawn JACK SWEENEY	20/07/2021	SIZE A3	Title: 08_Retaining_Spring_JS	
	Checked Eoin White	22/07/2021			
	DO NOT SCALE DRAWING			DWG. NO.	Material: Rubber
THIRD ANGLE PROJECTION 			REV.	Scale: 1:1	Sheet 9 of 9

## Regulatory Specifications

### Unique Device Identification System (UDI)



Conformity is achieved with labeled and numerically ordered cartridges

EU Regulations require a UDI for each significant part associated with a medical device under article 24 of EU 2017/746



## Regulatory Specifications

### Unique Device Identification System (UDI)



Conformity is achieved with labeled and numerically ordered straps that also contain the CE marking

## Unique Device Identification System (UDI)

### General packaging requirements in accordance with articles 25 & 26 of EN 2017/746 of the BCT

Manufacturer & Compliance officer  
Jack Sweeney  
University of Limerick, Co. Limerick, Ireland  
16152069@studentmail.ul.ie

Self test - Concussion Detection Device that uses a small blood sample to determine the severity of a concussion

UDI - #000001 - 21/07/2021

CE Rated

European Market

Class C

Sterile

New

Contains - 1 strap and 4 capsules

Strap - Multi Use

Capsule - single use

Strap must be sterilized before each use

Strap must be stored out of direct sunlight

Capsules must be kept in their individual packaging until their use to reduce the likelihood of contamination or false activation

## Concussion Market

**6.8 Billion**

Current Value  
2019

(Markets&Markets, 2020)

Country scope - U.S., Canada; U.K.; Germany; France; Italy; Spain; Japan; China; India; Australia; South Korea; Brazil; Mexico; Colombia; Argentina; South Africa; Saudi Arabia; UAE

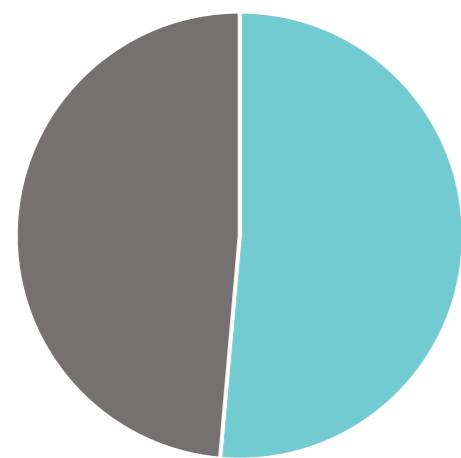
**8.9 Billion**

Future Value  
2027

(Markets&Markets, 2020)

Estimated to have a compound annual growth rate (CAGR) of 3.26% from 2020 to 2027

## Concussion Treatment Market

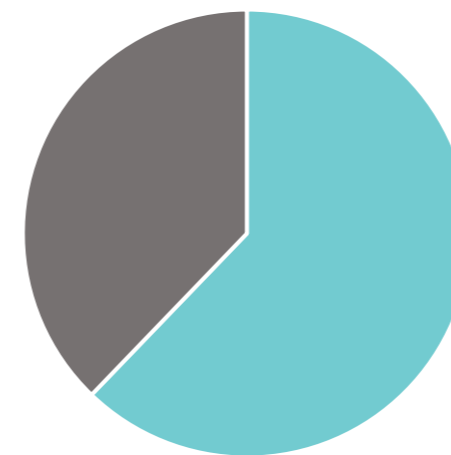


**51.4%**

Current Market  
Stake 2019

(Grand View Research, 2020)

The Treatment and Assessment segment dominates the market with a 50%+ revenue share as of 2019



**62.2%**

North American  
revenue share 2019

(Grand View Research, 2020)

In North America the treatment and assessment segment dominates the market with a 62.2%+ revenue share as of 2019, owing to the favorable reimbursement policies in healthcare

## Key Companies in Concussions

### Advanced Brain Monitoring Inc

Creates diagnostics device such as their sleep profiler, therapy device such as their Apnea Guard and other Neurotechnologies such as their B-Alert X-Series eeg system

### Raumedic AG

Creates a number of Neuromonitoring devices such as a multi-modal neuromonitoring catheters

### Nihon Kohden Corporation

Creates a number of medical devices such as Pulse Oximetry devices, Co2 Sensors and their AED device. They also produce disposable EEG electrodes.

### Compumedics Ltd

Creates a vast number of devices such as their Neurology Amplifiers and recorders but they also create a DWL TBI detection device that scans blood vessels in the brain for concussions

### NovaSignal Corporation

Creates a number of different blood flow analysis devices such as their NovaGuide 2 and the Lucid 2.0

### InfraScan Inc

Creates a device for intracranial hematomas detection using NIR spectroscopy to detect the injured parts of the brain

### Oculogica

Creates a pupil tracking concussion detection device which relies on ocular motility and other types of brain function measured through pupil tracking

### BrainScope

Creates a device that assesses head injuries of patients for both brain bleeds and concussions using eeg recordings.

### BioDirection Inc

Creates a concussion detection device called the NanoDx that uses a blood sampling kit which detects the biomarker proteins within the blood to detect concussions

### Integra LifeSciences Corporation

Acts as a wholesaler for many of the top medical device companies around Europe but does not create its own lineup of devices



**BCCT**

## Branding & Packaging

Each capsule is individually plastic wrapped with a cardboard base in order to reduce the risk of injury from accidental discharge

Both the plastic wrapping and the cardboard will be removed before use

Plastic wrapping

Cardboard Base



Plastic wrapping interferes with fit and so must be removed to fit capsule into the strap



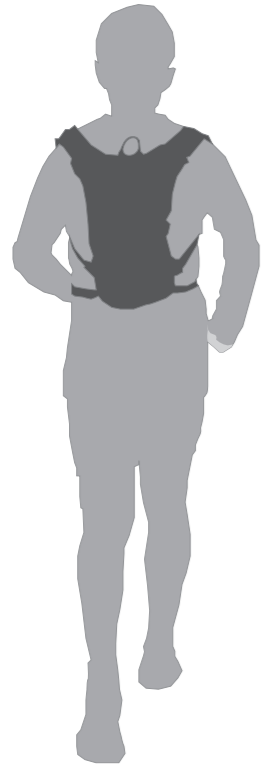
# Marketing Board

The strap and 4 individual capsules will come as a single package upon initial purchase but packs of capsules would be available to purchase on their own



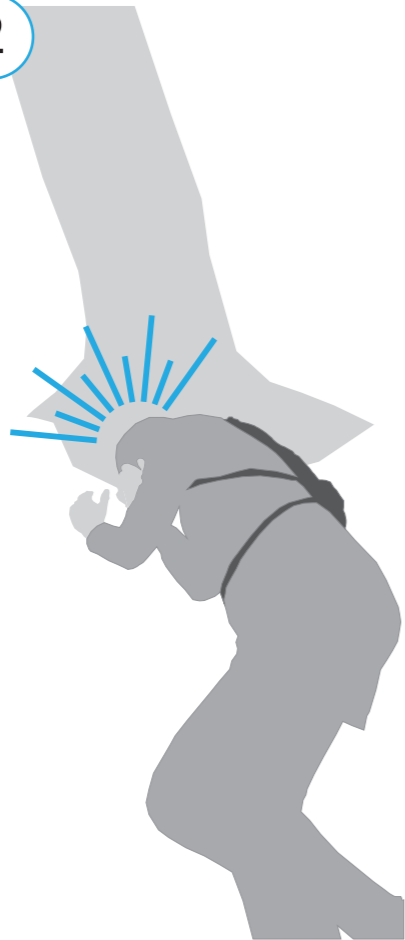
# Storyboards

1



Athlete goes for a run

2



They trip and suffer a head impact

3



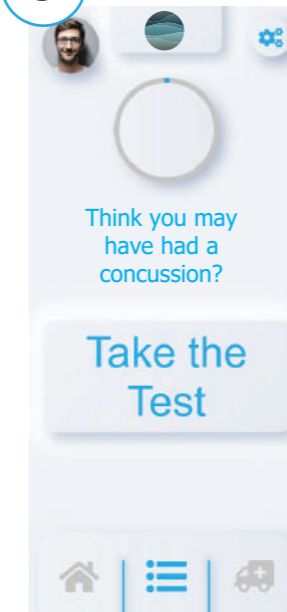
They reach for their phone

4



They then take out their phone and open the BCT app

5



After Navigating to the test section and they start the test

6



They select that they have the BCT device

7



They follow the instruction on the app



# Storyboards

## Capsule Insertion

1



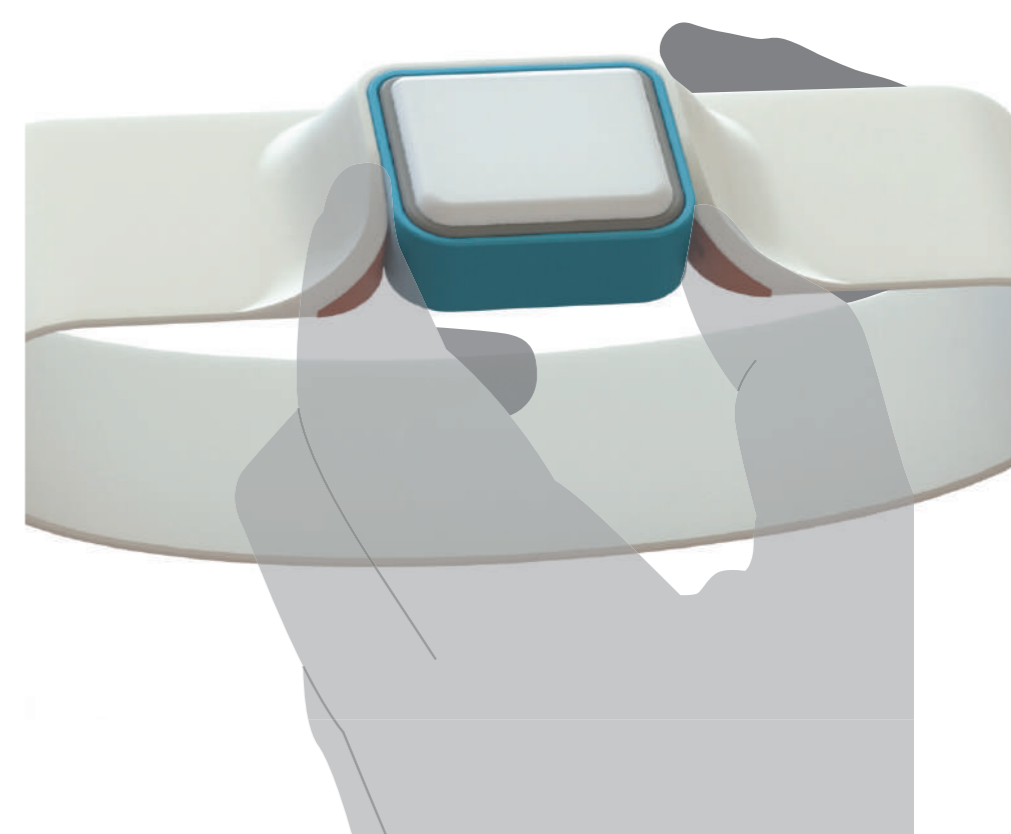
Remove the capsule from the packaging, position it so that the rails slide into the corresponding gooves

2



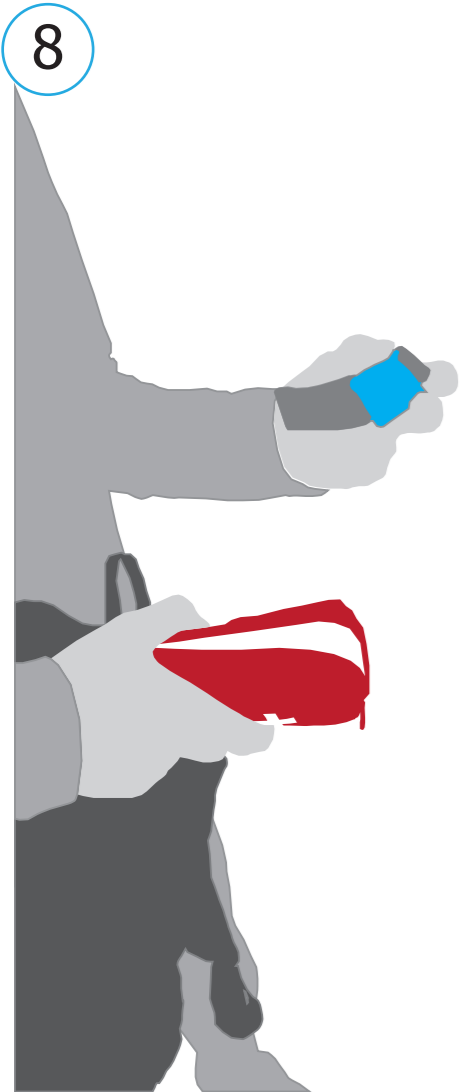
Slide the capsule into the strap itself

3

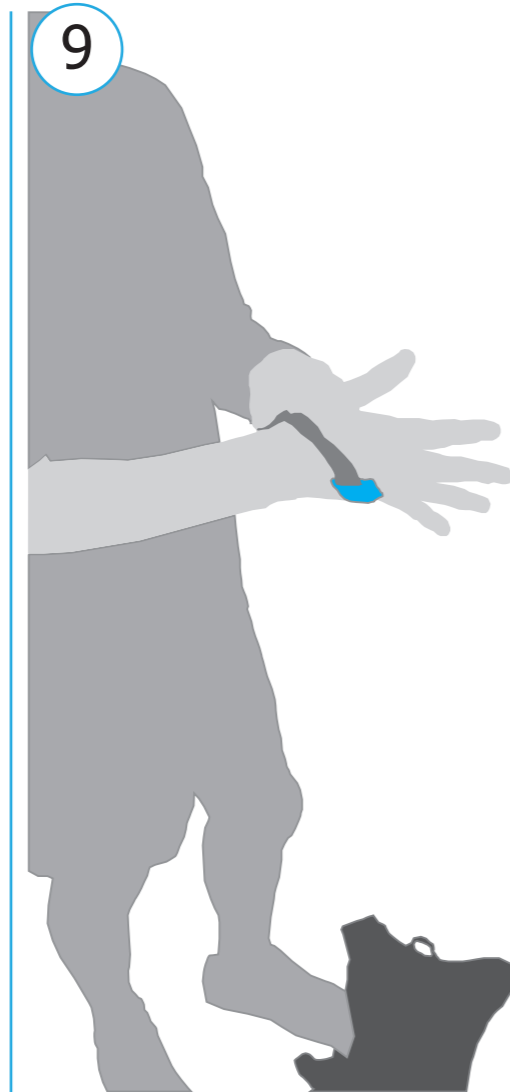


Push it in firmly until it is fully pressed into the strap

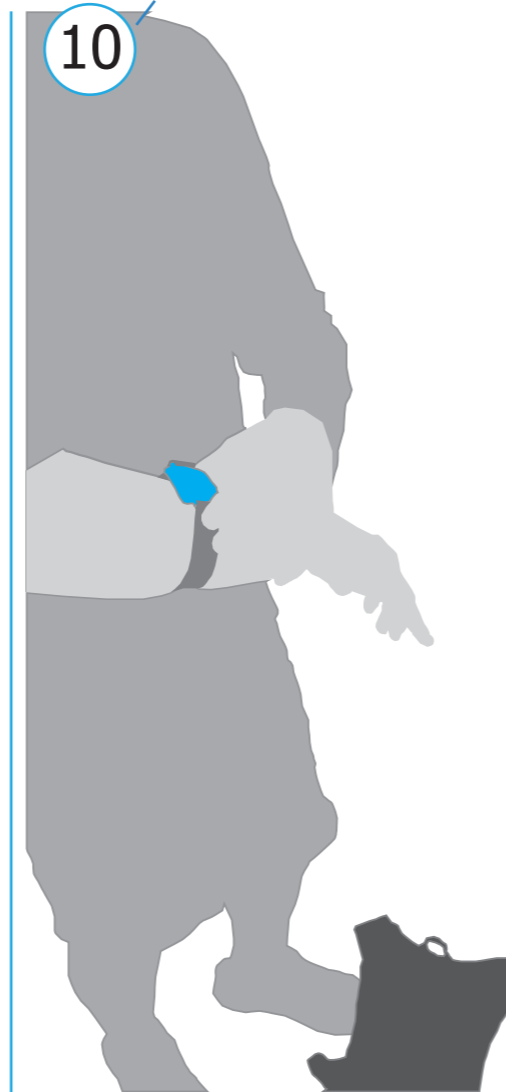
# Storyboards



8 They get the BCT from their first aid kit and insert a capsule



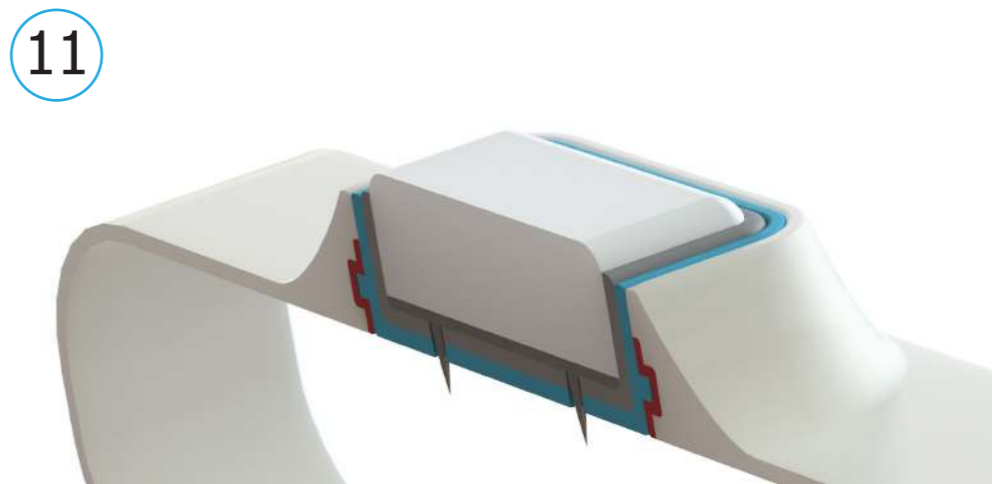
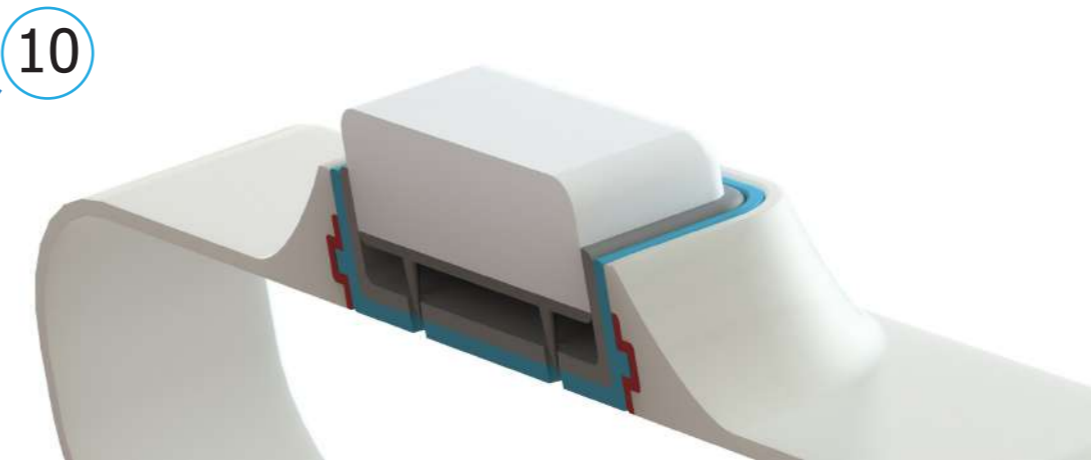
9 They roll up their sleeve for better access to clean skin



10 They adjust the strap to get a clear alignment



11 In one rapid movement, they press down hard on the capsule



# Storyboards

## How it works

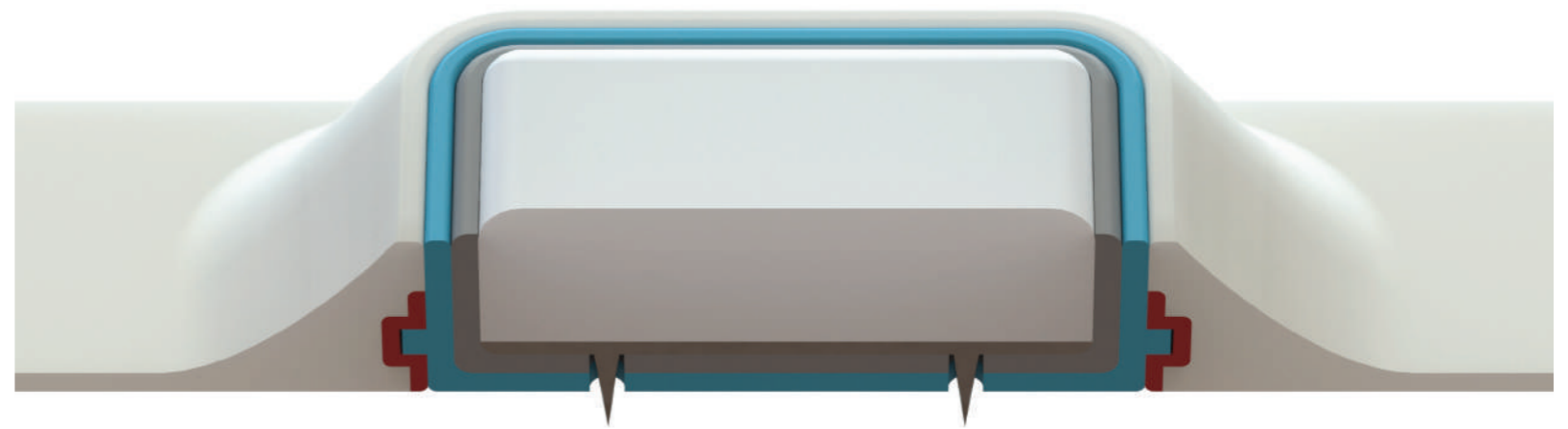
1

The needle bed and chemical pack is primed with a spring and once it is removed from the sterile packaging, is ready to be activated.



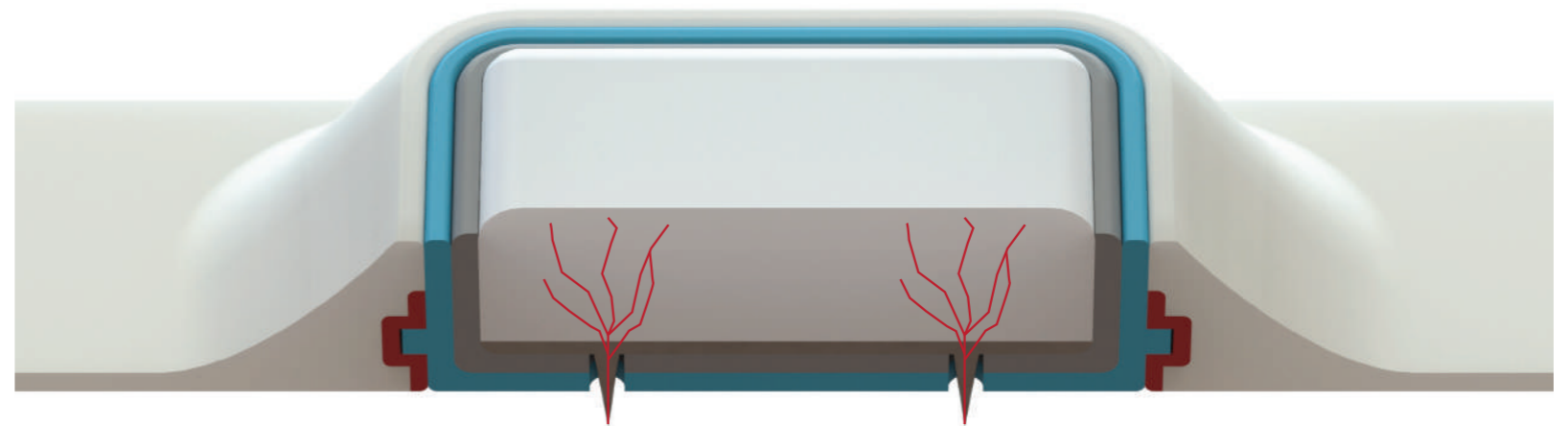
2

Once the Needle bed and chemical pack has been depressed fully with a slap, it pierces the skin causing a sample size blood droplets to come to the surface.



3

The small diameter needles use capilleric action to draw the blood up into the chemical pack above.

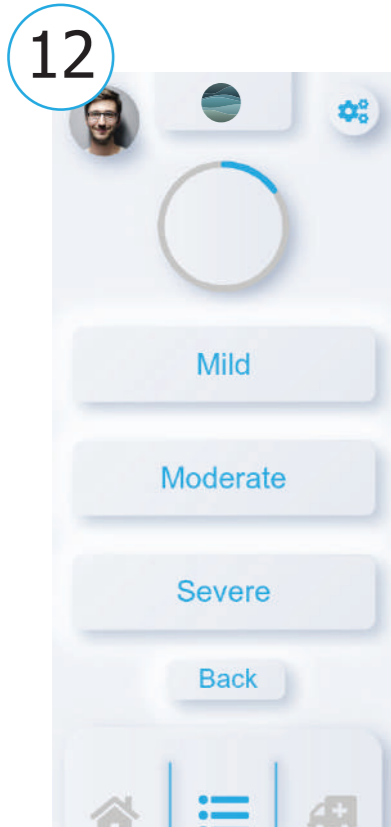


4

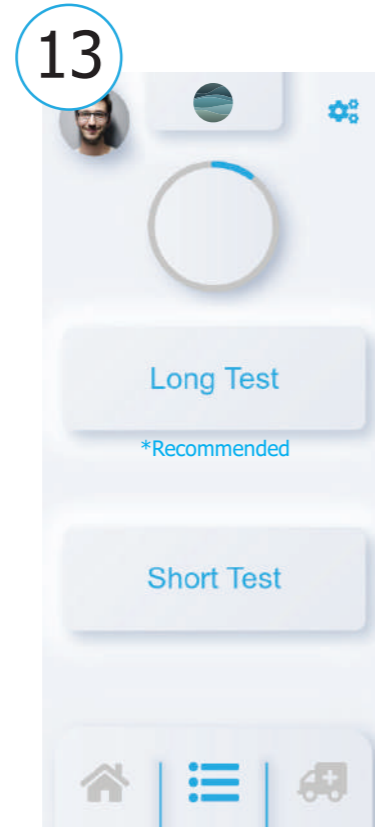
The chemical pack then reacts with the P/C-tou proteins within the blood, changing colour depending on the ratio of tou proteins in the blood. The greater the concentration, the greater the severity.



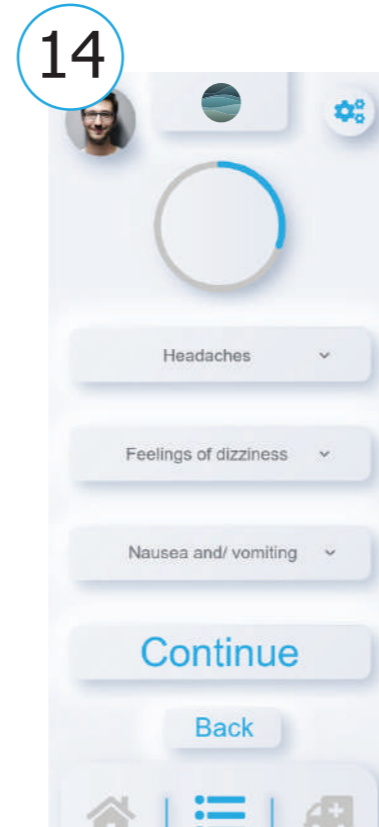
# Storyboards



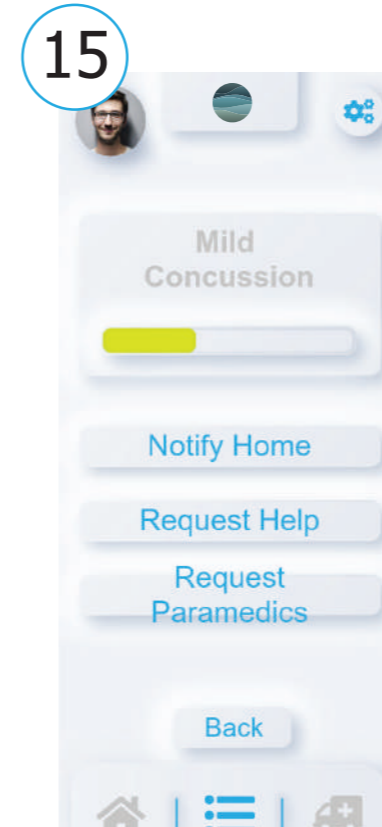
After a few minutes developing they enter their results of the test



They then choose between the MRPQ test and the MPAI-4 Test



They complete a cognitive test to verify the blood test results



They are then give the result and options to return to safety

# Regulatory Pathway

Type  
Rule 4a

Class  
C

## MDCG 2020-16

Risk Level  
High individual risk and/or  
moderate public health risk

Examples  
Blood glucose self testing,  
HLA typing, PSA screening

Further explored in the following

[Design History File -2. Verification - Regulatory Requirements](#)

# Essential Requirements Checklist

Reference	Source	Requirement	Verification Method	Verification Reference	Reason
PRD-0001	False Negative	Device must detect concussions	Clinical Trial	Academic Report	
PRD-0002	False Negative	Device must detect concussions	Clinical Trail	Academic Report	
PRD-0003	Dimentional	Device must fit users arms	User Testing	Results of testing and IS data	
PRD-0004	Use error	Device can be used by impaired users	User Testing	TBC	Due to the restriction of irish covid 19 policies, users could not be tested
PRD-0005	Usability	Device must be easy to put on	User Testing	Results of user testing	
PRD-0006	Usability	Device must be easy to assemble	User Testing	Results of user testing	
PRD-0007	Interface	Device must inform user test was successful	User Testing	Results of user testing	
PRD-0008	Interface	Device must inform user of test results	User Testing	Results of user testing	
PRD-0009	Manufacturing	Capsules must be easily and cheaply produced	Product Verification	TBC	Due to the restriction of the project timeline, physical models could not be created to be tested
PRD-0009.5	Manufacturing	Device must be assembled as per specified drawings	Product Verification	TBC	Due to the restriction of the project timeline, physical models could not be created to be tested
PRD-0010	Sterility	Device must be easily cleaned and sterilized	User Testing	TBC	Due to the restriction of the project timeline, physical models could not be created and tested
PRD-0011	Sterility	Capsules must be sterile prior to being used	Product Verification	Results of packaging	
PRD-0012	Dimensional	Device must be compact	User Testing	Results of user testing	
PRD-0013	Dimensional	Device must be light	User Testing	Results of user testing	
PRD-0014	Dimentional	Strap must be adjustable to fit multiple arm sizes	User Testing	Results of user testing	
PRD-0015	Manufacturing	Strap must be durable for multiple uses	Product Verification	TBC	Due to the restriction of the project timeline, physical models could not be created and tested for duability
PRD-0019	Usability	The needle bed must not accidentally activate	Product Verification	TBC	Due to the restriction of the project timeline, physical models could not be created and tested
PRD-0020	Sterility	The needle bed and surrounding area must be sterile priot to use	Product Verification	TBC	Due to the restriction of the project timeline, physical models could not be created and tested
PRD-0021	Packaging	The capsule must be packaged in such a way to not harm user prior to activation	Product Verification	TBC	Due to the restriction of the project timeline, physical models could not be created and tested
PRD-0022	Packaging	The capsules must be packaged as to not become contaminated	Product Verification	TBC	Due to the restriction of the project timeline, physical models could not be created and tested
PRD-0023	Packaging	The packaging must contain the IFU and all relevant information under EN ISO 13485:2016	Product Verification	Results of packaging	
PRD-0024	Packaging	The packaging must contain the UDI of the device	Product Verification	Results of packaging	

Conclusion.

# Conclusion

Concussions and mild traumatic brain injuries (mTBIs) are a constant threat to action sports athlete who constantly push the boundaries of both their bodies and what's perceived to be possible. Unfortunately the risk taking ethos and nature of the sports can often lead to severe injuries such as mTBIs. Concussions and mTBIs are injuries that athletes can recover from but in light of research, a second one sustained within a short period does cause permanent, irreversible damage to the brain. Reducing the likelihood of repeat concussions and thus secondary impact syndrome (SIS) would greatly reduce the rates of permanent damage caused by these injuries.

To reduce the likelihood of this occurring, the project developed a 2 stage concussion detection device that can inform users when they have suffered a concussion and recommend action to mitigate the risk of incurring a second concussion in the allotted recovery period on 2 weeks post concussion.

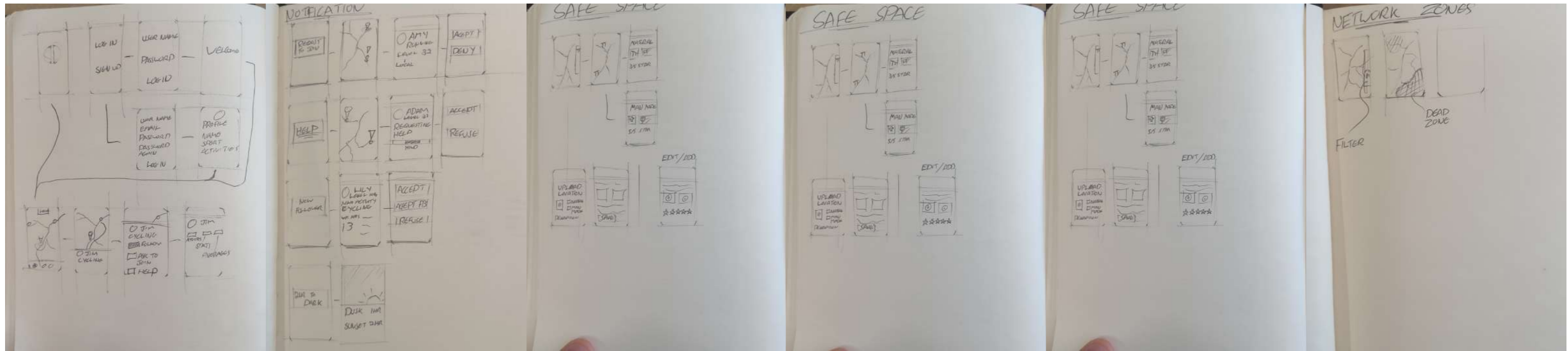
Combining both a bio-marker and cognitive test allows for a much greater degree of accuracy when determining the users condition than any individual test and allows for the reduction of false negative with its double verification method.

Further research into the devices mechanisms and efficacy would greatly enhance the devices claims but due to the limited time and scope of the project and the time frame in which the project was conducted (during a global pandemic) some aspects of the design could not be tested and so the validity of the mechanisms were inferred from other similar methods that are currently available or being developed. Any aspect of the design that could be tested within a reasonable time frame and with the means available was tested to verify the usability and functionality of key features.

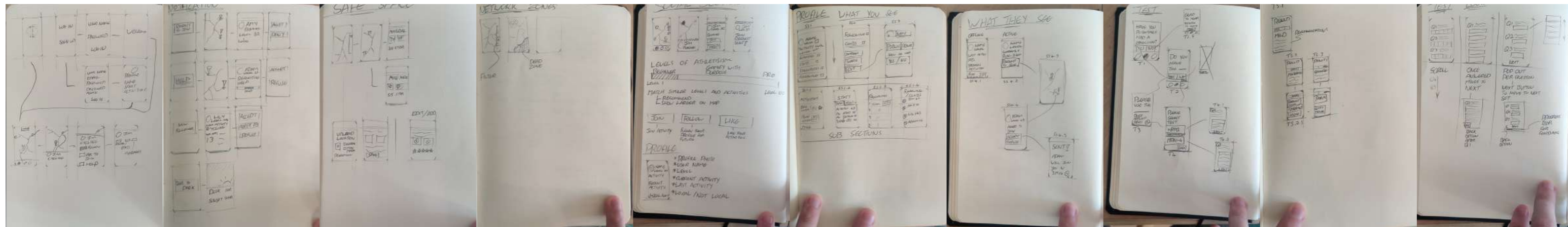


# Appendix.

# Appendix

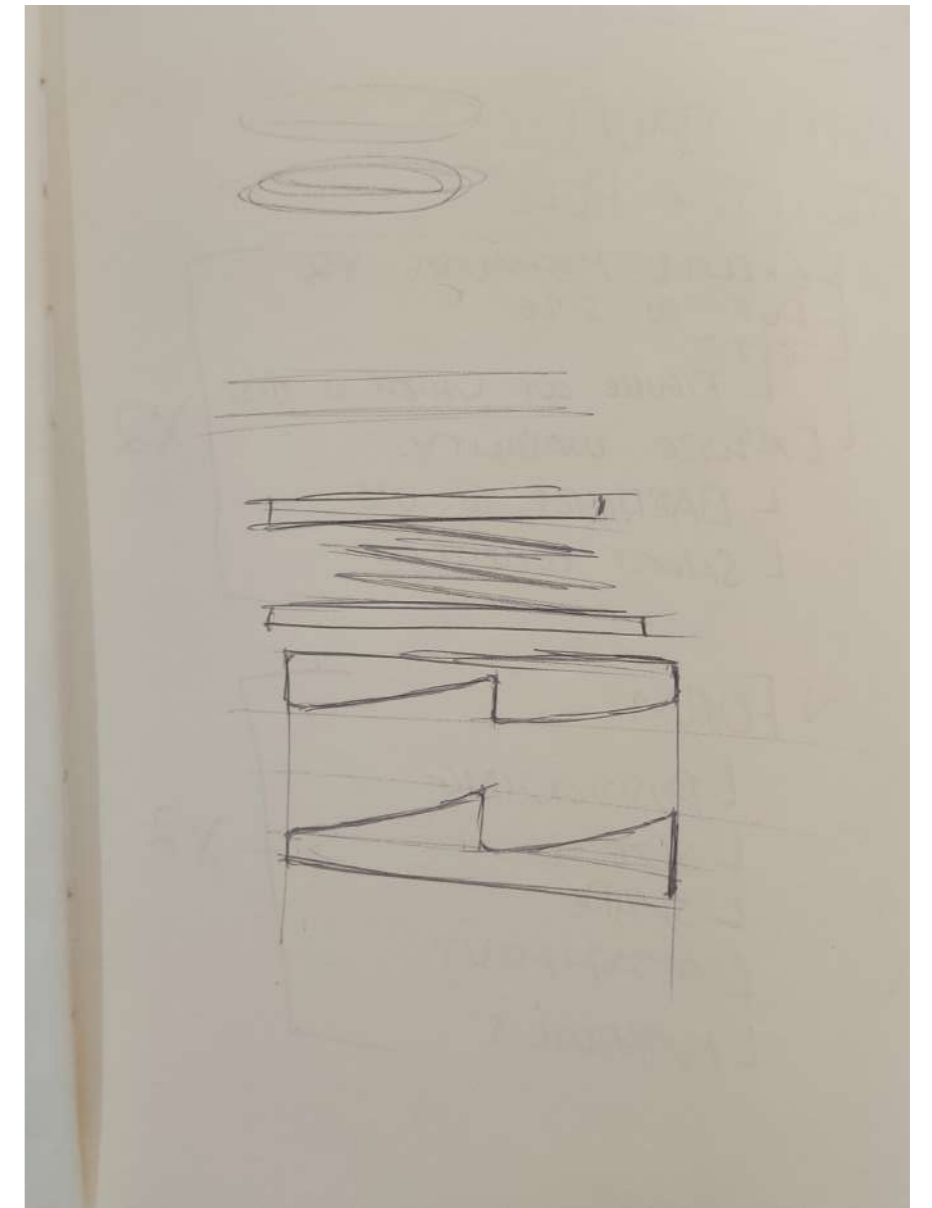
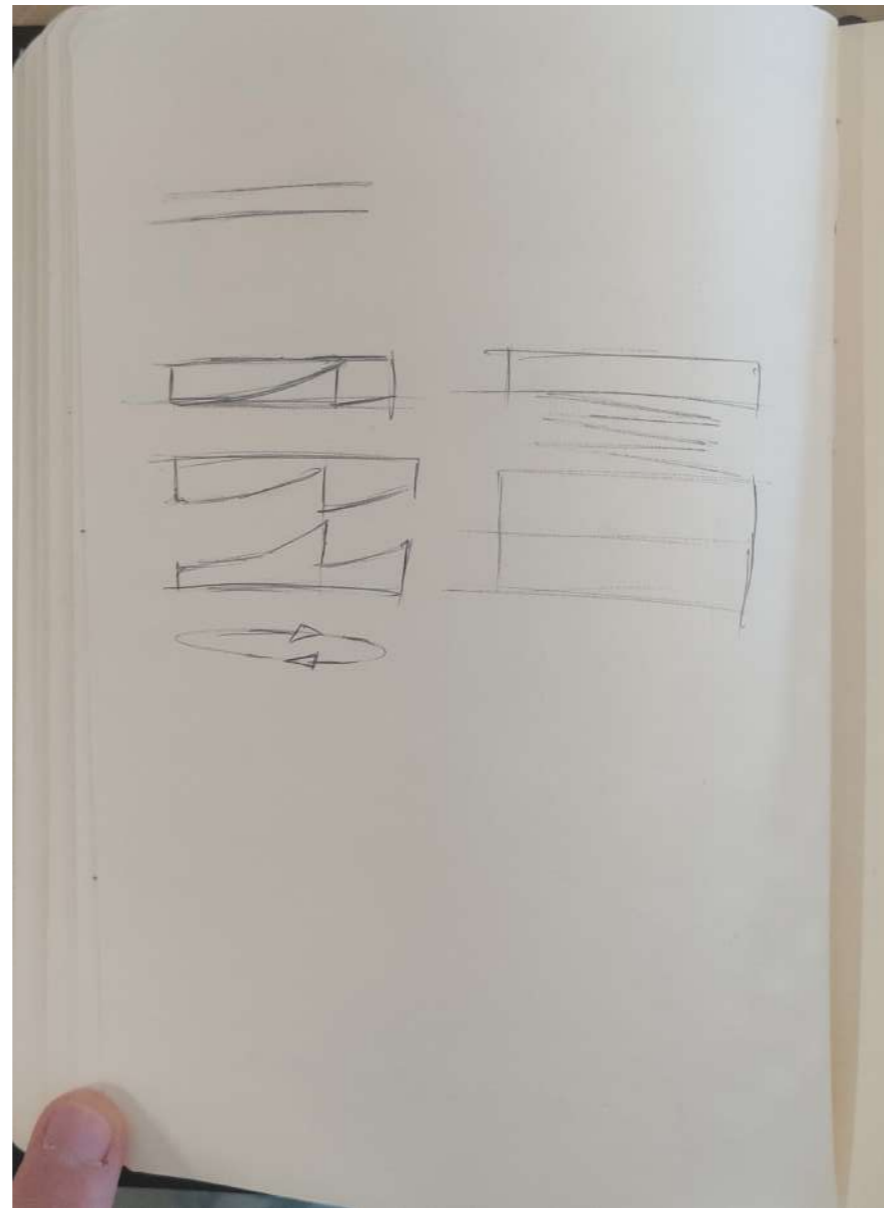
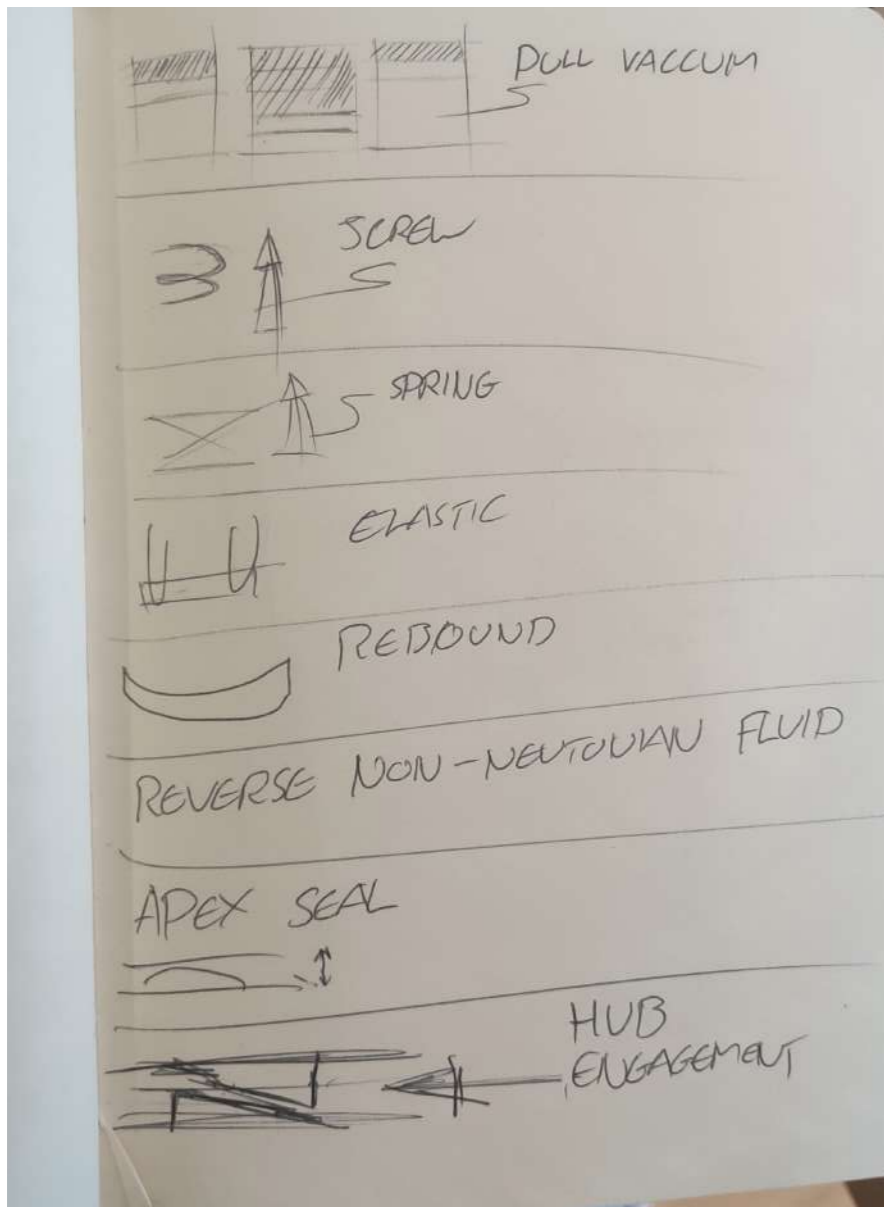


A - 1 Additional App Development



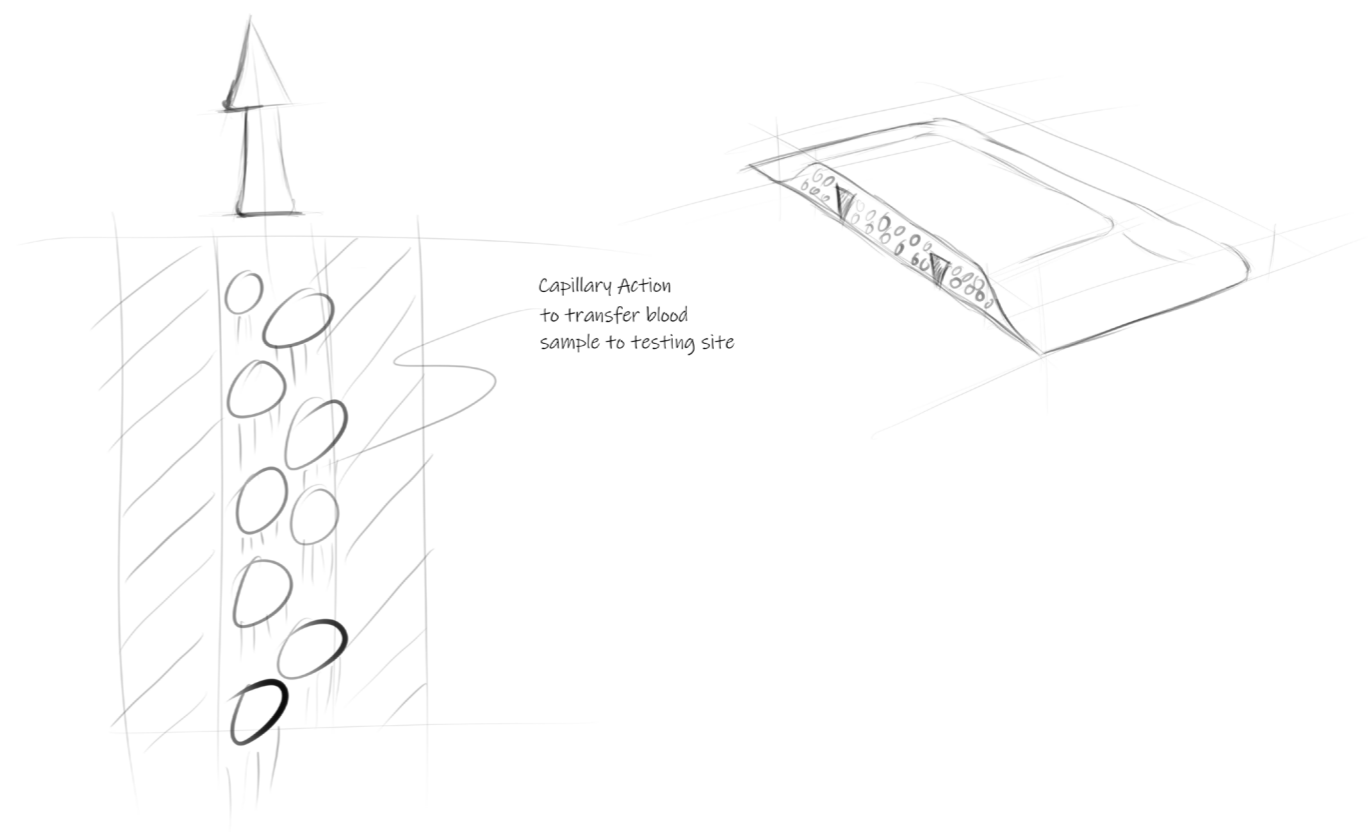
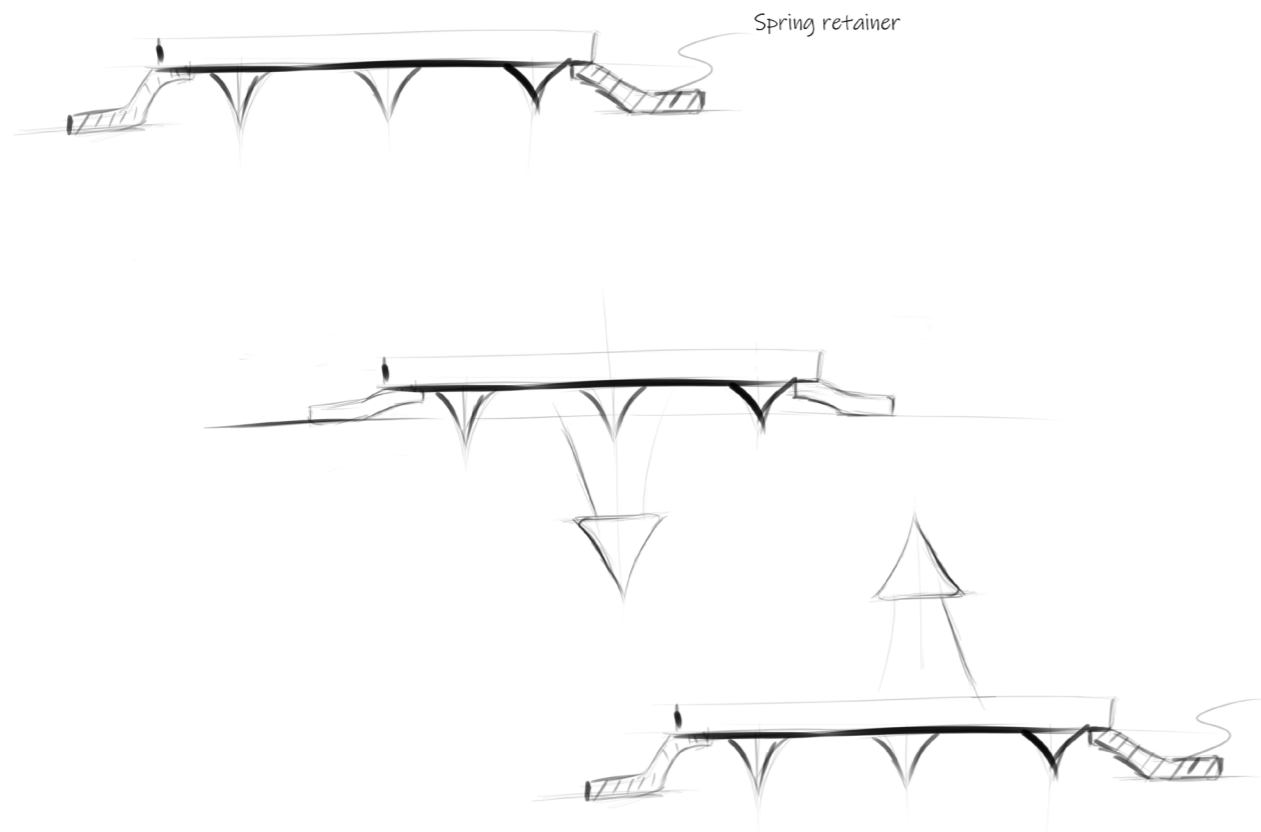
A - 2 Additional Further App Development

# Appendix

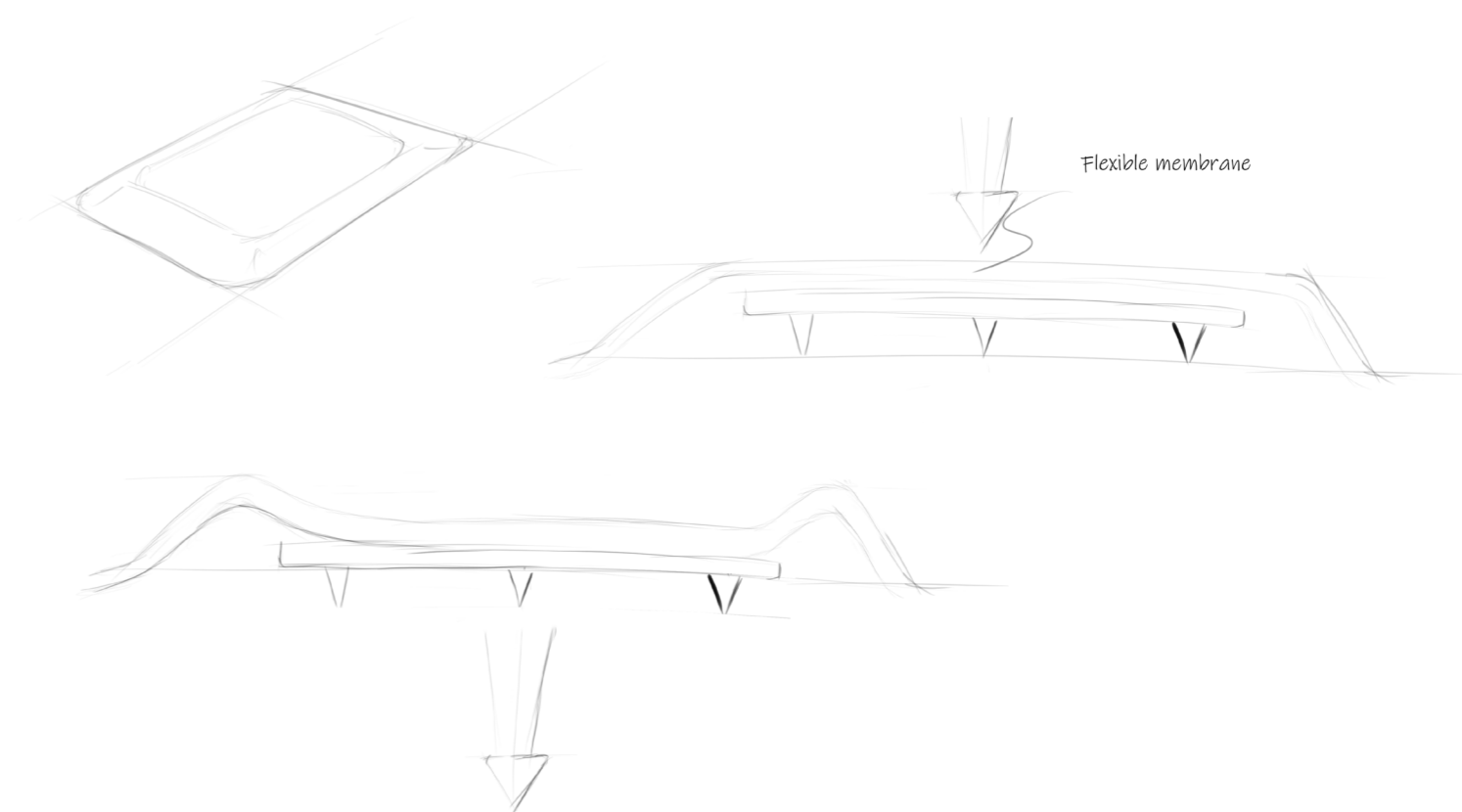
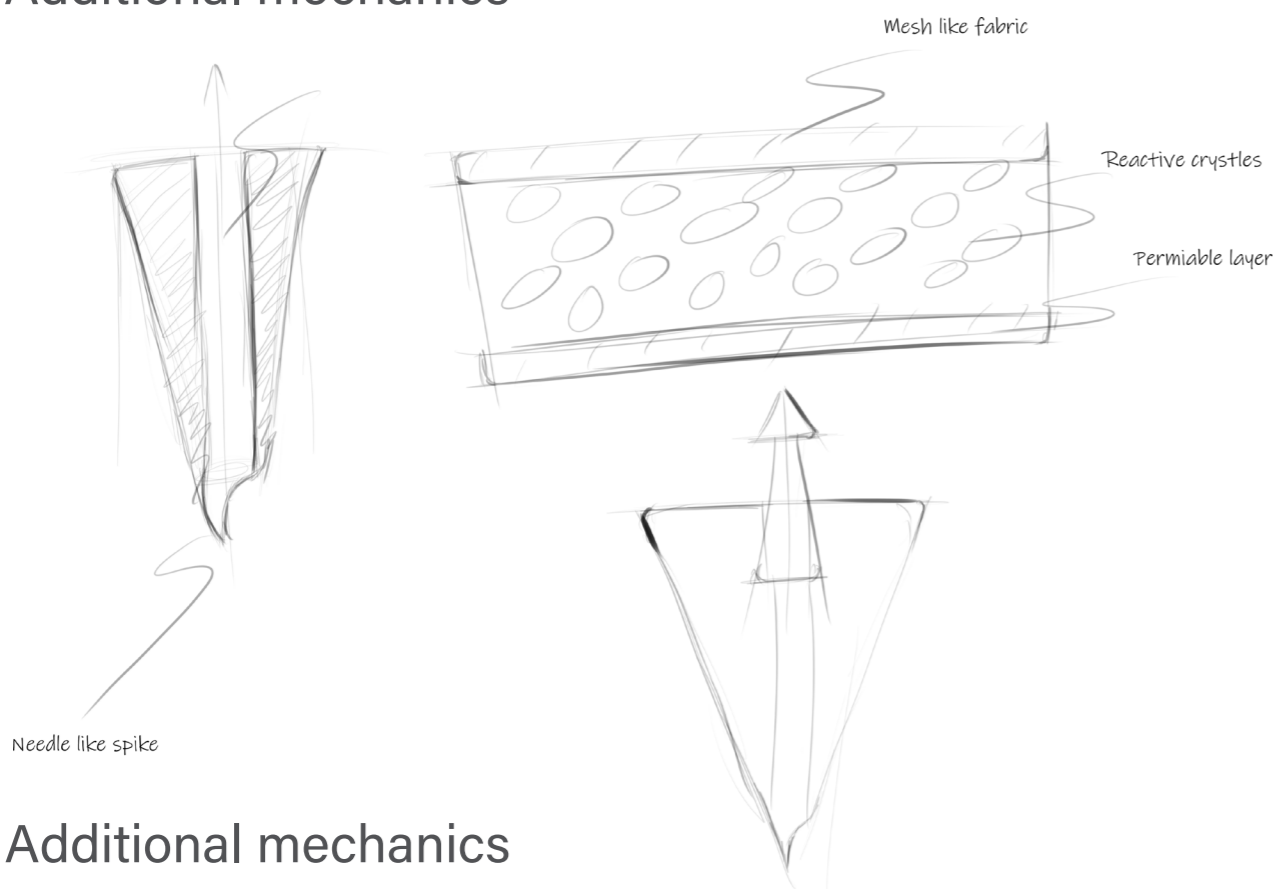


A - 3 Additional mechanics

# Appendix

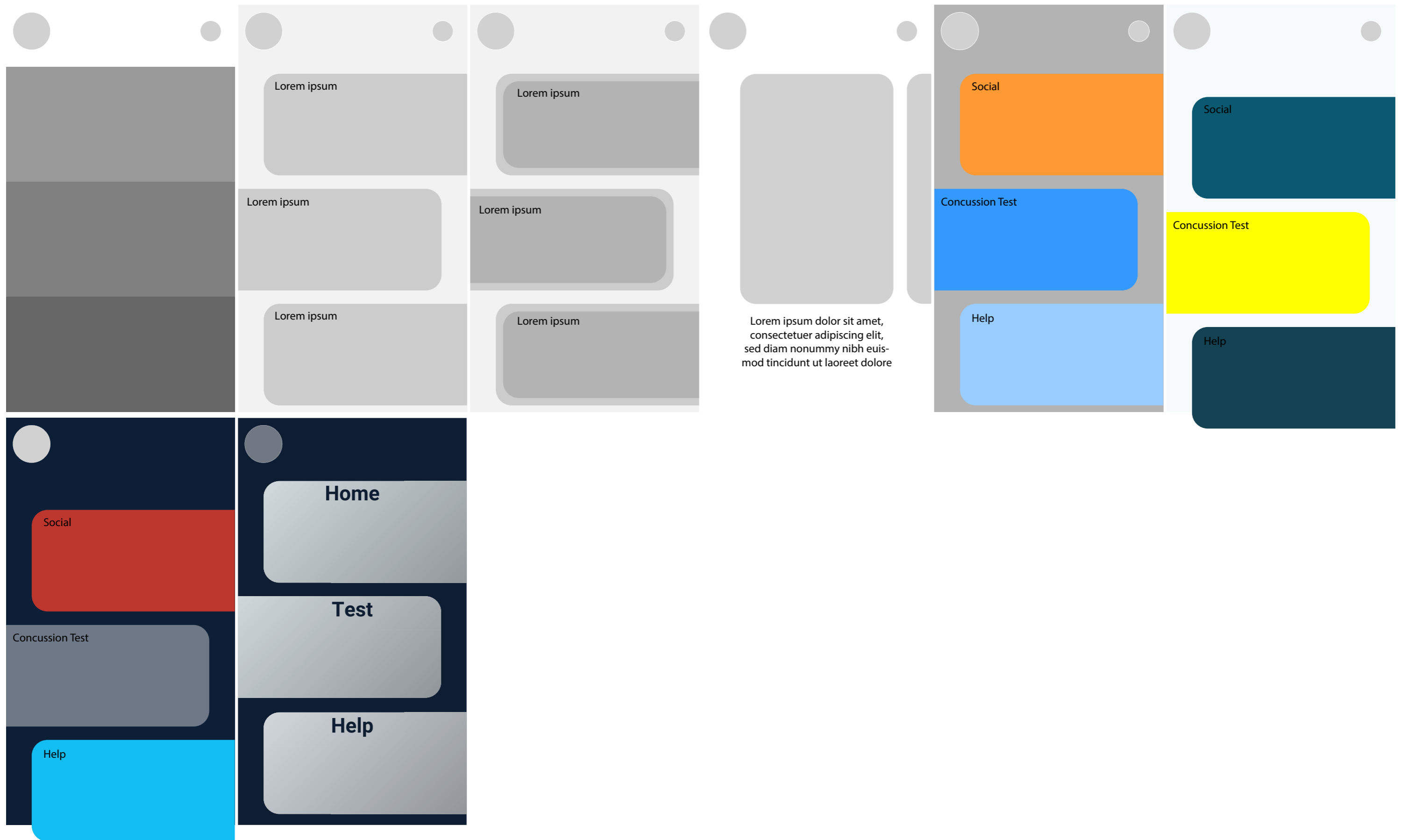


## A - 4 Additional mechanics

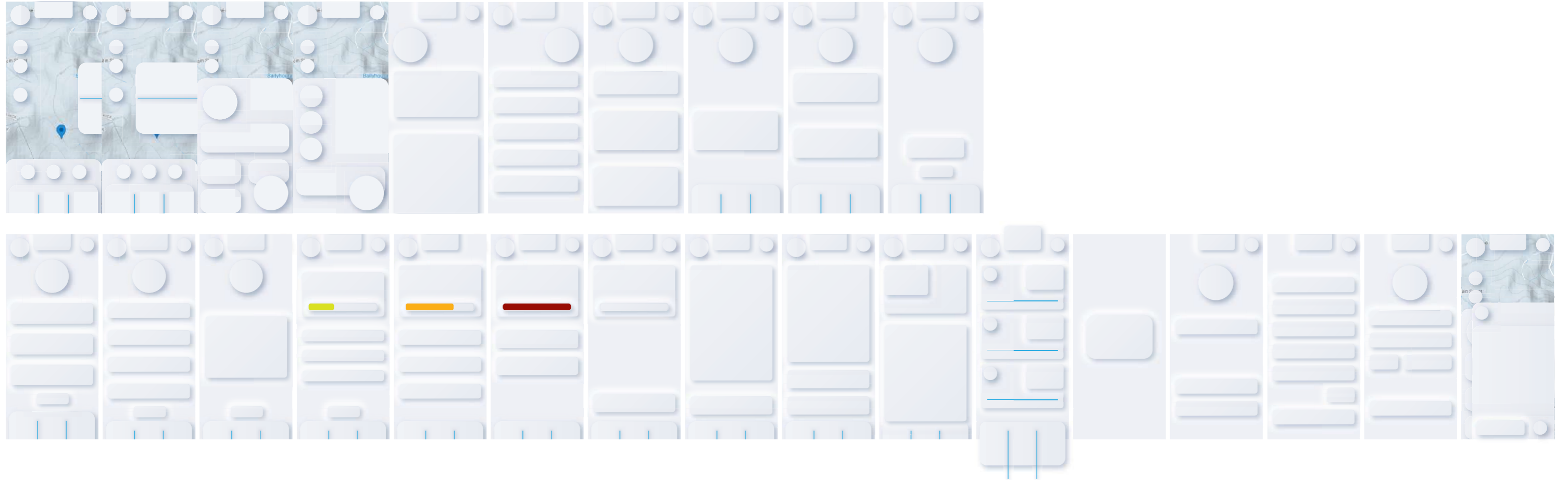


## A - 5 Additional mechanics

# Appendix

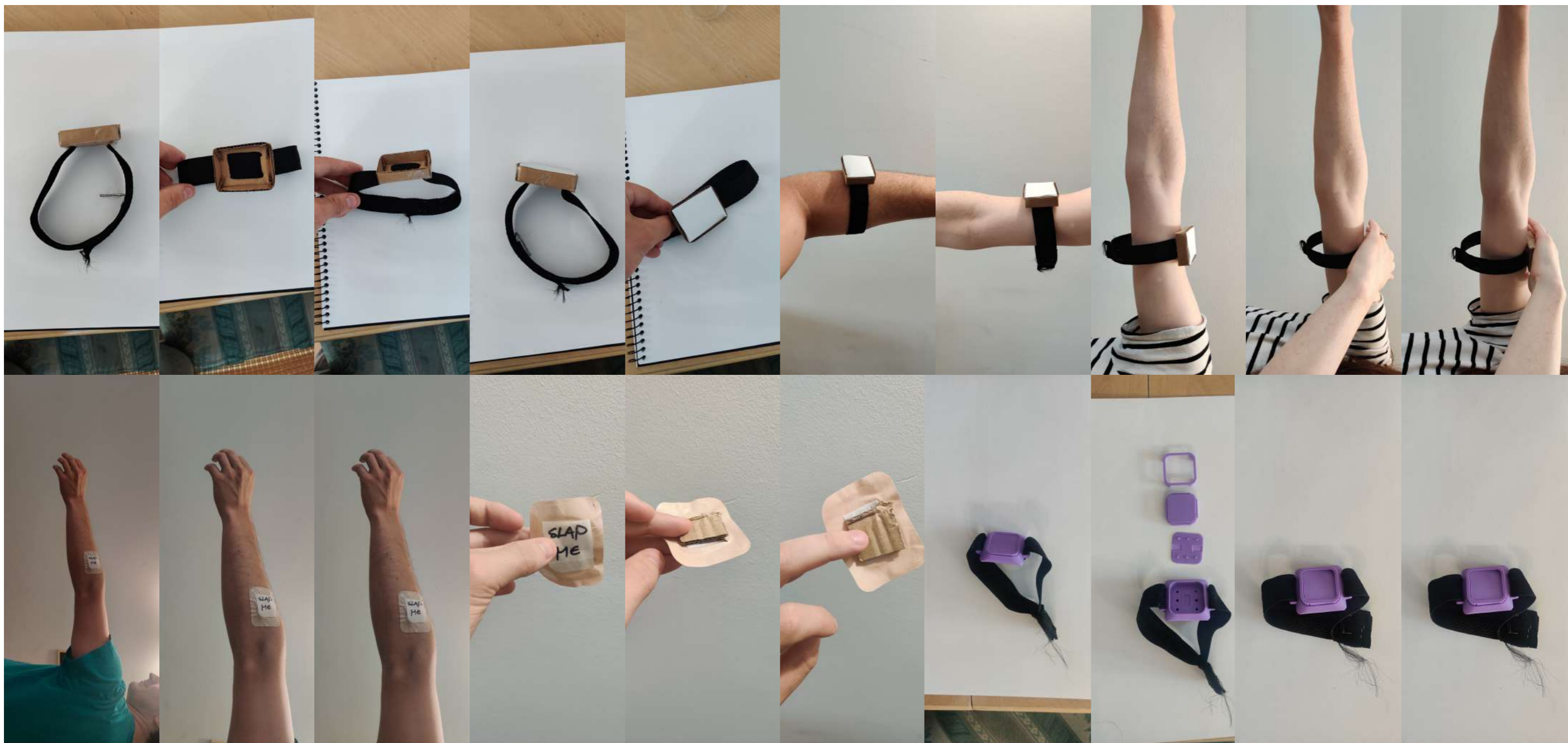


# Appendix



A - 7 Additional Aesthetic Design for the App

# Appendix



A - 8 Additional Prototype Images



# Appendix



Design History File -1. Design Inputs - Concept Development - Story Board - Ones to use

A - 9 Testing in suite



# Appendix

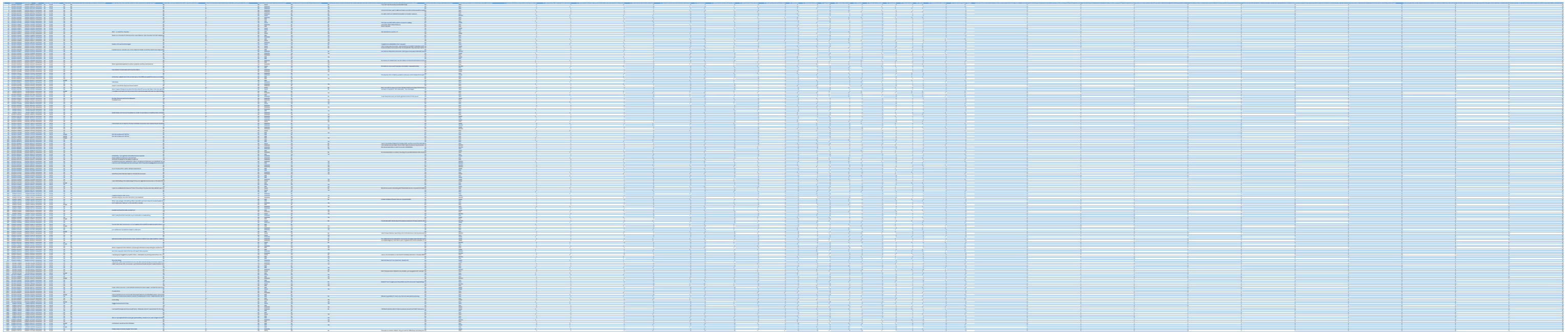


Figure 34 - Survey data raw

Design History File - 0. Feasibility - Research Phase - Primary - Concussion in Action Sports CES-D

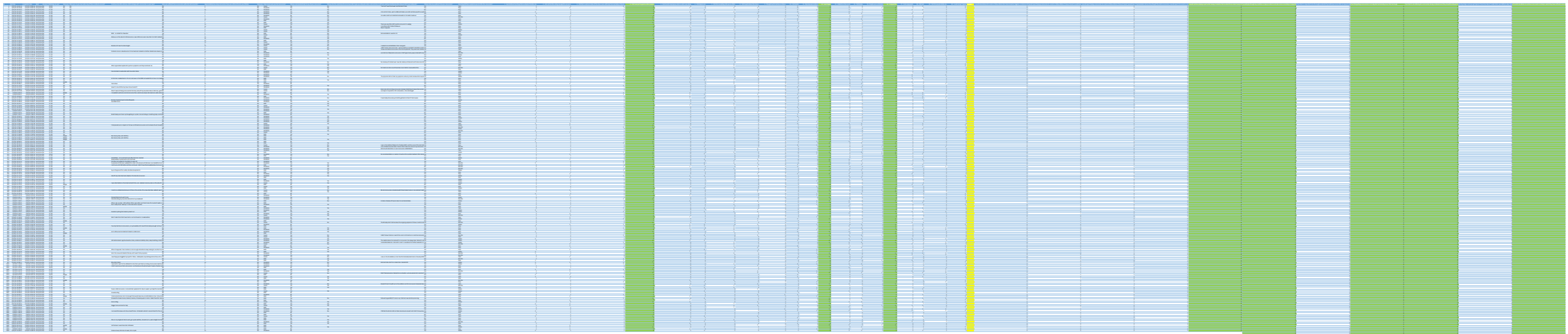


Figure 35 - Survey data ordered and values assigned

Design History File - 0. Feasibility - Research Phase - Primary - Concussion in Action Sports CES-D

# Appendix

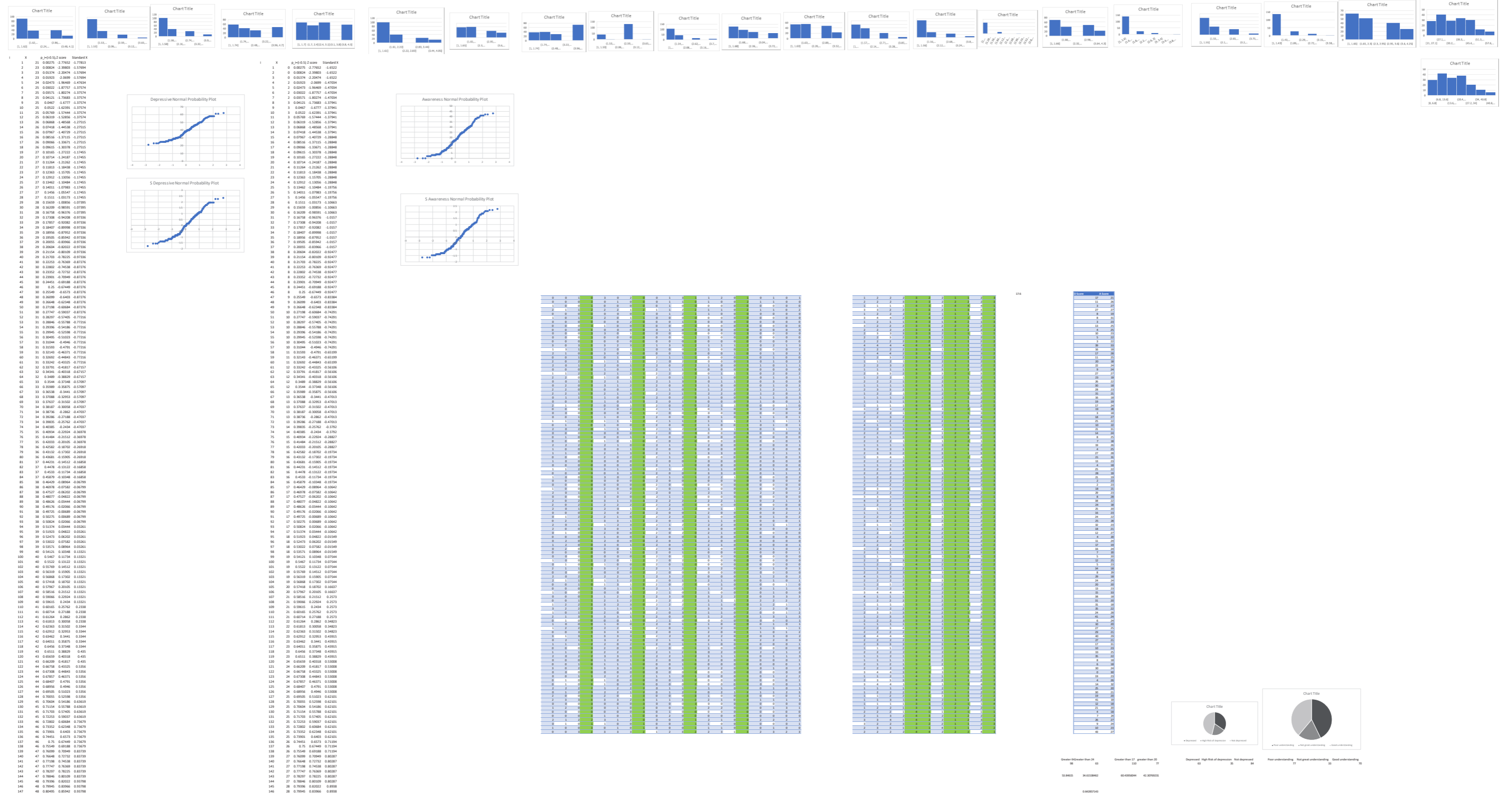


Figure 36 - Survey validation of normality

Figure 37 - Survey depression and concussion awareness workings

Design History File - 0. Feasibility - Research Phase - Primary - Concussion in Action Sports CES-D

# Survey Raw Qualitative Data

## How the athlete managed a concussion on their own

Mild - so rested for a few days

Woke up on the side of a hill lying prone, I was mtbing on open mountain (no trail) I realised what had happened after a few moments, I stayed put as per my training (outdoor instructor with advanced first aid) and checked everything worked and that I wasn't bleeding before I started to move. Took sometime and a sugar hit to stave off shock and eventually after about 10 mins I started walking with my bike. After checking my head by shaking and inverting without pain or dizziness, I got back on the bike and finished the ride tentatively.

Rested until I was functional again

Crashed once on a double jump, hit my head and cracked my full face. Rode home slowly and sat on the couch and made sure I didn't fall asleep. Usually it was get home and rest without calling asleep. Snowboarding was usually sit in the lodge for a while until I felt a bit better and then go for a few easier laps.

When appreciated explained to partner symptoms and they monitored me

Face planted at speed while night mountain biking.

At the time, I walked back to the car park (was on the MTB) and waited for an hour or so before driving back home. I then took a few weeks off the bike and when I did get back on I took it very slowly and mitigated risk and bought a new helmet

Told others

Haven't a clue till this day how I drove home???

Wasn't aware of being concussed at the time, came off my mountain bike on 50k race, got back up and proceeded on to the finish line 5km away only then my mates noticed something wasn't right when I cycled passed them in the carpark. Whole 5hr race never came back to my memory!

I struggled to get back onto the horse but then rode home slowly. My head only really started spinning later that evening. I spent 2 days in bed.

No idea. People arrived shortly afterwards.

Stumbled home

Breath deeply and took my time getting to my feet. Concentrating on breathing helps me find my equilibrium. I've had quite a few knocks

I had passed out on impact on the two confirmed concussions and someone found me within minutes each time. The other time I was with people

Not ride my bike until i felt fine

Not ride my bike until i felt fine

Immediately - try to get back home after dizziness reversed.

Slowly walked my bike back to the trail head.

Sat down and waited for the effects to wear off.

In presence of dizziness: walk/call for a ride. In the absence of dizziness: turn back/finish race/head home.

I sat it out until I felt better and then continued. I didn't have the knowledge about concussion I do now.

lay on the ground for a while, ride bike slowly back to

Fell off mountain bike had a bleed on the brain & concussion

I was roller blading in the street and got hit by a car, regained consciousness on the side of the road and called 911 myself

I spent an undetermined amount of time in the vicinity of my mountain bike, realized I was having trouble thinking right, started for home. I'd like to describe how I tried to manage it, but honestly I'm missing most of the rest of that day from my memory and I didn't nothing to try to treat it, my partner was 9 months pregnant and I tried to play it off like nothing was wrong. In retrospect this was dumb.

Stopped biking and went home

Fell while riding my mountain bike and on my snowboard

When I was younger, I did nothing. When I was older I just took it easy for couple of weeks and drank lots of water.

Don't really know "woke up" in the road still on my bike

Avoided anything that made my head hurt

Didn't really think that it was bad so just continued on snowboarding.

I've only had minor concussions, so I just waited until I could think clearly enough to drive, then went home.

put a pillow over my head and stayed in a dark room

Self-administered cognitive baseline check, emotional stability check, deep breathing, stretching

When it happened I had a helmet on and enough adrenaline to keep skating for another hour. It wasn't until the drive home that I realized i wasn't okay. I went to an urgent care that night.

Sat in the snow and stared at the sky until I wasn't dizzy anymore.

I was flying my hangglider by myself in Tahoe. I attempted a top landing and lost focus for a few seconds and got blown over the back. When I got my senses back I packed up my hangglider and went home

Mountain biking

I was dumb. I went to the cafeteria for a bit, then went back out skiing. Concussions lead to poor decision making.

I didn't even know I had a concussion. I just became confused and wasn't aware of where I was. I somehow got down to the base of the mountain before a ski patrol helped me.

It was a mild concussion, I only had bad symptoms for about a week. I just kept the room dark and quiet, wore dark sunglasses when I had to go outside, and took it easy.

Snowboarding

I had some dizziness but not enough that would make me uncomfortable to drive. I drove home immediately so I could be monitored by my family.

Checked for broken bones, balance, memory. Checked pupils in mirror. Called friend for ride to ER

Horse riding

Stagger home and ask for help

I put everything away and drove myself home. Scheduled a doctor's appointment for the next available time

Was on my longboard late to work, got speed wobbles, missed a turn, went straight into the barrier of a bridge

rest because i would see stars otherwise

Smoke a bowl, drink lots of water, fish oil pills

## Survey Raw Qualitative Data Why medical advice/treatment was inadequate

"Just rest" was the answer, but that didn't help  
2nd and 3rd times, went to A&E and triage nurse told me there would be a wait of 9 hours so I just stayed up with a friend for 5/6 hours to make sure I kept getting better.  
my rugby coach just splashed some water on me when I woke up  
There was very little staff could do only assist in waljing  
none there, didn't attend follow up  
Wasn't required.  
Not applicable to question 10  
I needed more rehabilitation than I was given  
I didn't know I was concussed , I was knocked out and didn't remember anything, I went to hospital with a broken back, didn't know until my friend told me I was out cold for a minute or two, but the hospital never checked up on this.  
I knew more about concussions than the hospital did. They never even mentioned the word "concussion", only briefly describing second-impact syndrome. When I told them I knew what that was, they just let me walk home alone.  
Just told me I likely had a concussion. Didn't give me any way to deal with issues  
No memory of incident even now. No memory at time and sent home once stitched up  
No head scan done could have been more helpful. Huge waiting time  
The physician did not take my symptoms seriously. He let me leave the hospital against medical advice although I was cognitively impaired and should not have been allowed to make this decision.  
Brain scan did not show concussion damage. Stretching of valves that control hormone release caused 2years of PCSD with no physical damage.  
Just kept in hospital for 12hr observation, then discharged  
It was barely discussed, just told to get back to them if I had nausea  
I was in the middle of Mexico for the Baja 1000, and the nurse at the road side medic stand was woefully underprepared  
I am a female mountain biker. The drs Didn't take into account my concussion history. Didn't tell me anything other than to rest a few days. Didn't explain long term symptoms  
Not enough education on post concussion rehabilitation.  
No recommendations on where I should go for possible treatment after recovering as much as possible naturally.  
My last concussion came along with three broken bones in my skull and treatment really concentrated on that. I was just told the concussion would wear off.  
Unclear schedule of how to return to normal activities.  
The ER really didn't tell me about the ongoing symptoms I'd have or what to do about them. I didn't know I had one. I was hit by a car in a hit and run on and my concussion was diagnosed by my gp about a week later. The ambulance and hospital staff missed that and (as i learned 6 months later) my fractured foot.  
The medical advice I've received for concussions has always been tailored to what to generically, but, it seems there is no connection between a "type" of concussion and "type" of concussion treatment...only a blanket of generic activities that will moderate symptoms.  
incomplete diagnosis, returned to sport, no guidance for further evaluation or treatment  
I was on the US skeleton (1 man face first bobsled) team back in the early 2000's. Every one on the team had multiple concussions. The protocols were significantly different back then. We generally took 2-3 days off before we were back in action. This is obviously not good  
Rest and relax, don't no screen time. General info  
Didn't feel personal or tailored to my situation, just very generic do's and don't.

Research hasn't caught up to the problem, my first concussion happened approx. 2004 and I was too young to understand  
Refused to give MRI/ CT scan/ x-ray. Told me it was alcohol poisoning.  
I felt like the doctors did not take me seriously enough and I didn't know enough to get a second opinion.  
There was no solution offered. They just said the "MRI shows some heavy brain swelling that is going down. There is not a lot we can other than monitor symptoms."

# Appendix

Unknown Speaker  
Hello, Hello,

Unknown Speaker  
is this Matthew? Is jack here for the interview? Not too bad, not too bad things. Fair,

Unknown Speaker  
fair?

Unknown Speaker  
Yeah, sure.

Unknown Speaker  
Yeah, well, this kind of it's an informal car. It's an informal interview. And essentially, it's, I'll ask questions, I'll let you ramble away and sort of, hopefully you'll get something out of it at the end. So, if you're happy enough with that, so

Unknown Speaker  
maybe you might catch something all the way where you might have a question for me. Exactly.

Unknown Speaker  
So you're saying you had experience as an EMT, or first responder,

Unknown Speaker  
as an EMT here, so I'm gonna backtrack a little bit. I am actually voluntary with the civil defence. Okay, And that was purely just out of curiosity to see what it was, like, at that stage had no interest in doing anything medical, in any type of fashion at all. And when I started working with volunteering with Bill defence, and I sort of found myself sort of with other EMTs and with other say paramedics that were in the Civil Defence, you'd find yourself kind of doing events say it would be like a family formed a or civil defence have the contract with

Unknown Speaker  
the enemy. So they would have had it you know, a lot of days there. You're working alongside you know, what I learned from you sort of basic first aid classes, you know, normally taught by an EMP really got me interested. And I went down the route of getting my EMT licence. And so I started working, then I applied for a job in a company called Medi link for their private ambulance service. So that's sort of the bread and butter of their of your normal day to day is it normally sort of a Interstellar transfer, so somebody who has a spinal injury under in the monitor in Dublin need to be brought back sort of closer to home for the girl, like you said, After that transfer, and you're sort of your next in line, sort of breadwinner there, or what you're doing on a day to day basis is events. So they marry linked in particular had contract with Leicester rugby. Okay. So they would have had all the junior games and all the Senior Games, they normally throw the Senior Games it was going to say like, the more sort of favourites, the boss was favourites and stuff he would be doing is the Senior Games. Yeah, I would have dealt with a lot of adult but a few of the senior game. Sure, not many, dealt mostly with, say, the sort of school kids not as well as the sort of school games that merrylands recovering as well. And we've done a lot of them. And so, the interesting sort of thing from our point of view is, and we're sort of standing at the side of the pitch, covering the event from start to finish. So you're there to a concussion happens. Okay. And one of the things that sort of was a few years back, you know, it was

Unknown Speaker  
1717, I think, you know, typical years. What else? So, one of the things that was sort of interesting to myself,

Unknown Speaker  
that I sort of picked up along the way somewhere. And I was using caution to really be difficult to diagnose, and especially in the early stages, and where you might see somebody who gets don't talk about the head just as a as a random example. And they might get back up My spring back off on my feet, and I feel fine for the first minute or two, you know, sort of varies on the amount of time to feel fine for. And then sort of things sort of take a decline. And normally what they take to decline, they sort of, they go from zero to 100 return really quickly on sort of the symptoms are the compulsion setting, instead of my own personal experience. And one of the things that we sort of started to sort of develop, picked up along the way was when we first reach patient, and you started your assessment, one of the main things that I used to work on was, and we picked this up along the way was, you get the patient to remember three things. So it could be a colour, a place, and a date. You pick say three things that the patient is normally going to remember, you don't think the patient they date of birth. So we would have like I normally say, buy on January 18. For them, you know, my birthday sighs I say remember January 18, when the colour red and remember that place Belfast. And you say that when you sort of start your sort of your treatments about patients. Once you're, you know, you get your blood pressure cuff on, you said, the splc monitors the check oxygen levels, check heart rate, and you would obviously be sort of talking to the patient along the way. Yeah. So you give that a few minutes, and wait for things to sort of progress. But you ask the patient, the three things that they asked you to remember. And normally, I have number of times where a patient hasn't remembered that the site has remembered them three things they've always forgotten.

Unknown Speaker  
Okay.

Unknown Speaker  
An interesting side of things for for sort of diagnosing the deal. Now, obviously, we use a sort of, alongside, you're sort of presenting symptoms there as well. And, and it is it's really interesting subject because you sort of have the initial onset of where you also get a name, they know the mean. And yes, the pet their parents names, they know their parents name, they asked where they are, they don't know where they are, they can come back to them same three questions in a couple minutes time. And they've been sort of forgotten who their parents are, because they're, they're sort of not thinking about the panic starts to set in for them. And I had a lot of young people so I would have dealt with a lot of the interviewers, they still is not perfect for them, and they start crying. And it becomes almost like a hypertensive situation, sometimes nearly because they're so Lando probate, you know, the continent where they are the light strip, the rise of dust, one of the things that I sort of came across, sometimes as well was that the light was recognised. Yeah, and but again, so some of these things as well, when we, when we trained to be an EMT, we kind of work off of what our clinical practice guidelines and sort of the key words they're being sort of guidelines because the level of conflict with each other. So, for example, if you have your eyes to someone's house, and it's an old, classic example of this, where somebody would be able to step ladder, and they were painting their ceiling, ladder, if they hit their head on the way down off the floor. Well, they have to have a spinal, but you also have a feeling you have a nosebleed. So sort of a clinical practice guideline for spinal is to lay them sort of flat together, get them flat onto their back and immobilise the spine. And, but the one for nosebleed would say, as I'm setting up as getting forward, so you kind of have to use a little bit of judgement. To use this sort of judgement then when it comes to the cpgs. And getting back on track with the the concussions when we sort of again, so say we actually see it happening if we're watching that patient land on their head. You can actually see the mechanism mechanism of injury as well as editing. He may also have spinal somebody that's dropped directly down on top of their head. You could be talking spinal as well. So you get to see the patients and are thinking to do with immobilise spine, am once, depending on whether it is and as a spinal fusion, you go to full spine propulsion, you know, spinal board and get them off to into the ambulance also stretcher. And then, you know, you sort of follow your, say your your assessments along the way. So, you know, you constantly have that heartrate monitor hooked up to and you keep record of all this along the way as well. So we have pcrs patient care reports. And certainly these are the things that will stand here in a court of law. If it goes so far as you know, whatever happened. And so they have to be filled out. And, and they all get sent off then as well to the record kept all of them though, we submit to our job, I think they sent a copy of at HSE to pre pre hospital emergency care. And so when we did very little intervention for ourselves between and on the commercial side of things, very little sort of things that we can do to kind of resolve until the hospital, doctors are going after them. Okay. And I suppose even if we're on the sort of the human and Han abated, we'd probably bring them down in any way, just to be sure. Because again, it is one of the things that it can present in a really minor way for some people. Yeah, they can put them in a really major way for some other people. Have you any sort of question?

Unknown Speaker  
Yeah, we'll kind of have a bit of a list. But again, this is really great to know. So it is, and one of the big things I was going to ask was handover to the ER, or to the to the hospital staff. Is there a set? Is there a essentially, is there a set method to represent witness just concussions? Or is it the same as any other injury transfer is it just here's the files, and here's the patient.

# Interview Raw Data EMT

Unknown Speaker  
And so as an EMT, paramedic, each individual sort of developed their own methods to actually giving that handover. Normally it sort of follows a basic sort of method, a basic way, a basic way of doing that handover. And so you arrive to hospital patient on your stretcher, and the doors, you know, your driver will get I say, open the doors, you get the round plan, you get into the emergency department. And you're ready for the triage nurse to assess the patient, and as well as nurses normally come to you, first of all, you sort of have maybe a quick maybe 20 to 30 seconds there to get a handover. And And normally, you'll have this PCR that patient care report, you'll have your hand and you will start normally the way that I did it was he started the patient's name, patient's age, what happened to them. And if you some of you have all the the assessments that you've done on the patient, they have the heart rate, and whether they're reactive, or reacting to pain responses, you have all this documented there normally is sort of follow what I would call a sort of front page, the back page nearly about PCR. And it sort of gives they're not not sort of word for word, because it's a very long sort of winded document.

Unknown Speaker  
Yeah, for sure. But

Unknown Speaker  
normally, I sort of find Anyway, when you get to the hospital, the nurse just wants to know, it's a general overall view of what's going on. They don't want to know too many specifics, because they're going to go and you know, they have to I suppose they have to go and check their own assessments and their own readings and their own assessments for the patient. So they want to know, an overall basic point of view of what happened and what's going on. And, and what we've done to the patient as well. So if we've been mobilised by or whatever.

Unknown Speaker  
Okay, very good. And one question I do want to ask you about is have you ever had to assess athlete with a repeat concussion? So say, it took a knock in the first half, and it was kind of wasn't really warranted taking them off, but then they took a massive hit in the second and have you had to deal with a situation like that.

Unknown Speaker  
And not my memory, not knowledge and Okay, if I had to sort of speculate me putting myself into that position. And if I had witnesses being knocked the first time, and I'm down for the second time, I don't think the two months would change. Okay, you know, obviously, this is the second lock anyway, the SEC, the patient has to go into hospital. Yeah. During the rugby game anyway, it could be hard to sort of say, Well, you know, worked out with a desk that knocked the head there 10 minutes ago, they're they're taking a second look, it could be hard to say that unless the game was actually stopped, and the pace, assess that, and they've never really come across. Normally anyway, if if the patient is, you know, take a big hit normally straight off anyway, even if they're not on hospital or into the back of us, even if they want flows and fields to get checked out. And then they want to sit by the sidelines, that can be there. And yeah, this is also met, I've dealt with patients who have had concussions in the past, they would have had, you know, over the years or whatever, previous having another concussion,

Unknown Speaker  
have you found any difference between the two?

Unknown Speaker  
There's no difference between the two. And from our point of view, we're treating immediately what's happening there in bed. So we, I mean, we're treating that concussion the same as any other concussion. And there's no deviation from the guidelines. And then if there is a second or third concussion, or if the patient has taken the first knock, and that appeared, Doc, and there's no sort of deviation from these clinical practice guidelines. And all that sort of confirm is the clinical practice.

Unknown Speaker  
Okay, very good.

Unknown Speaker  
Question no.

Unknown Speaker  
Oh, yes.

Unknown Speaker  
As essentially, but first thing first, suppose and how many years? Have you been working as an EMT?

Unknown Speaker  
And it would have been a CV here. August 2016, to December 2017. I was working for Betty Lynn Campbell. And like an athlete, you know,

Unknown Speaker  
that's, you know, I'm on the phone today. And we've got a puppy over in my, we all have sort of pre hospital emergency characters to the short sort of abbreviation of massive amounts of thinking. So the fact of the matter website, you can check and see who is a registered paramedic, EMT, etc, etc. So, as well as working for, you know, many links, you'll have to copy across the link here to check to check register. And Mike is seven to one. payment was down to one or nothing. Okay, fine. It was just so that look, I am actually empty. Meaning that every year

Unknown Speaker  
yeah. Fair enough. Okay.

Unknown Speaker  
Because that kind of that was leading on to essentially it might not be applicable. Because, because you've only got two years on the job, but have with the introduction with their and pro and other modern safety devices. Have you noticed that? Have you noticed even have you noticed less concussions or more concussions in those two years? But it might just be too

Unknown Speaker  
short of a time frame? Really? Yeah.

Unknown Speaker  
Yeah. More than understandable. And I suppose Finally, is, do you think there's a place for innovation and regards to?

Unknown Speaker  
And absolutely. And I know that like I know, even from what you hear from being within being an EMT, you hear the goings on? I'll say the EMT world. I don't say there was talk. I think it was 10 years ago, there was talk of nurses and EMTs being able to basically if somebody has a concussion, no minor concussion, and to a point where that they could actually still, you know, play on or you know, sit out and then play the next game. Yeah. You MCs nurses being able to, to sort of fulfil that role. That's one of the things that I sort of disagree with. So notice the intervention still going on. In my, in my sort of if you'd asked me like, what could be done better? Yeah. And the claim the clinical practice guidelines themselves. They're very, very general. Like our r1 for Goshen is head injury. So it's head injuries a paediatric and adult. And it's very, it's almost like, you know, these arrow diagrams that you would have done in play school. Can you see a head injury, maintain the airway, and oxygen therapy, and it's just parallels pointing to the next box. And I think that they're very, very, very generalised. And for a new EMT in the field, and if you're somebody who is not experienced, and I don't know what it was, I was lucky enough that I got faced with a paramedic Frank pain with an old dog. And you he was medium got along with wildfire. And it's funny, because one of the only people I got along with that relationship. And, you know, friends was showing me things like a lot. And there's a lot of things by the way that you know, and you're supposed to do as an EMT that you're expected to do as an EMT that, you know, aren't actually shown to you within you as only, you know, a few weeks worth of training to be an EMT. And so, there's a lot of things that aren't actually shown to say like suctioning somebody who has a tracheotomy. And Frank actually sat down with me and, you know, showed me one day and transformed the background. And they're the tracheotomy patients say, from domains to gold I have from wherever else that wherever else. If you'd asked me Sorry, it's just me, but could be implemented into diagnosing concussions. Like that little tip there that I was saying earlier, where you ask the patients remember three things. Yeah. And I think, you know, again, it's really small. Yeah. But if you combine that with the symptoms

that the patient is actually presenting you the mechanism of injury, yourself, many definitely there to say, look, this is 100% concussion. And that's the hardest part, I find actually diagnosing the concussion. Yeah, that can take you out of a pitch for 20 minutes before you've diagnosed it. The symptoms start to develop and shoulder ugly head, they go from zero to 100. Really quickly.

Unknown Speaker  
Okay. That's very interesting to know. It's kind of funny that Britons read literature, you don't really you don't come across. It's only when you start talking to EMTs, and paramedics that yeah, that essentially, they're the ones that are on the front line are able to spot those differences.

Unknown Speaker  
Yeah, exactly. Okay. Any other they

Unknown Speaker  
have chat with one other paramedic? And there's actually I'm I'm mocking biker, so I was chatting to one of the medics at an event a couple of months back and about before locked on, or in between lockdown, I should say. And yeah, essentially, it was a much shorter conversation. It was just me chopping up the pitch or sidetrack, but yeah, it ran along the same lines that and essentially, the, the guides and the Yeah, essentially, the guides that are used are too general, they don't specify enough for the diversity of different injuries that are that are possible. And it tends to be a lot of training on the field rather than what you're actually taught.

Unknown Speaker  
Exactly.

Unknown Speaker  
Which seems to be a bit of an issue. Well, not a bit of an issue, but it could be potentially a bit of an issue if you don't get on with the person you're paired with.

Unknown Speaker  
Exactly. When you worked at the private they will quite happily put two EMTs together because you could have two brand new EMT because they have the money and just sort of three or four kind of bold to say leaders there within the private ambulance field. Many Lincoln's very linked to medical and Lifeline are sort of three of the top

Unknown Speaker  
Services paid off. You could do longer shifts. Maybe link was 22 hours. Wow. You could do a full day's work. And then they could turn around and say, Oh, sorry, Ross get the call into

Unknown Speaker  
any port forever. And you can't say no. Job like, yeah.

Unknown Speaker  
That's and then you're expected to perform.

Unknown Speaker  
Exactly, exactly as they normally the events as well as being sort of pitch side, which would be sort of emergency. Yep. Emergency sort of treatments. That's normally all sort of, you know, rugby games and stuff. midday. Finishing over with by the time, you're sort of getting tired. And when I

Unknown Speaker  
sort of think that as well, like, Is there anyone else even that I could? Like, I know a lot of EMTs paramedics are on authority being in the workplace. anymore, though, I mean, I could ask to see if anyone's interested in having a chat with you as rnc chair like points of view, you get the broader scope that it gives you.

Unknown Speaker  
Yeah, to be honest, I'm actually pressed for time on my research chapter. So I really appreciate it. But I don't think I'd have time to interview many other paramedics and EMTs unfortunately, otherwise, I'd love to do a full full breakdown or a load of interviews, but I just don't have the time and

Unknown Speaker  
the link over to our EPG to the clinical practice guidelines. Okay, perfect. For EMTs forehead injury is called head injury adults for a head injury paediatric patient. And it does everything that you know that we would follow. There's a lot of things that we've learned along the way that are better. Okay. Oh, yeah. Okay. Yeah.

Unknown Speaker  
You'd want to stick to them too strictly, Oh, absolutely. Brilliant. Oh, for sure. For sure. That's absolutely brilliant. Thanks for thanks for that.

Unknown Speaker  
I know he said your banking breakers. But it only started I got a maintenance licence up just before Christmas.

Unknown Speaker  
Oh, nice. What do you got?

Unknown Speaker  
To be able to go more than

Unknown Speaker  
fair? very fair. We only just started mountain biking. Have you only just started so

Unknown Speaker  
yeah. Just like the one that like

Unknown Speaker  
you'll learn you'll learn skills in the first bike anyway, for sure. Like I was, I was a coach for as my coach for three and a half years. Okay, so yeah, I've seen enough. And then I compete on the national team as well. A couple of different disciplines. So well used to seeing people come along and random boss bikes and try to do mountain biking, but the impressive thing is, they do it. It's close.

Unknown Speaker  
So it is yeah. Perfect. If you think there's any other questions or whatever, feel free to send me a message. Give me a phone call or whatever. I'm normally free all the time.

Unknown Speaker  
Yeah, sir. That's absolutely brilliant man. Thanks a million again, and best looking like biking in the future. Bye

# Appendix

Unknown Speaker

it's known as an informal interview. So I'll ask him fairly big question and then letting you ramble on and feel like there's something interesting in there, I might prompt you to continue on with certain details or

Unknown Speaker

I might ask certain lead and follow up questions. So you have been perfect, yes. Perfect. Perfect. Okay, so, first and foremost, can you tell me how many conditions have you suffered in your lifetime, given the definite tree maybe and there are all kinds of

Unknown Speaker

Mountain Biking never really. And was really involved in extreme sport for us and, and since I suppose

Unknown Speaker

since finishing up in us, but I haven't really been doing too much extreme sport since so I'm just kind of the time was mountain biking riding. Okay.

Unknown Speaker

Can you tell me about one of the situations because when your concussions and we think was a timing technique wasn't it timber? I wasn't there for that. So he'll have to tell me all the details. No.

Unknown Speaker

I think it was the one that was I wanted to cube heritage jewellery. The old ones. Yeah.

Unknown Speaker

The one that will travel. And there's Jimmy and someone that's influenced us as well. They're a bit non undershirt me going onto ones and over Afro. And there was a big rock and geezer bad fall. And just kind of shaken after as well.

Unknown Speaker

It was a fair fight now.

Unknown Speaker

That's probably my worst one. I would say. I'm more or less sure. You obviously. Remember a few more like the other things, but it was the worst one. Okay. So you're fighting? Really? Yeah. Can you tell me how you felt the moments after the moments after? Well, I suppose it was all kind of a shock, really. And I just didn't know where it was really, and just kind of shaking everything. And it was good to have the help of others that knew more voters and stuff, which was just training put me at ease and stuff. And yeah, I suppose it took a few moments to kind of fully come back to reality, kind of make sense. And like, it all happened so quick. And you're exactly sure where you were for the first moment or two.

Unknown Speaker

Yeah, I was I was that see somebody to reality come back shortly after the fair fight to get like, Oh, I know.

Unknown Speaker

One thing that was brought up by EMTs is there's something known as delayed onset symptoms. And did you experience any delayed onset symptoms? So adding 510 minutes afterwards, something else started or you may have got more dizzy or more fatigue? And really thought remembering Oh, no, not really. It was the first kind of two or three minutes that were the kind of most confusing and didn't really know what was happening. Okay, well, why don't we just sit down and kind of

Unknown Speaker

Let's settle for like a moment or two definitely, kind of brought it back to you.

Unknown Speaker

Okay.

Unknown Speaker

treatment after your concussion. Did you go and get checked out afterwards? Or did you

Unknown Speaker

know I just I filed a one of those in order reports.

Unknown Speaker

Just to ask them for both those are really

Unknown Speaker

really, I didn't have any after after effects later. So I'm

Unknown Speaker

sorry to Okay, where were you? Did you feel comfortable enough without having been checked over properly? Or was that

Unknown Speaker

well, I guess when when I didn't exactly notice any long term effects or didn't exactly see anything different and I just kind of hold to the vest and get gone. Sure. You don't need to worry Miss

Unknown Speaker

snow. Yeah. Okay, can you tell me a bit of time where you were you may have felt mildly frustrating maybe took a head off and had your bell rung or just kind of felt dizzy but you just kept going anyway for the rest of the day because Yeah, well I took a breather for an hour or two and I did I took a break after that one

Unknown Speaker

what it was advised by the safety officer I think was on was don't

Unknown Speaker

say that time

Unknown Speaker

but um yeah, it was advice take break Monday take a break. Like because that was on the things on the Sunday I'll take knock actually be in front of

Unknown Speaker

the rest of the rest of the day. The middle of the day.

Unknown Speaker

Yeah, it's probably the better option really.

Unknown Speaker

Definitely

Unknown Speaker

do within the next 24 to 48 hours Did you do any activity or any at

# Interview Raw Data Athlete

Unknown Speaker

all it kind of took it easy really. I'm sure it's kind of a read test weekend and kind of had to catch up on college work as well as to be away from again so neither me

Unknown Speaker

to cognitively

Unknown Speaker

fair enough. And on a

Unknown Speaker

in any of your other concussions Did you notice?

Unknown Speaker

Where again, you may have just took a small knock, but did you notice any?

Unknown Speaker

was anything affected? That when you continued on or if you continued on? Did you notice that it was affected?

Unknown Speaker

When I suppose your I suppose when I had more money when I suppose I was open

Unknown Speaker

in Krakow or Caillou happens. Yeah. And you remember that when they are?

Unknown Speaker

When I'm there again, there was water over there when the job's done. Yeah. Yeah.

Unknown Speaker

Yeah, yeah. Yeah. And

Unknown Speaker

yeah, I suppose it was hard to stay.

Unknown Speaker

And as as far as I'm on the bike I suppose we're after like just you wouldn't feel as as like confident to do an order things after happening even how even how minor was it all see nothing more nervous going through the next jumps in case you popped up and you're obviously a lot more like up this brave one point further. Yeah. Let me definitely be

Unknown Speaker

more like something like it I recall it alright. Yeah. Yeah. Do you consider stopping or taking a break? Once it happened? And well, surely after the after, they wouldn't take knock it take a break. Like, yeah, and demo minor ones. I I'm also just gonna, like,

Unknown Speaker

took it easy for the rest of this. Which I know which I thought was a good

Unknown Speaker

call of action. Really? And yeah, it's gonna be

Unknown Speaker

fine. Yeah. Okay. Will you fully aware that you sustained a concussion? Or was it just kind of felt a bit off? But that could have been just

Unknown Speaker

one less was? I wasn't exactly. overly open up on the whole thing. And so let's be honest, I had like, a bad experience. Like, I wouldn't be too aware of the effects and what could happen. Okay.

Unknown Speaker

Luckily, b

Unknown Speaker

we have only been like, overall, overly informative, and others. And so yeah, just can get a bonus wasn't too serious. Okay.

Unknown Speaker

Can you tell me if having crushes or experiences or the effects of the concussion has changed your interaction with the sport?

Unknown Speaker

My suppose I suppose as you grow as you go, to see more danger, really. And I suppose I, I want to like

Unknown Speaker

go through a lot of more of The Basics, mountain biking again, and just work my way up again. And like I wouldn't go straight for something just just like a todos effort. I, I kind of like, make small steps like, like working in smaller jobs, and then working my way up again. And I suppose it has influenced me overall perception to the danger of the sport. It makes sense. And yet

Unknown Speaker

did it put you off to speaking at all? No, no, no, definitely. No, no, definitely. It's not

Unknown Speaker

supposed to sway week on this COVID dies down and definitely be back in says Yeah.

Unknown Speaker

Did encourage you to either invest or make to ensure you got better protective equipment. And yeah, well, I, I suppose they are in the labour years in college, I tried to get some of my own gear as much as I could. And like, kind of hypertrophied more safer on the bike.

Unknown Speaker

Which

Unknown Speaker

would influence

Unknown Speaker

and yeah, so yes, yeah.

Unknown Speaker

Okay. Did you feel that the equipment that you got active?

Unknown Speaker

And I suppose I use that

.

Unknown Speaker

in combination with the equipment. And I felt fairly, fairly competent in the equipment I had then I like, was that the default base was it was good to have for the more extreme trips and could have your knee and knee

Unknown Speaker

and what the, what they call the guns, yeah. The word keypads. Niva. Exactly, Yeah, sorry. Yeah. That's Yeah, yeah. No, yeah. And it was good to have them independently, not just depending on

Unknown Speaker

Yeah.

Unknown Speaker

Okay. Can you tell me about a situation where you may have witnessed the athlete get to have a concussion or potentially have a concussion?

Unknown Speaker

Yeah. And

Unknown Speaker

he was barely actually and tissue is trying to jump on one of the only vaguely remember though, she was trying to jump somewhere. He was a first time doing a one of the more major jumps one or two more bigger jumps like and she was trying to get more confidence and she

Unknown Speaker

You fell over, she was in the same situation as I was in the intake knock, and kind of shaken everything and it kind of brought the whole scene into her in like, the perspective again. And yeah.

Unknown Speaker

Can you tell me Did you try and continue?

Unknown Speaker

And my team she kind of took a rest for an hour or two and, and she went on the on nutrients or things like that.

Unknown Speaker

She didn't want to do extremely. Okay.

Unknown Speaker

Did you know why they

Unknown Speaker

are? Can you speculate why they continue? or Why did you? Why did they continue with us? Yeah. And what what I suppose sheesh, I suppose it isn't every day you're at these big events, these big adventure parents and she was trained like, and warm down in the more on more easier trades when she was there. When she when she wasn't beating more up to the more how to dreads after having a concussion. Yeah. Okay. Do you know if anyone tried to attempt to stop writing for the rest of the day?

Unknown Speaker

And I think I'm not sure who hadn't saved the ox also was at the time bush and think the advice that she that she take a break initially, and how she felt after that was the roll call Really? And then she said she keep keep it different way the blue trails. And yeah, she was okay.

Unknown Speaker

She hadn't had any more.

Unknown Speaker

Okay, and then, finally, essentially, do you think there's a place for innovation in regards to what we've discussed today? So concussion safety equipment or the way it's dealt with?

Unknown Speaker

Sorry, Jeff, what do you think there's a place for innovation? And either in any place we've got so between them, I suppose.

Unknown Speaker

I suppose more maybe

Unknown Speaker

information on the on like, the effect of having that fall in in in more extreme sports, it's also definitely helped and proved people's overall perspective of the dangers, the dangers of us. And I guess having having a making information more freely available? Definitely. If maybe I've had to overthink.

Unknown Speaker

Suppose I want to run just

Unknown Speaker

back over. And you didn't have any of you had any dealings with EMTs or medical staff in regards to injuries you sustained in national force.

Unknown Speaker

That's right. And have you had to go to any other ambulances? No.

Unknown Speaker

No, no, I was I was looking. Thankfully, I didn't get into any two series. Anyway, that's, that's what has to offer, which was it was really looking back. Yeah. Yeah. All right. That's

Unknown Speaker

pretty much it. I know Jackie. I think I'll stop recording though.

# Appendix

Unknown Speaker  
There we are. Okay, there you go. Perfect.

Unknown Speaker  
Things. Not too bad, not too bad as yourself.

Unknown Speaker  
Yeah, driven demented by online teaching and all this. I can well imagine. So, yeah. So yes, I think I think probably we're all cheering that at this stage, you know a bit of a bit of online fatigue probably has kicked in, Oh, definitely apologise for another.

Unknown Speaker  
I don't panic. So what like, What can I do for you? So, essentially, I think it's essential on the leading of my research it's on. I'm more specifically looking at individual

Unknown Speaker  
athletes and people who will do events on the room, such as mountain bikers, such as motocross riders, or skiers, snowboarders and in how repeat concussions affect them long term. So emotionally, behaviorally, and so on. But I'm also very interested in the work you've been doing at the

Unknown Speaker  
pressure Research Centre. Yeah, kind of, essentially, just wanted to have a casual conversation about the future of the research that's going on, and potentially the future of concussion protection.

Unknown Speaker  
Yeah, for sure. No problem at all.

Unknown Speaker  
So obviously, a lot of

Unknown Speaker  
crying coming from is from team sports, from collision, sports, all those kind of things. Obviously, concussion, I think, I think that's the first message is that it's not just a rugby injury. That's probably the first piece of messaging that needs to needs to get out there. Because I think, with conversations and with certain amount of qualitative analysis that we've carried out in the last six months in particular, there is this tendency to try and pigeonhole question as a as a rugby issue, and that it's involved in that sport, and it doesn't exist anywhere else. So I think I think that's the first kind of that's the first barrier that needs to be overcome. And like in terms of in terms of research around around, say, the individual sports you were talking about in terms of cycling and motocross and surfing

Unknown Speaker  
There is there is evidence to suggest obviously there is that there are concussions in those types of sports.

Unknown Speaker  
But how it's reported in a lot of the individual sports is it's treated as a head injury as in, it's talked about in terms of laceration and damage, as opposed to actual brain damage that's done. From from what I've seen anyway. For sure. For sure.

Unknown Speaker  
Especially cuz I've been doing my own research, and interesting, a lot of different surveys along the board groups. And it echoes that, and a lot of MPs and a lot of especially are, they go straight for symptoms, and deal with symptoms, but they don't actually even address the concussion.

Unknown Speaker  
Very interesting to hear you actually with us as well. Yeah, it's true. I think, I think it's, um, I think it's, that's, that's where we're at. This is, this is all still emerging, it's all still,

Unknown Speaker  
it's still very new in terms of all of these, this these discussions. And to be honest with you, anything that's realistically all within 10 years now, this stage is really out of date, or entirely out of date, because how concussion and our understanding of concussion is a is emerging at this particular point.

Unknown Speaker  
The latest consensus as they have an open question is coming out early next year, which is, which would be interesting just to see where, where, where they go. And then to see how far they've moved on from the previous iteration of that of that consensus statement.

Unknown Speaker  
I don't know how much is going to have changed. Because

Unknown Speaker  
speaking with with it with a couple of the members who are on their consensus statement,

Unknown Speaker  
they're kind of have that opinion as well, that whole space is evolving so rapidly at this stage, that we've really got to be very agile in terms of how we understand and how we treat concussion as well.

Unknown Speaker  
But there's there's a few, there's a few core things that that go through in terms of, you know, how we detect and how we train reduce, and then obviously, how we treat as well, I think those are the doors those doors are some Those are some points that maybe we can have a chat about as well, you know, for sure.

Unknown Speaker  
Yeah, for sure. Starting on protection of

Unknown Speaker  
the big Yeah. Yeah, it is it is. And, again, looking at the last consensus statement, it's still,

Unknown Speaker  
it's still very vague in terms of what we can do to reduce concoction incidents,

Unknown Speaker  
across sports, it's still extremely fluid in terms of our understanding. Most recently, we carried out a systematic literature review, in terms of neck strength, which was meant to be this

Unknown Speaker  
kind of anecdotal evidence to suggest that if you can get somebody's neck stronger, that's going to

Unknown Speaker  
increase the rigidity of the of the neck, and therefore, increase the connectivity between the head and the rest of the body. So it makes perfect sense in theory that this is this is this could be used as a mitigating factor, they have used it in in stuff like cyclocross, they have spoke about putting in various supports in around the neck, but then that creates an additional problem that if the neck is so rigid, that what happens, you know, if you fall off, and the damage that could be subsequently caused. So it's the same in, in, in those collision type

# Interview Raw Data Researcher

sports, like rugby, soccer, GA, all those kind of things that, you know, we've been told for years. And I did it myself, you know, because my background is all strength conditioning, years ago, of trying to connect the head more to the body. But what we found from our systematic review was that the evidence just doesn't exist. It does not exist to say that if I improve neck strength, that is automatically going to reduce concussion incidence. No, that's not the case. What it does is that it says, If I improve neck strength, it makes my neck stronger. But it doesn't, it doesn't. It doesn't say that this acts as a mitigating factor for

Unknown Speaker  
against against concussion. And so that was really interesting finding, we found three papers. That's kind of head said, Listen, next week, we'll, we'll try and act as a mitigating factor against concussion. But there was no, there was no follow up. So there's no kind of there was no evidence to say that this and we've implemented this. And now these are the these are the results that came out the fire side. So it was really interesting. One in terms of how you reduce concussion, obviously the other stuff that are very popular that are kind of been talked about at the minute are helmets and Scrum caps and go machines and all these things that are again, proposed to to mitigate against concussion, but even in the most recent consensus statement, and I would imagine it's not going to change this one. Stuff like Scrum caps, helmets, comp shields, again, there's no evidence to suggest that they're that

Unknown Speaker  
They reduce concussion, calm shields can detect. So there's lots of really cool computer method be able to detect impact. And they'll be able to detect the force. That's that's been transmitted through through somebody. But again, that's, that's

Unknown Speaker  
a force recognition as opposed to a concussion reduction strategy.

Unknown Speaker  
I carried out some very interesting qualitative analysis on interviews with ex professional players.

Unknown Speaker  
Last year, in terms of quite their opinions were around screencaps of GM shields, they are of the opinion that Scrum caps were purely just to save their ears and to prevent against abrasions and cuts and that kind of stuff.

Unknown Speaker  
to to to a player, none of them said, Listen, yeah, Jesus, this, this, this is going to help reduce concussion or mitigate against concussion, it just stopped them getting caught. And it saved their ears from being torn to shreds radio, that was the kind of the, the general gist of it, but they had a clear understanding that if I take an impact to the head, my brain is still moving around. And if it's to shear and still move, and still bounce off the inside of my head, so I could as chrome cap gonna be if it's, if it's, you know, in protecting my brain, it doesn't make any sense, you know, in terms of in terms of that. So in terms of how you how you reduce it, I think the key thing we are finding is, is based on education, purely and simply just to the two things, how you educate, and how and how I, how we'd really clear that up for you is that

Unknown Speaker  
coaches and players, and people who are involved in sport, they have a certain level of declarative knowledge that they will tell you. So they will declare, I know if I do this, that that, whereas what their procedural knowledge is,

Unknown Speaker  
the follow on doesn't match what they're declaring. And again, that's what that's what's really coming to the fore. I'm having some very interesting conversations with, with researchers in Australia and South Africa at the minute. And it's the same problems are coming up against that declarative knowledge, as opposed to the procedural knowledge, why people say and why people do are entirely different. So it's actually the down I think the biggest thing you can do from a prevention point of view is education, proper education, in terms of in terms of how how you educate coaches, players, parents, individuals who are involved in the sport, and also behaviours, which was a really interesting,

Unknown Speaker  
modifiable factor as well. I was on

Unknown Speaker  
abusing about about 10 days ago at this stage. And it was the one question I asked, in terms of it was a panel of retired players. And people were kind of saying, Listen, concussion is terrible concussions is concussions that? How do we know try and

Unknown Speaker  
reduce it? And I asked the question around behaviour, you know, what, what, what can we do to modify player behaviour and all those kind of things? And there was no real one answer to be honest with you, you know, those it's kind of that that's really nice, but it's not really the solution to our goal. And I don't agree with that. I think I think behaviour is huge in terms of how you mitigate against this stuff, I think back a few weeks ago, and Peter Manny is the player on his back and he could, that's behaviour that could be modified. The following week, it was xandra figures, and that was behaviour that could be modified. So I think I think that's a big one.

Unknown Speaker  
Again, based on research that we've carried out,

Unknown Speaker  
I think you can do that modifiable as well as workload. How do you manage workload off players in terms of how much exposure are they getting to, to to concussive and sub concussive hits. So we can manage workload in terms of how many contact hours we have in per month, and then consequently, per season, every time you go to train, you don't have to be involved in full collision practice. It's not necessary, it is not necessary. So therefore, you can modify workload as an actual a real modifiable factor

Unknown Speaker  
against against against concussion.

Unknown Speaker  
And another thing as well, is that whole thing about

Unknown Speaker  
real open conversations between players and coaches, huge, because at the minute, again, based on interviews carried out during the summer of last year,

Unknown Speaker  
a lot of players have a fear of telling their coaches and telling their their their mentors that I come across, I have a concussion. Why? Because they're going to be dropped, contracts dependent, labels dependent. And then as a consequence, they kind of go well, I'm gonna say nothing. So it's it's there's there's a there's a few there's a few things that need to be that need to be kind of addressed. I don't know how useful that is to you. But that's, that's kind of the Patriot that that we're seeing at the minute. Yeah, I know that. That even that goes in

Unknown Speaker  
Semi amateur semi professional,

Unknown Speaker  
sort of enjoy individual sports like cross country skiing or mountain biking or motocross again, a lot of athletes aren't telling anybody because again, they're afraid to get dropped, they're afraid to get to lose their contracts on getting that training in, nothing needs to get in.

Unknown Speaker  
So not very interesting. But it's also that folks that correlate between team sports on individual courses, books and have

Unknown Speaker  
that sort of inherent need to not tell anybody in case they get that. Yeah. And there is that certainly look at looking at all the things that we've we've seen as well, there is that kind of a complete reticence on behalf of the players to say this, and

Unknown Speaker  
I'm not seeing anything, because, well, there's a whole cultural thing as well behind us, you know, if I'm, you know, if I, if I go and take skiing, or take motocross or take anything, if I wrote for an ACL

Unknown Speaker  
or PCL or some other ligament in my body, I'm going to have a limp. It's that visible thing that people can see. They understand I'm injured, so therefore I can't move. Whereas with concussion it is this

Unknown Speaker  
is this thing that goes on inside my head, nobody can see us, nobody can

Unknown Speaker  
accurately

Unknown Speaker  
tell me exactly what's going on here. So therefore, I kind of choose to ignore or not declare symptomatic, I am

Unknown Speaker  
sure, for sure. And I suppose on to the next talking point.

Unknown Speaker  
What do you feel will be the future protection against concussions?

Unknown Speaker  
Yeah, it's it's an interesting one. Like I'm, I'm looking at this now for for a good few years. And I still have the belief and for the foreseeable future, I don't think there is one test. I just don't think there is one test to say, Listen,

Unknown Speaker  
this is going to definitively tell you that you have a concussion? I don't think there is a scan. I don't think there is what I don't think there is one scan.

Unknown Speaker  
dti may be better than MRI. But

Unknown Speaker  
it has to be used with a whole array of tests that need to be that need to be instigated. I don't think biomarkers are a solution in themselves either. I think they have to sit in,

Unknown Speaker  
in amongst an array of tests. If you And again, that's my own conclusion. But again, if you look at the a lot of the research that has come out around this, it's it's very similar there, there is no one

Unknown Speaker  
measure, there's some very interesting stuff happening. There are some very cool stuff happening.

Unknown Speaker  
I saw a demo of a piece of kit called reflections. It was coming out of Penn State University, which was quite cool. But again, that was based on handle coordination. And it was really cool panel. And it's still in development. Still in testing at the minute, I'm not sure where they are at the minute. But that's that was that that's that was One really cool thing. There's other

Unknown Speaker  
lovely non invasive testing as well happening with

Unknown Speaker  
oxygen and cell metabolism. And they're using

Unknown Speaker  
lasers to try and

Unknown Speaker  
detect, you know, how oxygen is reacting within brain cells, and is, you know, our brain cells able to use the oxygen that they're getting. And it's really cool because they're starting to spot

Unknown Speaker  
that there's an enzyme in particular that thereafter.

Unknown Speaker  
Site site of florid c oxidase is this enzyme that's directly connected to metabolism. And if if they see that this that has brain cells, and the stress within the ribs detects that, well, therefore this person is still they still can cost. So there's lots of cool, you know, innovative things happening. To answer your question, I think solutions have to be mobile, and they've got to be non invasive, in my opinion, that those are the kind of things that

Unknown Speaker  
need to be looked at. So

Unknown Speaker  
the handle coordination

Unknown Speaker  
side of things is really useful.

Unknown Speaker  
So in in that bracket, I would put all your vestibular ocular motor testing. So going back to the basics of like psychometry, and seeing how my eye patterns are moving those, like any test, any test needs to be well needs to be this. It needs to be

Unknown Speaker  
non tradable.

Unknown Speaker  
So any, any of the current corksport stuff, I think there's, there's a problem. There's a problem with that, because it needs to be random and not open to manipulation is probably the best way of putting that to you.

Unknown Speaker  
So the vestibular ocular

# Appendix

Unknown Speaker

motor side of things are really cool because, again, they're transportable, they're movable. It's not it's not new technology. It's around it around for

Unknown Speaker

A good number of years, trying to detect hand eye coordination in the likes of dementia and whatnot just to see, can you can you track your own patterns? And there's some nice applications in around that.

Unknown Speaker

So that's a part of the solution, probably biomarkers on the lines of the, the oxygen and the seven metabolism stuff, maybe another part of the solution.

Unknown Speaker

There's some interesting stuff happening in blood biomarkers as well, at the minute. There's a lot of interest around NFC, last bread as an actual marker, as opposed to just looking at the tau proteins that are that are existing.

Unknown Speaker

But again, they're just all looking at different aspects and try to accurately identify what are the ones that that that exist in concoction, because there's some research to suggest that a lot of the biomarkers that the researchers were looking at in the last eight to 10 years, if you had done, if you carried out a high intensity interval training session, and I've taken some biomarkers from you, you will display similar symptoms to concussion, because your body is just under distress. So it's a case of how accurately you can make a biomarker that's directly associated with with with a concussion or concussive symptoms, or somebody who's you know,

Unknown Speaker

has been exposed to a lot of sub concussive impacts. So I think there's, there's, again, very long winded answer, but it's going to be, it's going to be a sequence of events, it's going to be an array of tests.

Unknown Speaker

But again, to me non invasive, random, not open to manipulation. And looking at current sides and testing for for sports like like, like rugby, I don't think they're sufficient. I don't think you have enough time to, to diagnose. So it needs to be something different. But not just something different, something that's very practical, very useful, and very specific to the condition that you're after.

Unknown Speaker

Okay, really, really.

Unknown Speaker

If you didn't harbour on that, big researchers are

Unknown Speaker

difficult to find difficult to distinguish pretty intensive exercise. Caution, when the other ones are interested to find out is

Unknown Speaker

how do you actually come across the advocates for these for the researcher? Is it? Do they come to you or

Unknown Speaker

go? Man camping for people are Dazed and Confused?

Unknown Speaker

And yeah, it depends. Like you mean, say, for example, some of the some of the qualitative research that we that we carried out last year. That was all so it does this mixed methods to answer your question.

Unknown Speaker

So say, for example, those interviews were a specific criteria.

Unknown Speaker

I contacted people that I knew who played professional rugby,

Unknown Speaker

and just had a conversation, because chances are very high, very high percentage chance that those players were exposed to concussion, because, again, any of the literature that you see anybody who was exposed to

Unknown Speaker

150, you know,

Unknown Speaker

Category A games, you know, they're going to be they're going to have a certain amount of concussion exposure, particularly if, if if they've been involved in a game for the last 10 or 15 years. So that's how that original sample came together. And then you just get referrals to other professional players. And that's just how it is not specifically, you know, we weren't specifically going after

Unknown Speaker

players who were concussed. It was just, that's just a sample that we've that we managed to gather, just using the network of people that we have available to us at that particular time.

Unknown Speaker

From the we are running.

Unknown Speaker

But we did run focus groups around concussion knowledge, attitudes, as well. And we approached

Unknown Speaker

a random survey in terms of recruiting parents, recruiting coaches, recruiting male players and recruiting female players as well, because as you're aware how females experience concussion is dramatically different to how males experience concussions, so it's important just to get

Unknown Speaker

all sides of the equation and at the minute, what we're seeing is that there is virtually no research into female concussion, personally non are any norms that we have around female concussion are derived from from male norms. And that's, that's a that's a massive issue, because there's so many other factors that you need to consider. So, yeah, recruitment

Unknown Speaker

focus groups and then obviously then some some

Unknown Speaker

qualitative type research that into

Unknown Speaker

into players and seeing what their fatigue levels are. And that's just common through research relationships that we'd have as well as through through the through the college and through the Irish research concussion centre. So this

Unknown Speaker

It's mixed, been honest with you.

Unknown Speaker

We're involved in European projects as well. So we have a nice research group that's based

Unknown Speaker

in Ireland, we've members in the UK, we've members in Denmark, we members in the US, we have members in Australia, more in New Zealand. So there's that's good, broad knowledge here as well. And I think,

Unknown Speaker

you know, in this space, people are willing to share it, which is fantastic. You know, it's not like, you know, it's not like a case of what we know, we know, I'm not telling anyone, this is a case of just what we know, we're going to try and share and try and pass out for the, for the betterment of the sport. And I think that's the key part as well, particularly, from my perspective, this is about this is like, you know, a core part of what we're trying to do is if you protect players within you protect the game, we want to we want these games to, to continue not looking at, you know, any kind of drastic measures of ban in tackling in schools and getting rid of rugby and all this kind of stuff. That doesn't make sense. Because just think of all the repercussions of that of sedentary behaviour, physical fitness, physical, you know, physical activity, so it doesn't make sense to approach it that way. So we're trying to just make the, the game the games better. And just trying to say, listen, how can we identify? How can we educate a little bit more? How can we change some behaviours, and this is the evidence behind. So that's, that's kind of where we're, we're coming from reading. Really.

Unknown Speaker

It's very interesting. Again,

Unknown Speaker

there's obviously a lot of researches going on, and will be going on into team sports like rugby, like gay that have that emphasis on concussions. But it's also very interesting to notice that

Unknown Speaker

surveys and looking for, and recruiting for

Unknown Speaker

a couple of other sports that are more individual based or even on an amateur level. And it was very interesting to see them. It was almost like a mass mobilisation of people wanting to come and help them wanting to come into that area to help out because they felt that it was just they were being left out. Like though Yes, there's a lot of research being put into team sports, individual athletes, they feel like they're being ignored in this area. So it's very interesting.

Unknown Speaker

It is it is and that's that that's a key point, everything that we're trying to do at the minute, is how do we apply this to amateur sport, that's the that's the key piece, because

Unknown Speaker

professional sport are well maintained. They have lots of resources, they seem to have plenty of materials around them. But it's when you start discussing the problems that exist in amateur sport or elite sport. That's where you really see where where there's a lot of misdiagnosis, there's a lot of

Unknown Speaker

there's a lot of concussions just being missed or ignored, because of lack of knowledge, lack of awareness, and like, and then you just don't have the medical support. So you think of, you know, put yourself in any event, you know, that that involves that potentially working question is is is could happen.

Unknown Speaker

And, you know, the lack of medical support is is is fairly is fairly prevalent, to be honest with you. I've, I've had multiple conversations with multiple EMTs and paramedics. And they were gracious enough to explain their process with me. And it is very interesting process as well as between them for about 20 seconds of a handover to an ER doctor.

Unknown Speaker

And most of the time if there's a compound injury, so broken arm broken wrist or broken clavicle, typically, the concussion gets completely overlooked because broken clavicle or protruding bone is a lot bigger issue to them.

Unknown Speaker

Very start start popping on.

Unknown Speaker

Yeah, Agreed. Agreed.

Unknown Speaker

Yeah, like I mean, that's kind of, it's just interesting. It's just,

Unknown Speaker

I became to see how you progress. And what you come up with, in terms of in terms of is that you're coming at it from a design point of view.

Unknown Speaker

So So I mean, that's, that's interesting, just to see what's there because we are continuously trying to find, you know, what are the most effective, mobile, non invasive methods of trying to diagnose and trees, and then a little bit down the line, manage, you know, concussions, because obviously,

Unknown Speaker

you know, some symptoms last hours, some some last days, some can, you know, speaking to a couple of x players, and they've had symptoms for 18 months, 24 months after, after the event. So it's just, it's how you it's how you manage that one, you know? Yeah, I think you pretty much described my responses

Unknown Speaker

by specifications

Unknown Speaker

Yeah.

Unknown Speaker

It's good to it's good to help you, oh, good to give a couple of good get different opinions as well. And things, you know,

Unknown Speaker

but but like, just keep me posted, let me know how you're getting on.

Unknown Speaker

Because Because we have we have, we have three master's students at the minute, or just all looking at different aspects of it and such as the size of such as the size of the issue. That's, you know, it's too much work for a person. So it's always good to, you know, this, just chunk

it out and just give specific pieces of work to specific people. And just and just let them you know, let them off and see what they come up with. Oh, definitely. Yeah, there's a lot. Like I've, essentially a month, a month to get all my research done for this. And then

Unknown Speaker

seven months of design work. So it's definitely a lot of work. Yeah. And it feels like just leaving a lot of aspects that I'd want to continue on. Yeah. Yeah. That's just how it is. How it is. Yeah. And like, I mean, in terms of design, what do you what do you what were you approaches in terms of, we take user centred approach. And actually, we find the basic needs of the user rather than

Unknown Speaker

rather than just addressing the symptoms that we'll get from

Unknown Speaker

more emotional and more cognitive approach, and seeing how we can change attitudes using

Unknown Speaker

their product service or system and flooring, that entire range of possibilities to see which one works and see which one is best suited for the Yeah.

Unknown Speaker

Yeah, that'd be interesting. That'd be interesting.

Unknown Speaker

Listen, keep me posted. drop me an email, and just let me know how you're getting on. If you could join us just just give me no show. Perfect. Thanks.

Unknown Speaker

No problem, jack. Take care yourself. Good to meet you.

Unknown Speaker

Bye



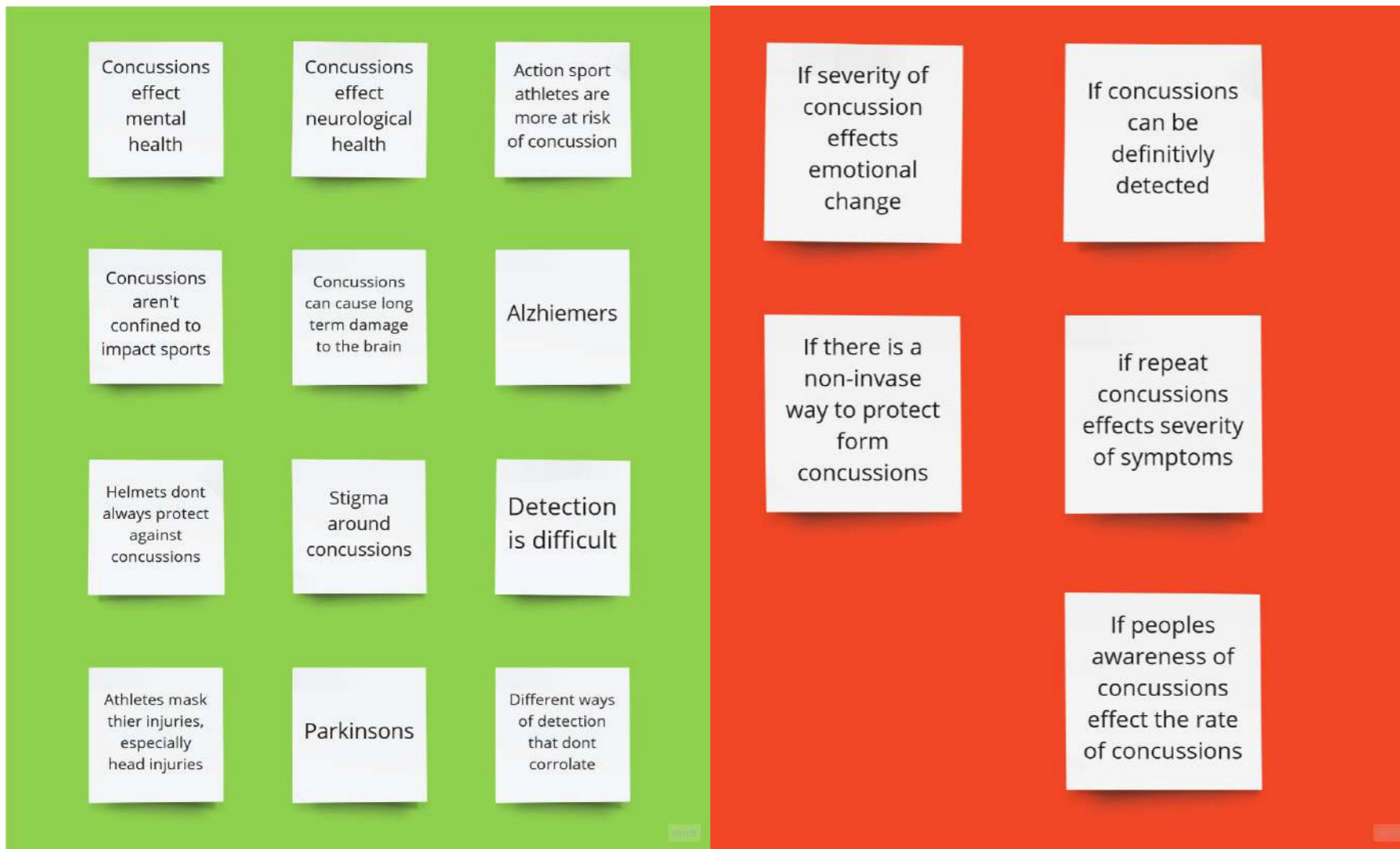


Figure 38 - Basic knowns and unknowns



Figure 39 - Stakeholder / Journey Map raw

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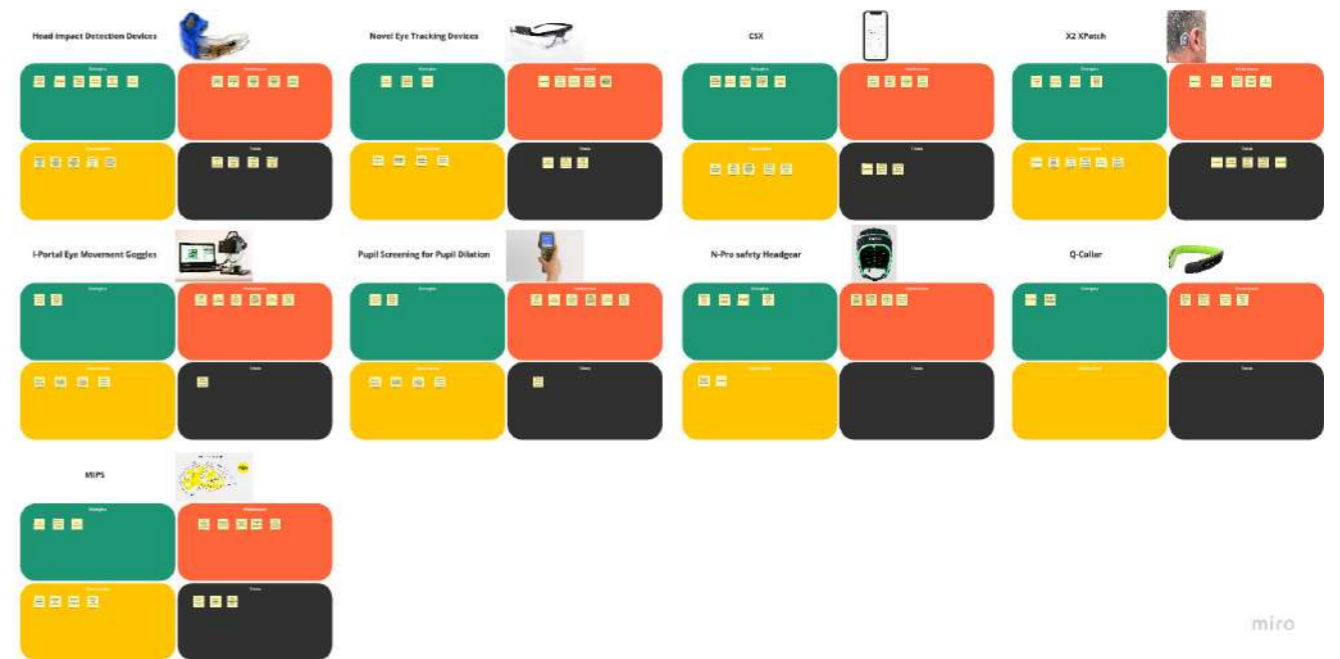
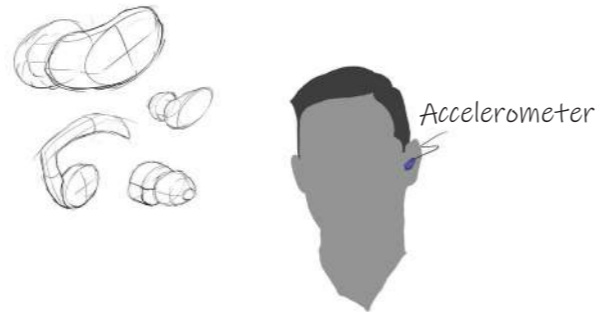
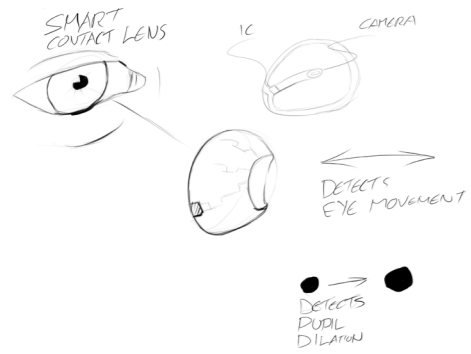
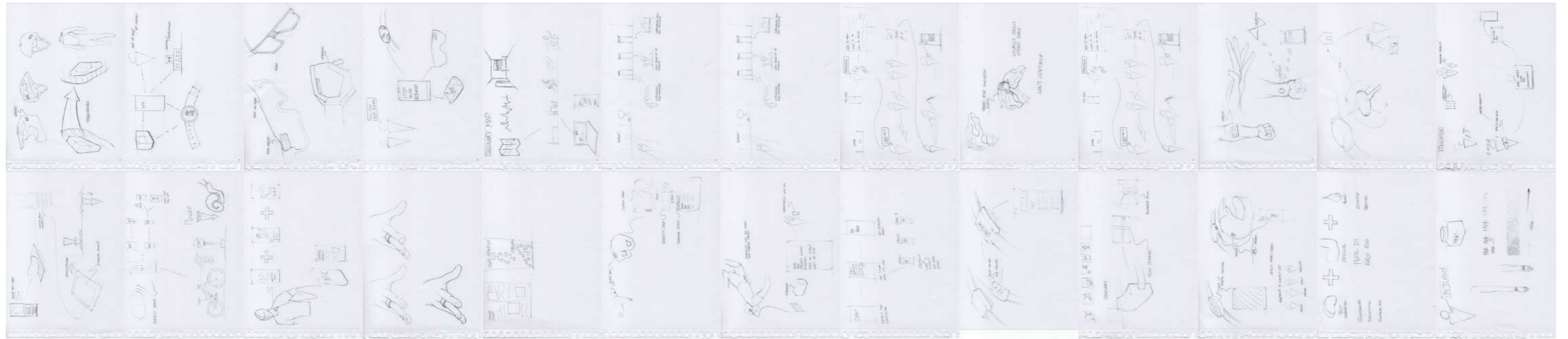


Figure 40 - SWAT analysis of existing methods

# Appendix



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