Project Journal

Jointreat

Windy Wen

Index

Preliminary Research

Domain: Digital media & Health

Using digital media as a method to give solution to problems around fitness and health.

General description:

I would like to design a community that collects, analyzes, integrates and shares datas of personal daily exercises. The goal of this project is to raise awareness around health and fitness, and also help and encourage users to build up good living habits.

Locate my project:

The focus group could be everybody or specifically on students, elder people, or people in hospital. People should care about this topic because ‘living’ is the most important things to do in life, and ‘care about living’ is a self- insurance that everybody should have.

Settling Direction

Digital

Emotional

Health

Technology

Safety

Wellness

Community

Fitness

Performance

Physical

Finally I decided to locate my project to a brace with technology to detect motion and body status to help users improve their performance and prevent injury.

Secondary Research

- The role of braces in sports:

To increase the stability of the joints, protect the joints and muscles during strenuous exercise or a large range of motion, to fix or reduce the amplitude of motion after joint damage.

- The pros and cons of braces applications:

Pros:

1. Protect the joint, increase the stability of the joint to a certain extent and reduce potential joint motion damage

2. Buffer external force impact on joint damage to a certain extent.

3. Help maintain joint stability after injury, limit the extent of movement of the injured joint, prevent secondary damage to the injured joint and help the recovery of the injured joint.

Cons:

1. The use of protective gear without pain will limit the extent of joint movement to a certain extent, affecting the performance of sports technology.

2. The pores of the skin at the joint with the protective gear are compressed, which affects part of the skin's breathing.

- Joint type:

1. Pulley joint: such as the knuckles of the finger;

2 ball and socket joints: such as shoulder joints, hip joints

3 elliptical joints: such as wrist joints;

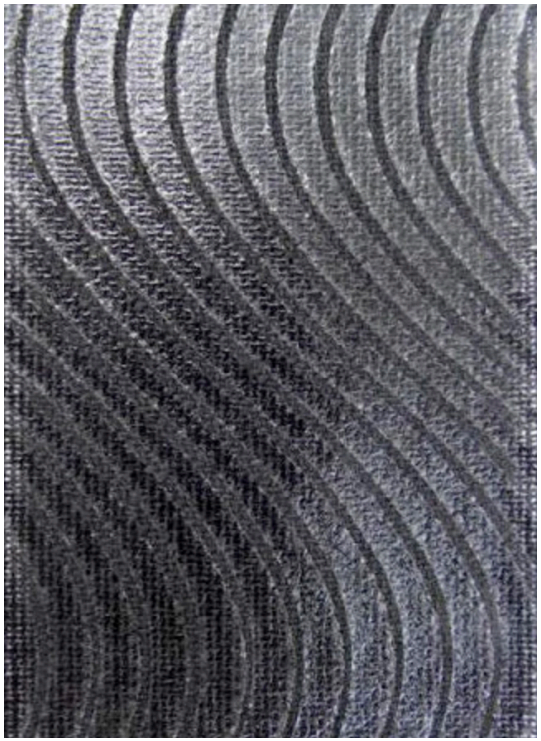
4 saddle joint: the intersection of the thumb and the finger bone, etc.;

5 planar joints: intercarpal joints, ankle joints, etc.;

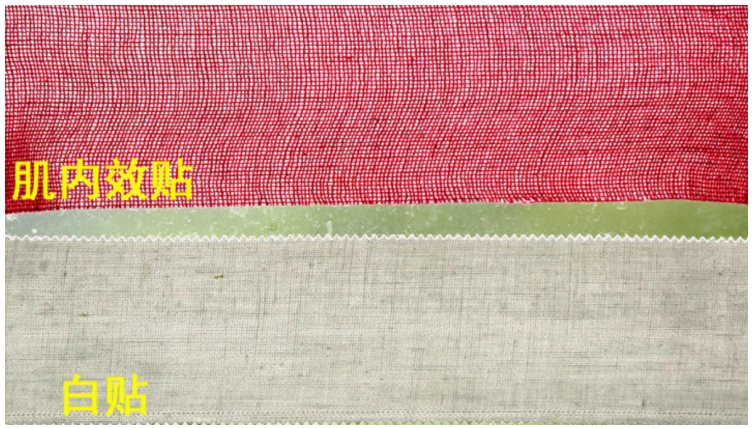
Secondary Research

Kinesio Tape:

The kinesio tape is divided into three layers: the outermost layer is a breathable and elastic waterproof cotton cloth (so the patch can be stretched within a certain limit, up to 130-150%), and the middle layer is usually low sensitivity acrylic adhesive. The rubber surface of the middle layer is distributed in a water-like corrugation (the width, spacing, wavelength and amplitude of the corrugations are specified), and the corrugation is also a key technology officially claimed to make the patch work. The glue applied on the qualified patch should pass the biocompatibility test, which is generally not easy to cause skin irritation and does not contain pharmaceutical ingredients.



https://www.zhihu.com/question/27995405/answer/56280588



https://www.zhihu.com/question/27995405/answer/56280588

Officially claimed physiological role and mechanism:

*Nervous application (stretching less than 30%): relieve pain, improve circulation, reduce edema

*Structural application (stretching more than 30%): support soft tissue, relax soft tissue, train soft tissue, correct posture, enhance joint stability

Secondary Research

Four key technologies for future wearable smart devices:

1. Human-computer interaction technology

Human-computer interaction technology refers to the technology of realizing human-computer dialogue through computer input and output devices. For example, direct and convenient human-computer interaction will be invented, such as the birth of AI voice interaction technology.

2. Virtual display technology

Smart devices will no longer need a screen. To be precise, the display mode will be a “light” screen that can be displayed in any space, instead of an LED display screen. The virtual screen will become available in any space. The carrier becomes a visual complement between human “machine” communication.

3. Cloud platform and artificial intelligence

PCs or smartphones will not be able to meet the processing of huge data in the era of IoT. The computing power of the device will shift from the current front-end data processing center to the back-end cloud platform. However, the massive amount on the cloud platform Data is only difficult to meet the development needs of the Internet of Things era by the current program operation and crawling. Therefore, artificial intelligence technology with self-computing and judgment ability is bound to become the next key technology.

4. Wireless communication and charging technology

At present, we are using 4G network. In the future, there will be coverage technologies such as 5G and 6G, and communication efficiency is better. Smart wearable devices are also important when using ubiquitous wireless communications. The ideal situation is to integrate wireless charging technology with wireless communication technology, and wireless charging while realizing data exchange, people will be able to enjoy wireless communication and wireless charging anytime, anywhere in any environment.

Jointension

Problem

With people's raising awareness of fitness and health, more and more people are engaged in sports activities. However most of the people does not have perfect understanding of the limitations of our body, and often over used it; and accidentally get hurt.

Another thing that makes me choose this topic is my parents both expirenced torn Achilles tendons while playing badminton. So these kind of issues happen often among people and there is a large need in joint protection equipment.

Opportunity

Currently there are lots different styles of wearable smart devices on the market to assist people exercise, but we ignored some of the safety issues that may arise from sports; and a large part of the problem comes from our joints. The existing sports protection that combined with the new technology are quite limited, and most of them are only used by professional athletes and also expensive. Therefore there is an oppotubity to design a practical protection device for the public.

Stakeholder

- People who had joint injured
- Fitness trainers / Coaches
- Doctors
- Athletes
- Product designers
- Technicians
- Elderly

Scope of work

Redesigning either knee, ankle, wrist or elbow brace with technology features, and make it safer and more comfortable for users.

Objective

I am designing a device that helps people to protect their joint and let people know their limitations to prevent from overusing their body. I would like to try to combine some of the popular technology into my project because currently existing wearable devices are mostly focusing on performances for example speed or acceleration, and body status such as blood presure or heartbeats. I would like to design a smart device that could give protection and tell the tension of the joint.

Precedents




Inspirations




Audiences




1st Design Brief

1st Design Brief

Design Criteria

User

- People who had joint injured
- Fitness trainers / Coaches
- Athletes
- Interested in fitness and health
- Normal income
- All ages

Functional

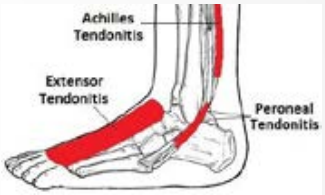
- Give enough protection to joint
- Give instant feedback
- Connect to electronic devices
- Personalized

Susainability

- Durable: long life-cycle
- Easily fixed and recycled
- Sustainable material choice
- Affordable and accessible

Ergonomic

- Could be customized to suit all body types
- Give support at right places
- Material that fit the skin



Manifacturing

- 3d printing
- Hand sewing
- Laser cutting
- CNC

Aesthetic

- Minimalism
- Building connections to users

Market

- Sport equipment stores
- Gyms
- Individual customers

Jurisdictional

- Data collecting permission
- Quality standard
- Biology support

Distribution

- Provide warranties and after-sales service
- User instructions

Cost

Material:
- Sustainable fabrics
- Chips
- *Metals, small amount plastic

Retail:
- Affordable
- Around 50 to 200

Precedents

I narrowed my topic down to specifically focused on Achilles Tendon injury, becuase it is the biggest tendon of human body and it is easily torned and hardly to be recovered as before. Therefore, I looked through several foot braces in different form and indication.

Aircast Air-stirrup

Indications

- Acute ankle sprains
- Chronic ankle instability
- Distal tibia/fibula stress fractures
- Edema control

Features

- Stirrup design with anotomically contoured sheels conforms closely to the ankle with minimal bulk in a shoe.
- Semi-rigid stays prevent inversion/eversion while allowing normal plantar flexion & dorsiflexion.
- Medial/Lateral aircells are pre-inflated

https://www.bruker.com/applications/metals.html

Aircast Sport Stirrup

Indications

- Chronic ankle instability
- Prophylactic use

Features

- Same features as the Air-Stirrup ankle brace but with a narrower design for less bulk in a shoe

https://www.amazon.com/Aircast-AC141AB08-Air-Stirrup-Universe-Support/dp/B00Y7WJQW0

Precedents

Indications

- Acute ankle sprains
- Chronic ankle instability
- Prophylactic use

Aso Ankle Brace & Aso Axis

https://www.medco-athletics.com/products-medco/braces-supports-casting-splinting/ankle-braces-supports/aso-ankle-braces-supports

Features

- Lace-up ballistic nylon sock with open heel
- Two non-stretch nylon stabilizing straps
- Neoprene closure keeps laces and stabilizing straps secure
- Aso -- has two removable plastic stays for extra medial & lateral support
- Aso Axis -- has a power profile design without removable stays

Swedo Ankle Lok

https://www.physiotherapystore.com/swede-o-ankle-lock.html

Features

- Lace-up ankle sleeve with open heel
- Made of triple layer vinyl laminate
- Medial and lateral plastic inserts and internal U-shaped spiral stays
- Elastic back panel eliminates irritation on the Achilles tendon

Precedents

Indications

- Acute ankle sprains
- Chronic ankle instability
- Prophylactic use

Active Ankle

https://www.activeankle.com/

Features

- Hinged ankle support with medial/lateral plastic stays
- Replaceable foam pads
- Two adjustable Velcro straps
- Extra distal strap can be added for anterior drawer support
- Works well with custom orthotics & OTC Insoles

Gii Sts

https://www.amazon.com/STS-Orthotics-Casting-Impression-MEDIUM/dp/B01N10HWJI

Features

- Footbed attaches to neoprene ankle cuff
- Footbed can be replaced with a custom orthotic
- Low profile design fits easily into all shoe types

Precedents

Indications

- Alternative to taping
- Mild chronic ankle sprain
- Prophylactic use

Stromgren Double Strap Ankle Support

https://www.homehealthcareshoppe.com/stromgren-elastic-double-strap-ankle-support

Features

- Slip-on ankle sleeve made of 4-way stretch spandex mesh
- Two -- 3” wide elastic straps with Velcro closures
- Low profile design

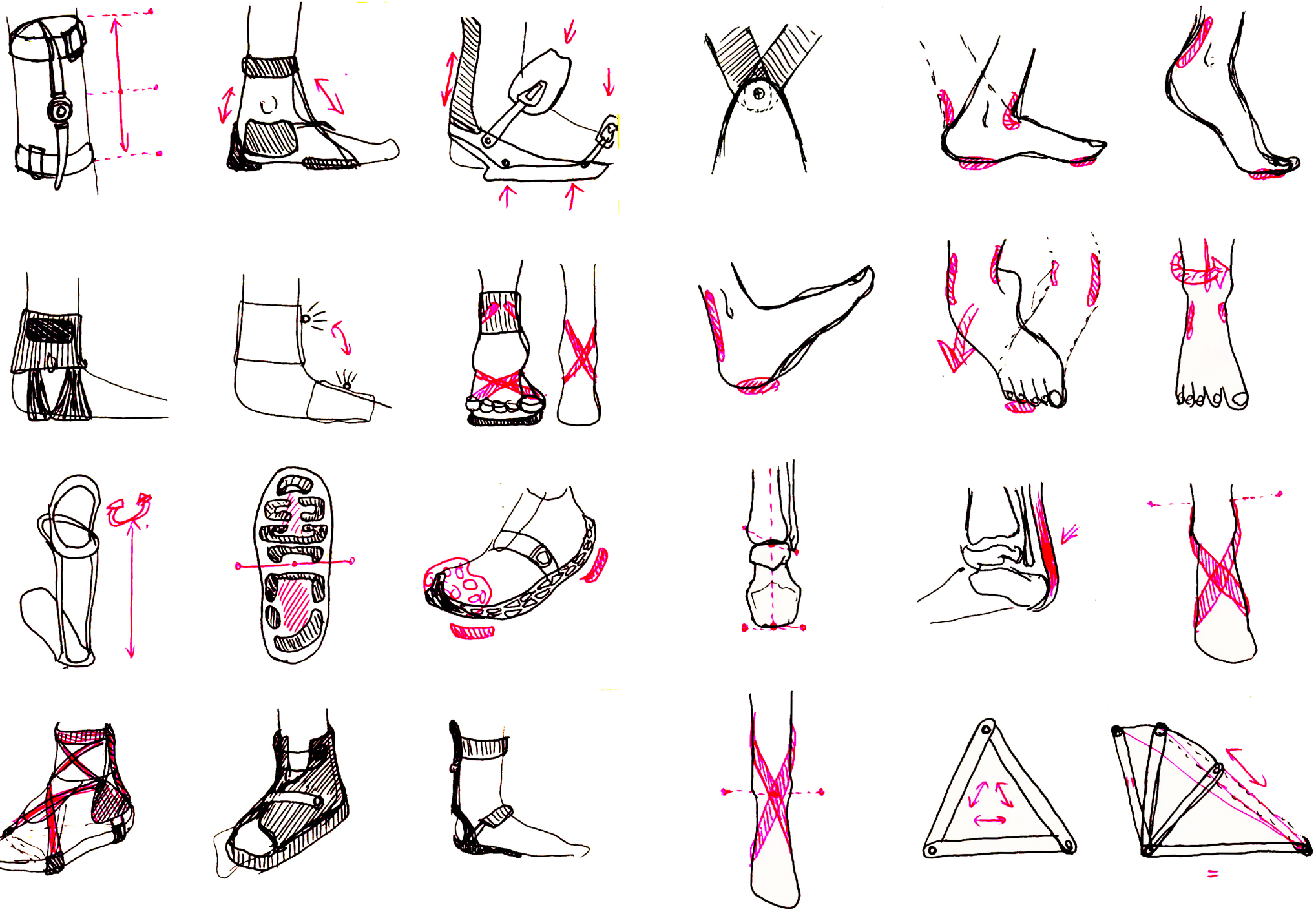
Stromgren Stirrup Lock

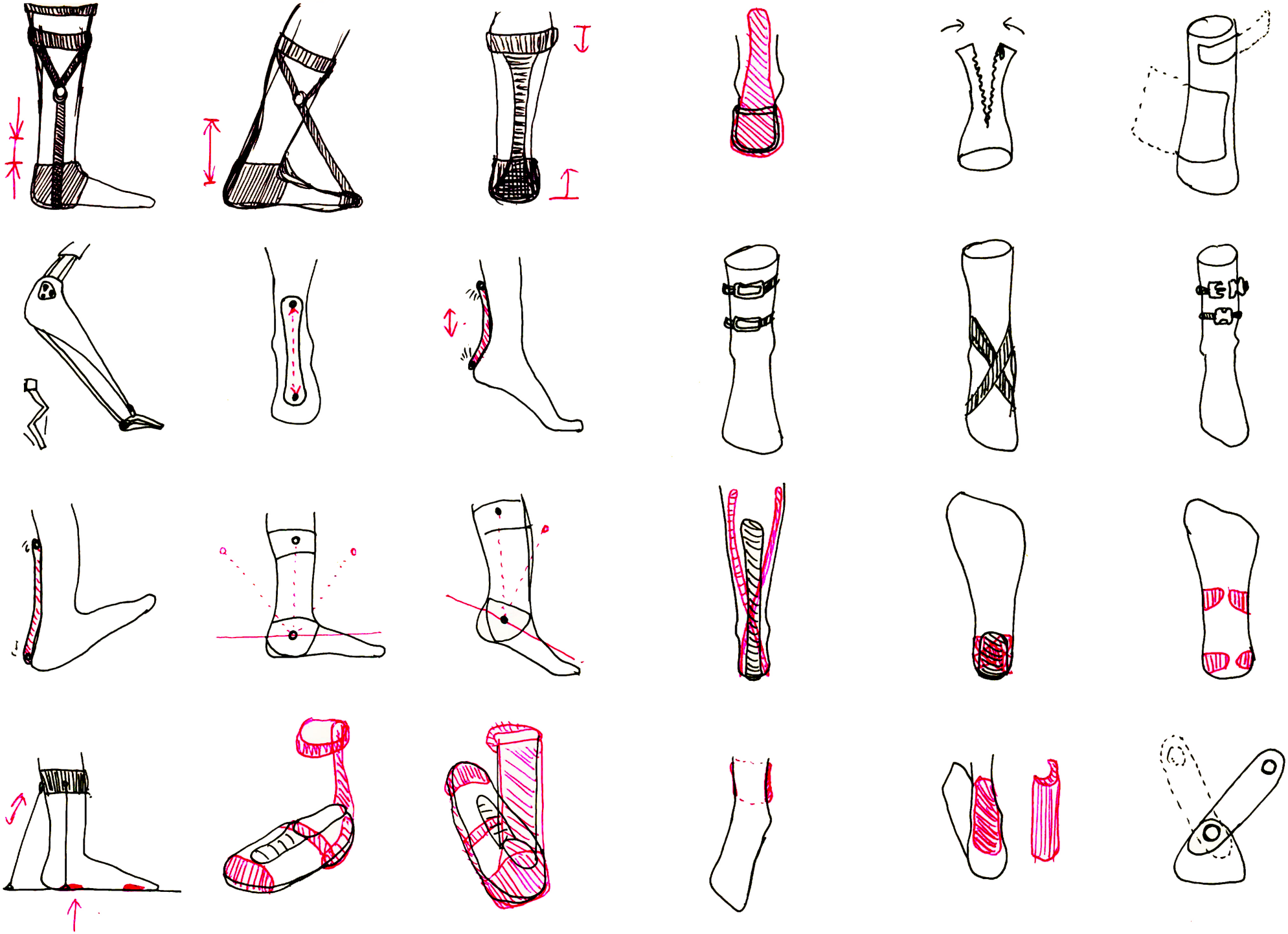
https://shop.kintec.net/stromgren-stirrup-lock-ankle-s.html

Features

- Slip-on ankle sleeve made of 4-way stretch spandex mesh
- Two -- 3” and two 2” wide elastic straps with Velcro closures
- Low profile design

50 Sketches





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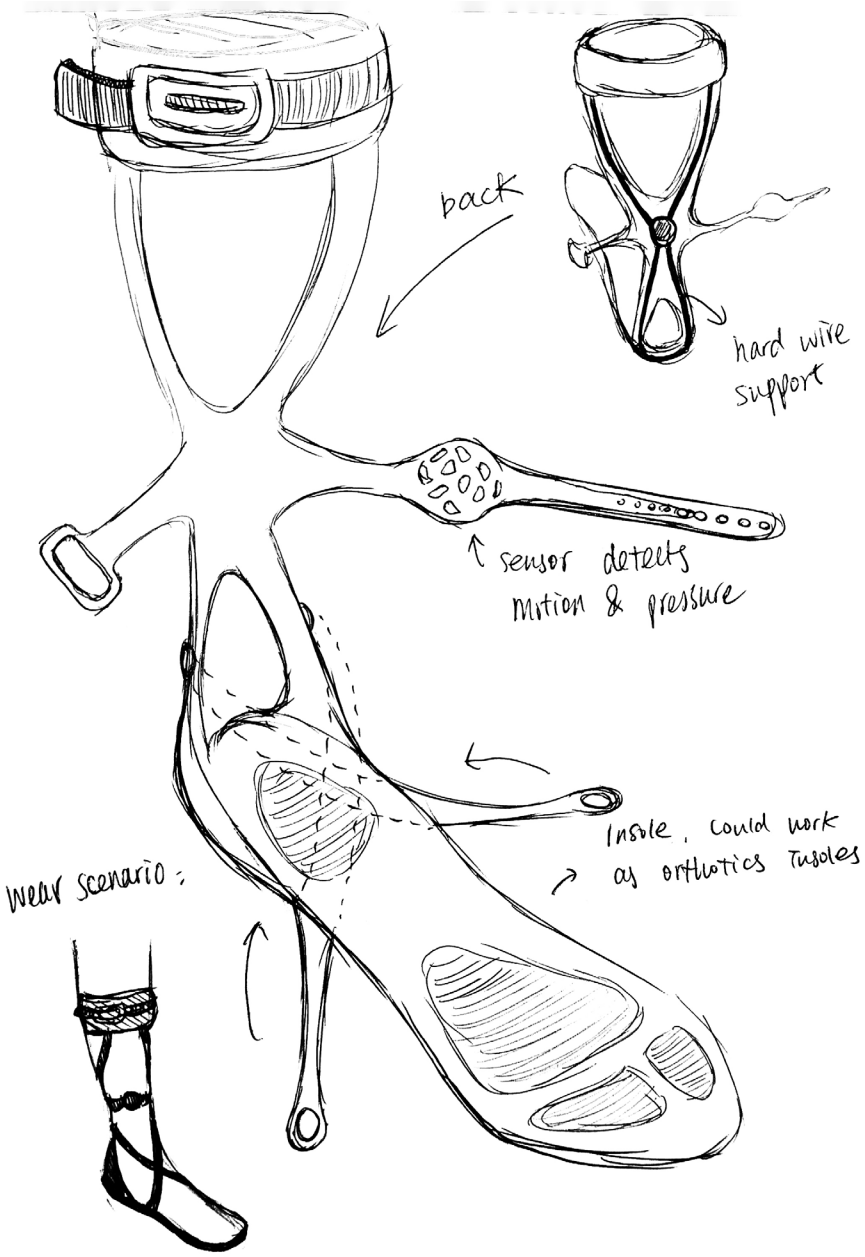
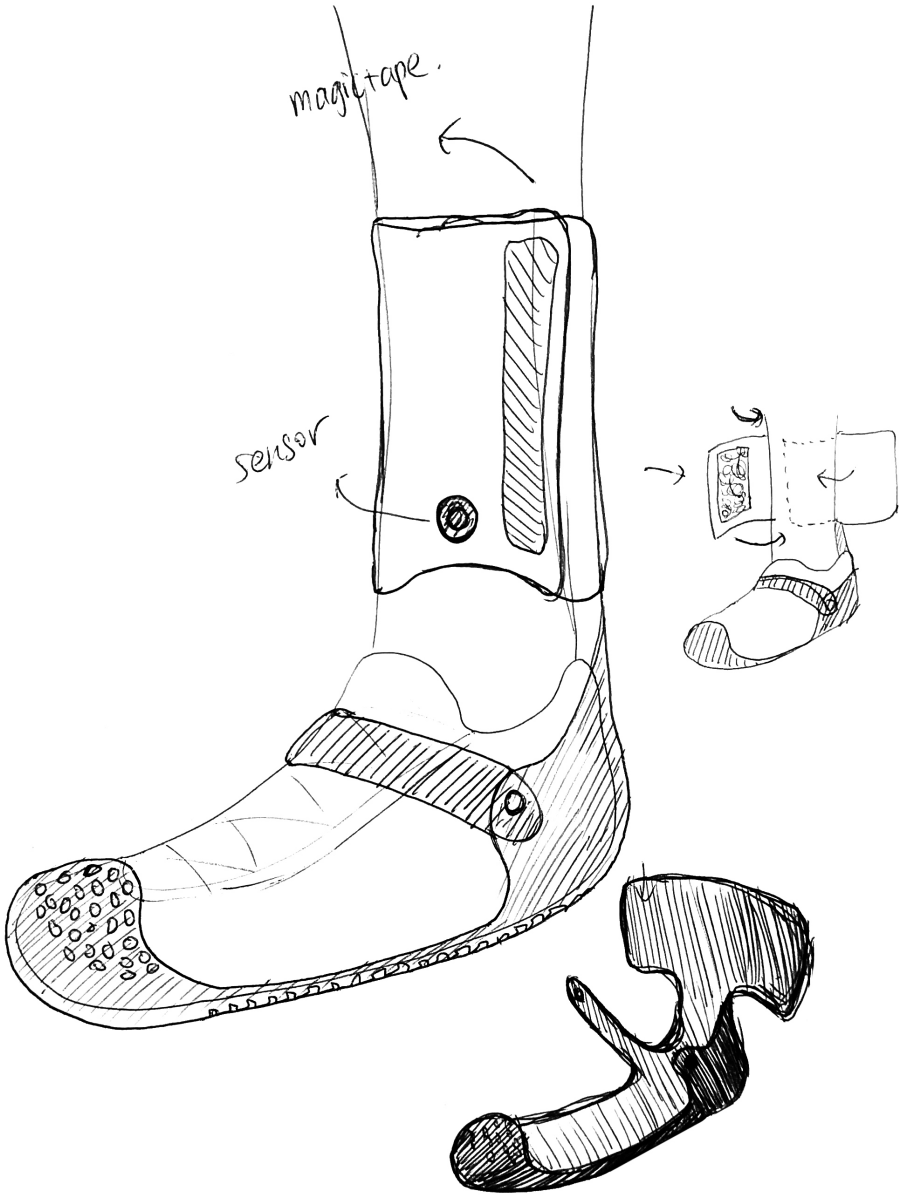

back
hard wire support
sensor detects mition & pressure
Insole, could work as orthotics insoles
wear scenario:

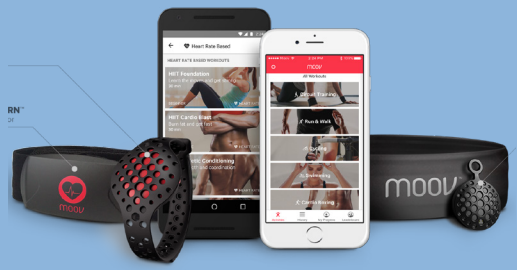

magic tape.
sensor

Tech products

Skulpt Aim https://www.skulpt.me/

Scanner: Measure overall body fat percentage in 24 different areas, identify relative strength of muscles and muscle quality.

App: In-depth body fat and muscle analysis; workout guidance to burn fat and build muscle strength for overall improved physique.



Moov https://welcome.moov.cc/

Band: Track laps and heart rate at the same time. Improve technique and efficiency by Moov app analysis.

App: Guides people while workout based on movement or heart rate in real time with audio.

Fitbit (versa 2) https://www.fitbit.com/ca

Smartwatch: 24/7 heart rate tracking, exercise tracking, measure sleep quality, with display screen.

App: Analysis data and provide guidance and insights, health and wellness tools for workouts, create communities with friends.

Tech products

Xsens https://www.xsens.com/

Xsens is the leading innovator in 3D motion tracking technology and products. The sensor fusion technologies enable a seamless interaction between the physical and the digital world in consumer electronics devices and professional applications such as Motion Capture, Motion Analysis, healthcare, sports and industrial applications.

Game Golf https://www.gamegolf.com/home/en-us/

Incorporating autonomous-grade sensors used by top automotive brands such as Tesla, GAME GOLF PRO features the industry's most advanced shot-tracking technology, enabling golfers to instantly track every shot in real-time hands free.

Polar Team Pro https://www.polar.com/us-en/b2b_products/team-pro

Designed for professional team sports, it combines high-precision GPS-derived movement data, inertial sensor metrics and integrated heart rate monitoring into a mobile and easy-to-use wearable player tracking system. Get valuable insights into athlete performance, prevent injuries associated with overtraining and win more games through actionable, science-based training data.

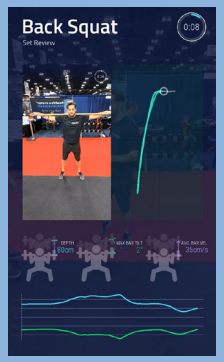
Tech products

Leap Motion https://www.leapmotion.com/

3D hand tracking: The Leap Motion software and hardware platform brings your bare hands directly into virtual and augmented reality. Leap Motion can be embedded directly into any VR/AR headset – no gloves or handheld controllers needed.

Ultrahaptics https://www.ultrahaptics.com/

Utrahaptics uses ultrasound to create rich, three-dimensional shapes and textures that can be felt, but not seen. With the technology, tools and expertise, user can add haptics to virtual objects, develop immersive holographic interfaces, and augment gesture control with natural tactile feedback.



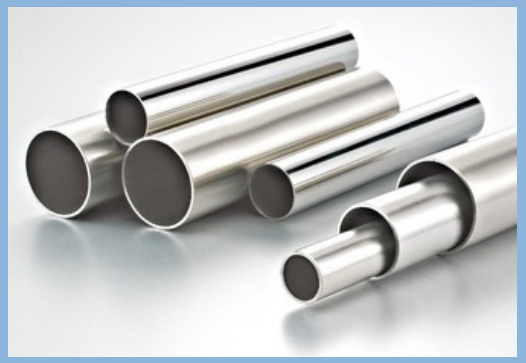
Smart Spot http://www.smartspot.io/

Smart mirror in gyms: Provides detailed motion analysis of 65 of the most common barbell and dumbbell exercises, with other fuctions like video replay, spine curvature, on-screen timer, instant bar path and analytics, and joint tracking.

Materials

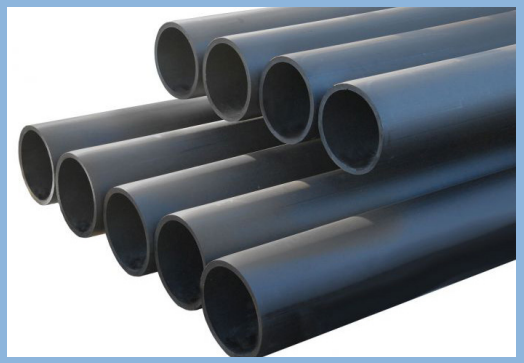
Supportive Material

Toughness, tenacity, light weight



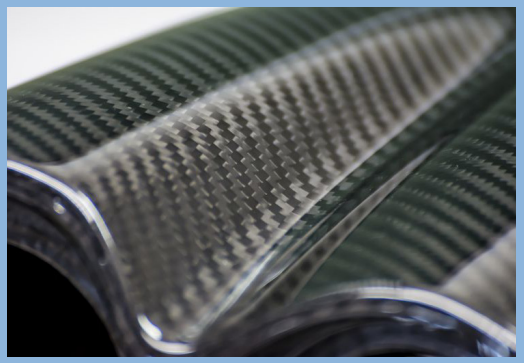
https://www.bruker.com/applications/metals.html

Metal/Steel, aluminum: strong, low cost, heavy, durable



https://www.indiamart.com/proddetail/industrial-pvc-pipe-4506560397.html

Plastic: low cost, light, low quality, short term use, brittle



https://www.thoughtco.com/carbon-fiber-manufacturers-820398

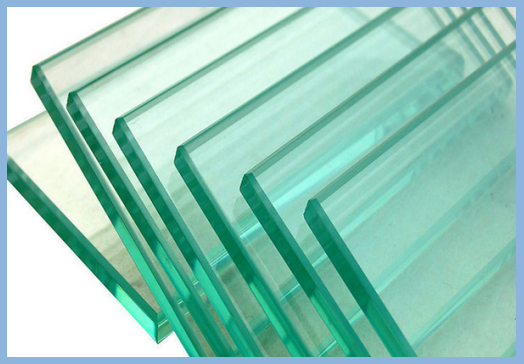
Carbon fiber: high cost, light, strong

https://www.usine-digitale.fr/annuaire-start-up/biomiscanthus,216152

Biomiscanthus: can't exceed 80 degrees, brittle than plastic, light

https://www.homedepot.ca/en/home/categories/building-materials/concrete-cement-and-masonry/

Concrete: low cost, strong, heavy, durable



https://www.glassonweb.com/news/glass-trade-fair-glass-reality

Reinforced glass: strong, heavy, NiS dangerous

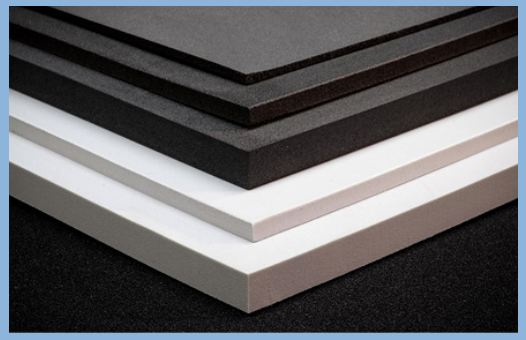
Materials

Padding Materials

Stretch resistant, toughness, comfortable to skin, breathable, skid resistance, wear-resisting

https://www.zenithrubberstore.com/shop/neoprene-rubber-sheet-commercial-grade-65a/

Synthetic rubber: neoprene



https://cosplayshop.be/en/product/eva-foam-low-density/

Foam: EVA

https://www.thefutonshop.com/blog/natural-cotton-versus-synthetic-fabrics/

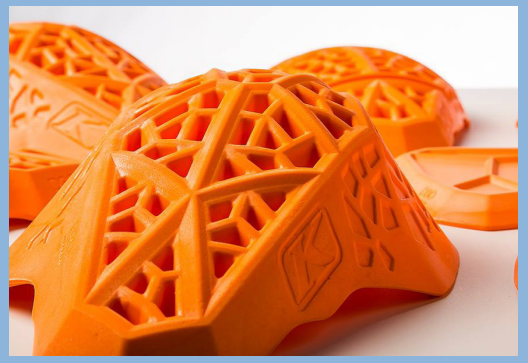
Synthetic fabric: Velcro, nylon, vinyl, spandex, Cooltech...

https://www.marshbellofram.com/bellofram-silicones/products/silicone-roll-material/

Plastic: silicone, PVC, PC

https://en.wikipedia.org/wiki/Cork_(material)

Recycled: Wine corks, Jeans

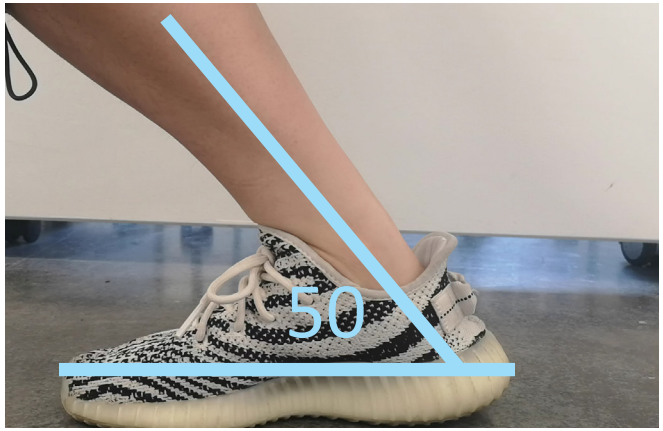


https://www.therokkercompany.com/2019/07/02/d3o-protectors/?lang=en

Protective material: ACF, D3O

Video Prototype

I asked people wearing different shoes to move their ankle to explore the differences of tendon flexibility between people.



Persona 1:

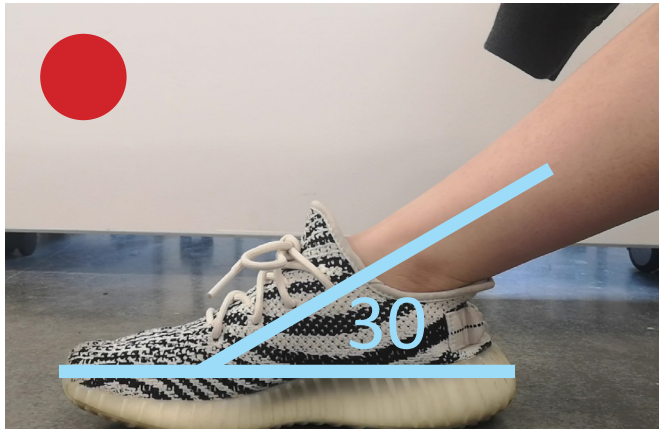
Myself

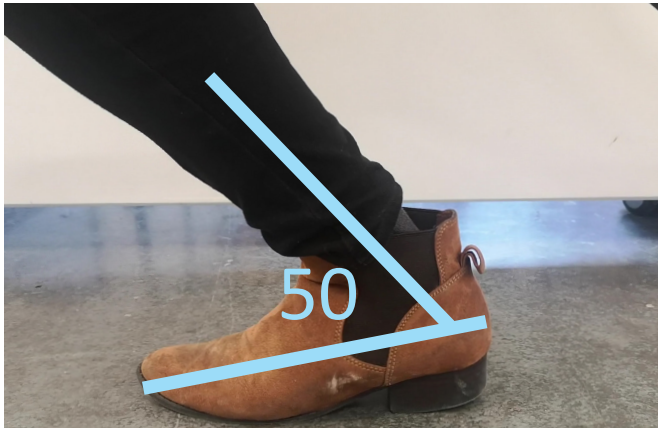
Shoe:

Low waisted

Sport activities:

- Go to gym 3-4 times per week
- Snowboarding





Persona 2:

Crystal

Shoe:

Mid waisted (restriction/force)

Sport activities:

- Barely
- Seating and standing for the most of the time

Video Prototype

The result shows that physical exercises plays an important role of how flexible one's tendon is.

Persona 3:

Ryan

Shoe:

Low waisted

Sport activities:

- Barely
- Seating for the most of the time
- Lots of walking

Persona 4:

Cindy

Shoe:

Low waisted

Sport activities:

- Riding horses every day
- Uses tendon a lot when riding

Interview with Catrina

Catrina works at Evolution Sport Therapy, and we had a interview over the phone.

Q: Can you tell me something about our Achilles tondon?

A: It is the largest and strongest tendon in the body. When the calf muscles flex, the Achilles tendon pulls on the heel. This movement allows us to stand on our toes when walking, running, or jumping. Despite its strength, the Achilles tendon is also vulnerable to injury, due to its limited blood supply and the high tensions placed on it.

Q: Do you think wearing a foot brace would help to prevent injury in any extend?

A: Surely it would help people to stabilize their ankle and give support. One thing to consider is the brace is to limit the motion while moving to prevent Achilles tendon from stretching too much, which on the other side you might not perform that well. So I suggest if your tendon doesn't feel uncomfortable, wear something light like kinesio tape would be a better choice. Also a proper warm-up is really important and helpful.

Q: Do you think it is helpful if there is technical feature in the foot brace, like a sensor?

A: Yes, I think that would be helpful. If the brace can show the tension or force in a particular area and remind people that would be really awesome. Also what you can do is to have a device that helps people to warm up their bodies, because people usually would forget or ignore some parts of their body, and that would probably cause injury.

Interview with Aaron

Aaron Oussoren is one of my professors this semester who recently torned his right knee. I had a conversation with him face to face.

Q: How did you get injured?

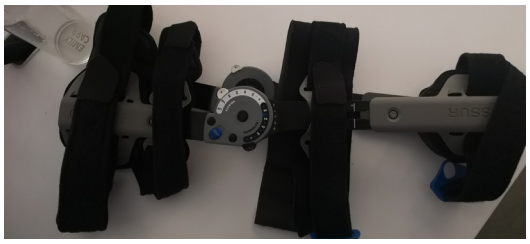
A: I felt down when running and dislocated my knee. I believe it is a torn three ligament injury and I did two surgeries for that. There are two kind of brace that I used, I was wearing the rebound directly after the surgery, for about two weeks.

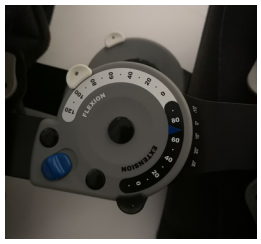
Q: What do you like and dislike about the brace?

A: I like the support that the brace had given me, it is strong enough because of the steel strips. They really works to ease the pressure of my knee. Also because of the steel, the brace is super heavy adn these two parts that stick to my knee is solid materials which is hard and uncomfortable when turning my knee.

Q: Is there any features that you like?

A: There is a cable at the back of the calf that use two metal strings to control the tension between calf and knee to make the knee is recovered in right angle. It is like there are three cables in different color, and you use a key to change every two or three weeks to adjust the tension, and just throw the used ones.





Interview with Aaron

Q: Are you satisfied with the material, quality, and price of the brace?

A: If I wear the brace directly to my skin it is actually better than with jeans. It would slip and move with my jeans when I am walking, so I wish the material could be more sticked to fabrics. It is quite expensive, the rebound is around $300, and the other one is $250.

Q: Is there anything you'd like to share with me?

A: I think there is an opportunity to redesign the brace that could be partly customized with lower cost. My insurance deducted some amount of the brace so I would be able to afford it, otherwise I probably wouldn't get it, and in that case it would effect my recovery.

Interview with My Dad

My dad ruptured his Achilles tendon when he was playing badminton.

Q: How did you get hurt? Do you think it can be prevented?

A: I was injured in the game. Personally think that if you do the necessary preparatory activities and protective measures, the damage can be avoided. Because I was exposed to a professional doctor during the treatment after the injury, I was tolded that professional athletes rarely break their Achilles tendon because their preparatory activities and protective measures are proper, and there are also professional coaches aside, so that accidents can be prevented to the greatest extent.

Q: Does the Achilles tendon injury have a big impact on your daily life? What are the main aspects?

A: The impact of Achilles tendon injury on daily life is obvious. Walking is inconvenient and requires walking aids. At the beginning of the injury, it is mainly inconvenience in life especially for self-care. For example, if there is no accessiable seat in the public washroom, it is really inconvenient for me. Another example, sometimes there is no elevator up and down the building; or even when I cross the road, the green light may only allows me to go half of the way. After two or three month, after removing the crutches, it is mainly inconvenient to walk, and I can take care of my daily life myself.

Q: If you are wearing foot brace when injured, do you think it can reduce the damage to a certain extent?

A: Agree. I did not protect my ankle when I was injured. If I use brace, it would effectively reduce the chance of injury, but the premise is to wear appropriate and effective ones; and fully warm up, also avoid fierce confrontation from the beginning.

Interview with My Dad

Q: Do you think there is any improvement needed for the ankle boots?

A: There are many kinds of ankle boots, different functions, different price points and different materials. I am using a moderately priced feature that is relatively economical. There is still room for improvement. First of all, the shoe size is often too large. Even if it fits, it is still very heavy and hard. It is one-third larger than my own shoes. Secondly, the elasticity is insufficient, and it is impossible to interact with the muscles of the feet. Third, although there is an adjustable angle function, but it is still too mechanical and not flexible enough.

Q: What are the advantages and disadvantages of the ankle boots?

A: The advantage is that it is fixed and prevents secondary injuries. The angle can be adjusted according to the recovery condition to increase the intensity of the exercise. It is quite convenient to put it on and take it off. The disadvantage is that it is too big and too heavy, not flexible, and the material is not modern enough to be taken off when exercising. It would be great if you can design it to be able to wear when doing exercise. Also, it is better to have some recovery function too.

Q: Did it give you enough support?

A: Yes. However, it should be noted that the support is related to the tightness of the tie. Because it is made of plastic material, and I am not able to control my own movement, I felt down once because the ground is too slippery. Fortunately, I have the ankle boots and worn it in proper way which prevented a second tear.

Interview with My Dad

Q: Are you satisfied with the materials, quality and price of the ankle boots?

A: Overall it is okay. Because it is made of hard plastic, the price is acceptable, the quality is average. When I took it off, the heel has worned out already. The time I used was nearly three months.

Q: Will you advise people to do some protective measures during exercise, such as wristbands and knee pads? Do you think this is necessary?

It is strongly recommended to add protective measures. At least to have enough prepare activities and warm up, plus protective braces to ensure that the probability of injury is minimized. Of course, the young man's body is flexible, it is ok to do sports without braces once the body is warmed up. However, I strongly recommend that protective devices should be used for exercise over the age of 35.

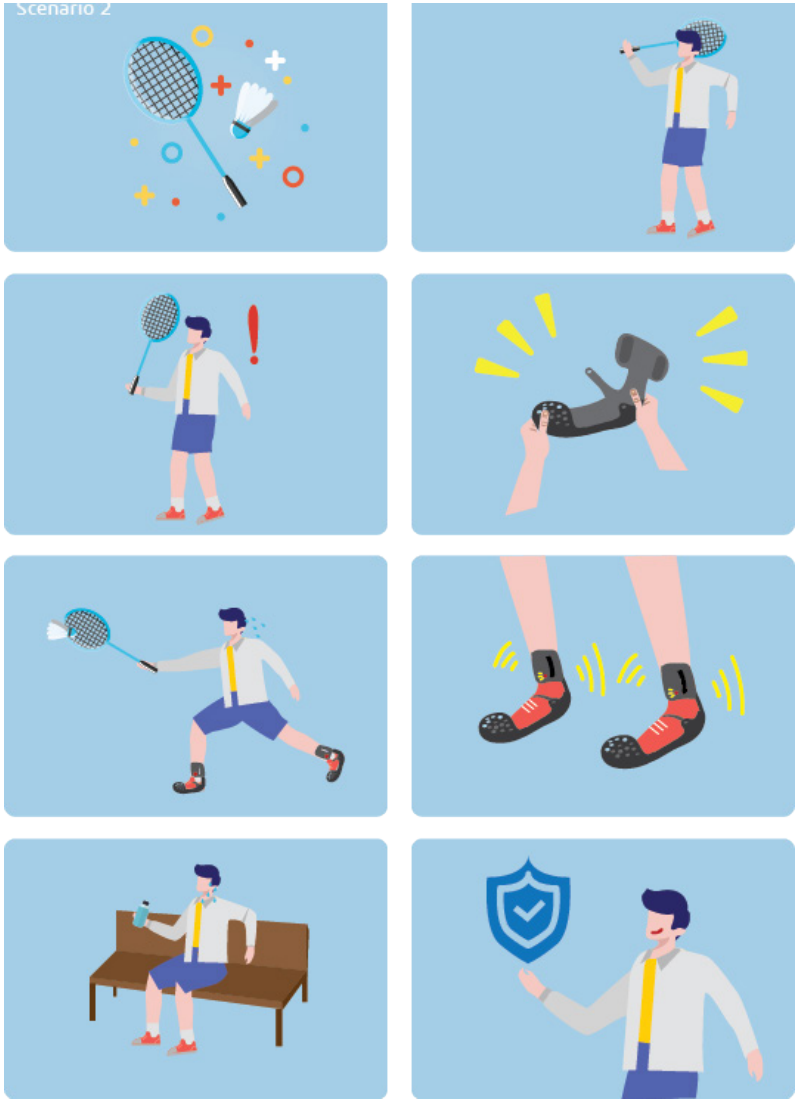
Q: Do you think that adding some technology to the brace/boot will play a greater role in joint protection?

It should be, I believe in the power of technology, but figuring out what specific technology should be used is your job as an industrial designer. But I think the key focus should be the design of joint protection, and make it supportive and flexible at the same time.

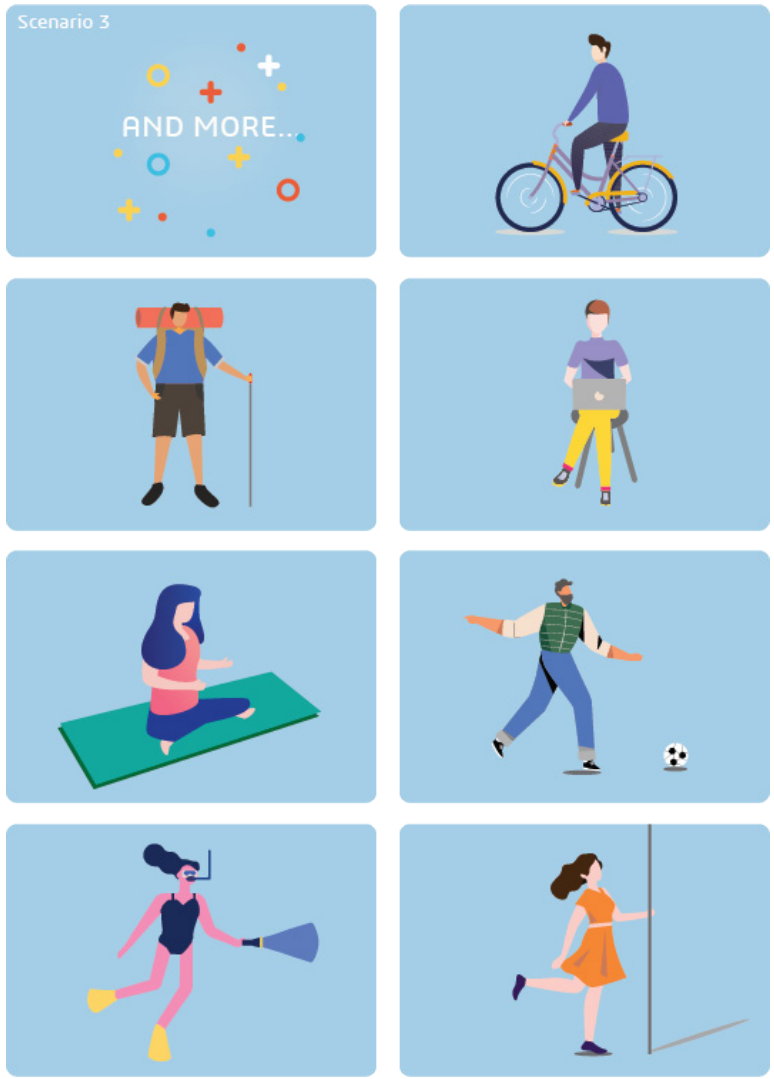
Q: Do you have any other experiences to share?

A: It was a painful and long experience, I hope everyone will not experience it. After recovered, I paid more attention to protection measures. If you are injured, it is important to follow the guidance of a professional doctor during the recovery process. It would be quicker and easier, and you can return to the game faster. Regrettably, I did not fully comply with the doctor's advice, so I have been recovering for six months.

Scenario



Scenario

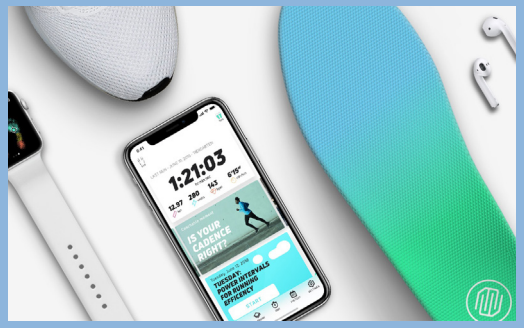


Tech Insoles

There is few precedent for protection gear with technology, so I looked up some insoles for references.

Stridalyzer http://retisense.com/

Stridalyzer uses a pair of insoles with a novel, patent-pending technology with multiple sensors integrated in them, to detect how your foot lands, rolls and pushes off the ground. Stridalyzer automatically understands that you are moving, and will start collecting data about your run.



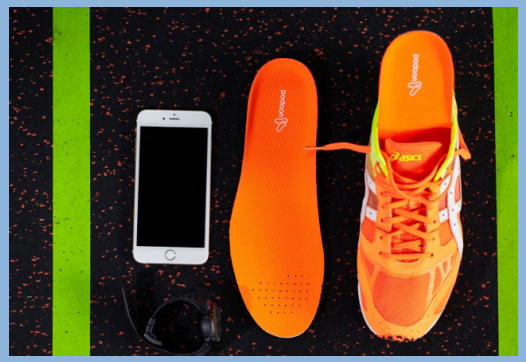
Runvi https://www.runvi.io/

RUNVI designed to help achieve full running potential. It make sense of the data to produce a tailored training plan that continuously adapts to personal goals, performance & progression and to deliver personalised coaching in real-time. RUNVI improves running technique, reduces risk of injury, and coaches running performance.

Digitsole https://www.digitsole.com/

Measure, analyze and improve your running performance. Equipped with an activity tracker that is more precise and complete than a wristband or a connected watch, the Sport Profiler© Running is able to analyze your sports performance in 3D and in real-time. This data will help you improve your performance, better manage your fatigue and detect the risk of injury.

Tech Insoles

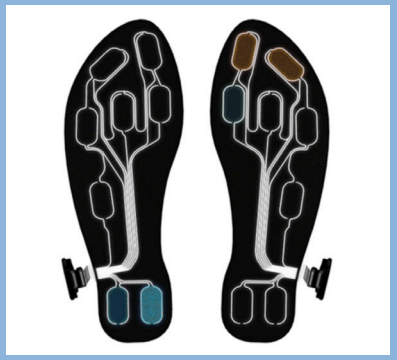


Podoon https://www.podoon.com.tw

Podoon is embedded with Nodic's nRF5 series sensors and provides running position monitoring reports. The data dimensions include walking, running, doing, and standing. Flexible pressure sensor, to monitor foot rotation and foot outside.

Lechal http://www.lechal.com/

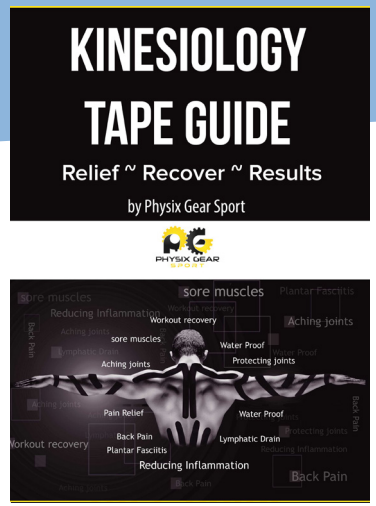
Wearable technology company Ducere Technologies launched the world's first pair of interactive shoes and insoles, which were launched in 2014 under the Lechal brand name. The footwear product uses Bluetooth technology. Through the App application and the use of vibration sensing, also known as haptic feedback, it interacts with the wearer, can provide navigation tools, or can track the activity track based on fitness.



Arion https://www.arion.run/

The pressure-sensitive insoles measure the direct interaction between your feet and the ground. The footpods accurately track the movement of your body. Combined with the ARION app it connects you to your running technique that wasn't possible before, to ultimately run faster, longer and safer.

Kinesio Tape Prototype



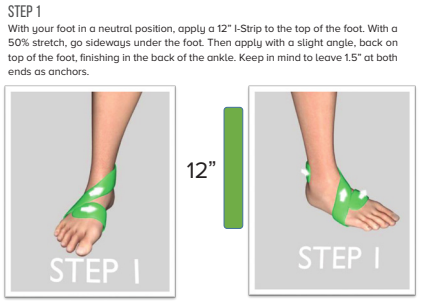
I tried to wear kinesio tape for a few hours with the help of Kinesiology Tape Guide and YouTube tutorial to see what form works better to stablize ankle and tendon. I have chosen four ways of wraping, which based on the previous research that makes most sense to me.

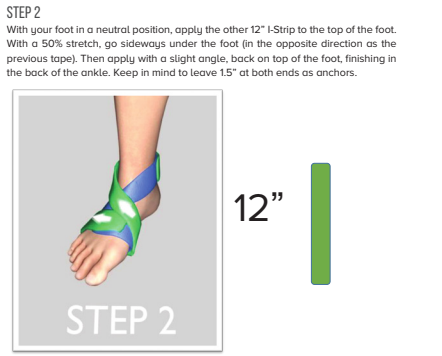
https://www.womenfitnessmag.com/

I wear them and went out for a walk and jog, I can feel the limit of motion and some support from my calf. It has a strong sense of presence so I don't feel comfortable, but feeling secure. Personally I prefer the one on the left between these two because I felt it gave me more support.

Although it is good to use the calf muscle to ease the force of Achilles tendon, it is hard to achieve it in soft materials that doesn't stick to human skin. Therefore, this kind of support limits material choice to tape and hard materials like metal or plastic, which is not ideal for daily use.

Kinesio Tape Prototype





Kinesiology tape guide

Next day I tried lower one that only wraps around the ankle. It gives more flexibility since it is not attached to the calf. The main purpose for these two ways of wraping are mainly for ankle stability, but it helps to limit my motion, and I was more confident to my movement.

I found that the X shape is a really good way to wrap around the ankle, it is comfortable and supportive, and I would like to try to use it in my design.

External Advisor Feedback Report

My first external advisor is Doctor Yang, who is working at the recovery center at the Beijing Sport Hospital, he is also the doctor that takes care of my father's injury. He claims that the product is doable and useful, but he does not know how refined I can make because it required lots of professional knowledge in medicine, and that would be a challenge if I don't have a complete design team.

Also, he mentioned that it is hard to prevent injury, it could happen in any situation that we cannot think of, so it is better to focus on post-injury stage or people that have great potential to be injured, for example the elderly. He would like to see me designing a device that could, instead of sense or prevent accidental, measure the tension of the Achilles tendon when doing different sports, and make an information board. So patients can see if they are eligible to do this kind of sport, for example, badminton is not a good choice because when you after jumped to catch a ball, the impact force of landing is massive; on the other side, table tennis would have less impact to achilles tendon since the feet is constantly sitting on the floor.

He also suggested other things that I can design for daily achilles tendon wellness, such as stretching or massaging devices, and it could be just a simple thing, like the small massage ball for patients; also there could be a device that makes the patients' daily movement more convenient since they can hardly walk after the surgery.

External Advisor Feedback Report

Then I asked about the gear support structure. He suggested that if only using soft materials, the x- shape would work better to stabilize the ankle, it is also good to have some extra support from the calf. He said there are lots of potential in my project and he is glad that students could pay attention to the topic of wellness and health.

My second external advisor is my dad, as the role of patient. He said he probably needs a protective gear for his Achilles tendon to prevent from second rupture, because it nearly cannot cure. The design concept that I gave him was mostly fulfilled his need. He is wondering how could I actually make it to work, which is the same question Doctor Yang had.

I found these feedbacks really useful, and I shifted my design a little based on the report. I would like to make my project not required too much professional knowledge, so that I would not design a thing that is lack of care and potentially hurt people. I shift my focus point from “prevent” to “take care”. I also shifted my target group to middle-aged, elderly, and people have walking difficulties because I discovered that there is little product that take care of their wellness, while there are huge needs.

Sketch Model

Exploring different forms...






Sketch Model









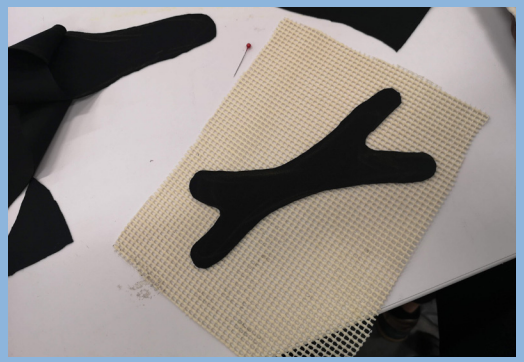



First Prototype

I chose three forms and refined them to make my first prototype.

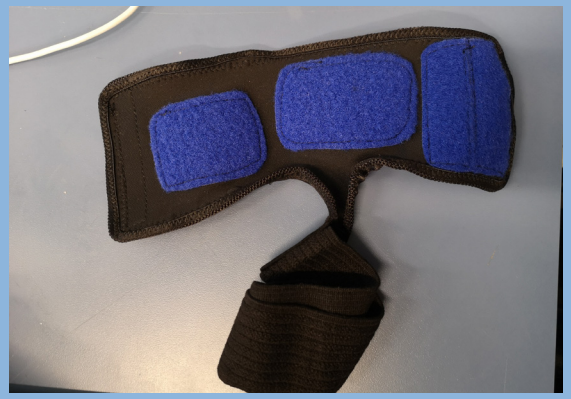
Protect "U"

This design wraps around the ankle from inside, then give extra support from two straps wrapping from outside to make the ankle more stable, and give more protection to the Achilles tendon.



First Prototype

I am using the zig-zag machine to sew the stitches to keep it stretchable.



“ElasTic“

The T-shape brace wraps around the ankle to give it support and protection, and the elastic band wraps aroud the foot with two X crosses to give it a second protection and make sure the force of each side is evenly supported.

First Prototype

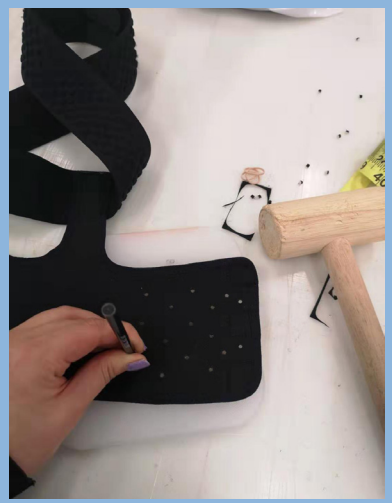
“Comfort”

This desigi is similar to the first one but make it smaller and lighter, however the result is not satisfying, it is lack of support of the Achilles tendon.

Second Prototype

Overall

For all three new prototypes, I changed the material to neoprene, which is the most common material used in braces and gears. I also changed the binding to a softer material so that it would be comfortable for all day wearing. Finally I put the Velcro at the very edge of the material so it could be fully attached to the fabric under, means the end of the Velcro won't tilt up a corner.



Second Prototype

“ElasTic”

I changed a different type of elastic band for this prototype. The new elastic band has several points popping out to build greater friction between human body and fabrics. I changed the location of the Velcro tape to cleaned up the messy surface of my first prototype.

Second Prototype

“Heeal“

I realized the C shape brace did not work out perfectly, so I came up with a new design which also mainly use the support of the elastic band. I put the neoprene at the back of the Achilles tendon so that the shape would be able to put a stretch sensor inside.





Second Prototype

Protect “U”

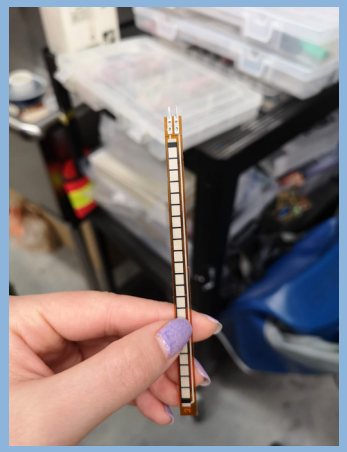
I refined the shape of the brace and changed the design of the Velcro tape. The old prototype has a problem that the Velcro hook tape is too hard, so that it hurts when I bending my ankle, therefore I made it two separate parts, so it can be bended at the middle.

Electronic components

The electronic components needed next semester for developing the technical function of the brace.

Stretch sensor

to use on the “heeal“



Flex/bend sensor

to use on the “ElaTic“

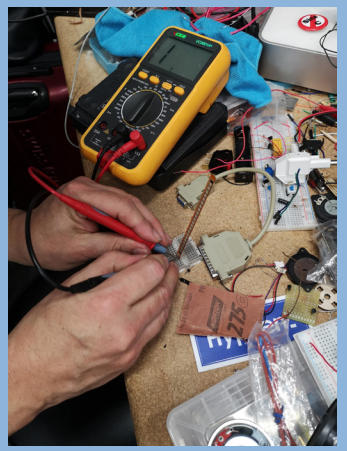
& “Protect U“

Force resistor

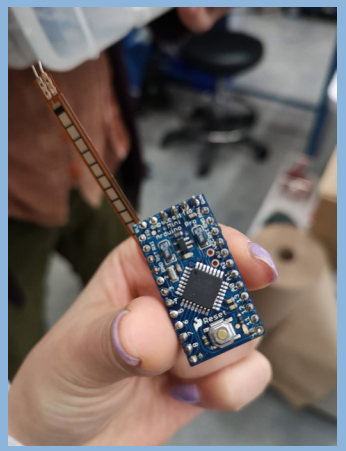
to use on all models

Force resistor

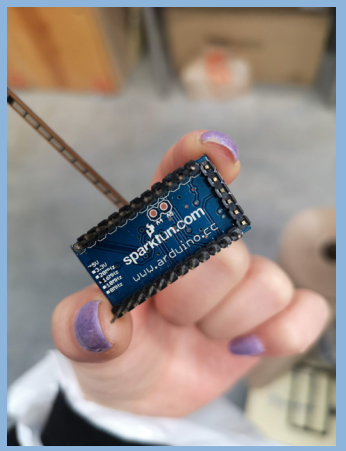
to use on all models



Testing bending force



Arduino Pro Mini



Arduino Pro Mini

Explanatory Document

Explanatory Document

Design Brief *refined

JoinTreat

Problem

With people's raising awareness of fitness and health, more and more people engage in sports activities. However, most of the people do not have perfect understanding of the limitations of the body, and often over used it; and accidentally get hurt. Currently there are lots different styles of wearable smart devices on the market to assist people exercise, but we ignored some of the safety issues that may arise from sports. The existing sports protectors that combined with technology are quite limited, and most of them are only used by professional athletes.

Stakeholder

- People who had Achilles tendon injured
- Fitness trainers / Coaches
- Doctors
- Athletes
- Technicians
- Elderly

Opportunity

Both of my parents ruptured their Achilles tendon lately, which rise my awareness. As their daughter, I am afraid of the second injury of their uncle, so I find this opportunity to design a foot brace for them, which embedded with sensors, to make sure they are not exceeding their limit. Currently existing wearable devices are mostly focusing on performances for example speed or acceleration, and body status such as blood presure or heartbeats, so I would like to focus on safty.

Objective

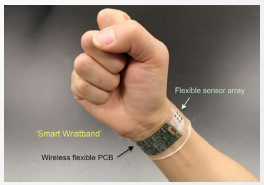
I would like to design a smart ankle brace that could protect and prevent second injury of the Achilles tendon rupture or Tendonitis patients.

Precedents




Inspirations



Audiences




Design Brief By Windy Wen

Design Brief *refined

Design Criteria

User

- People who had joint injured
- Fitness trainers / Coaches
- Athletes
- Interested in fitness and health
- Normal income
- All ages

Functional

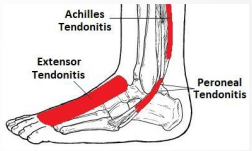
- Give enough protection to joint
- Give instant feedback
- Connect to electronic devices
- Personalized

Susainability

- Durable: long life-cycle
- Easily fixed and recycled
- Sustainable material choice
- Affordable and accessible

Ergonomic

- Could be customized to suit all body types
- Give support at right places
- Material that fit the skin

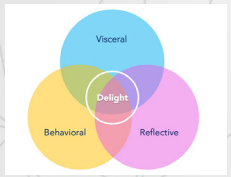


Manifacturing

- 3d printing
- Hand sewing
- Laser cutting
- CNC

Aesthetic

- Minimalism
- Building connections to users



Market

- Sport equipment stores
- Gyms
- Individual customers

Jurisdictional

- Data collecting permission
- Quality standard
- Biology support

Distribution

- Provide warranties and after-sales service
- User instructions

Cost

Material:
- Sustainable fabrics
- Electronic components
- *Metals, small amount plastic

Retail:
- Affordable
- Around 50 to 200

Design Brief By Windy Wen

App Development

Ideation

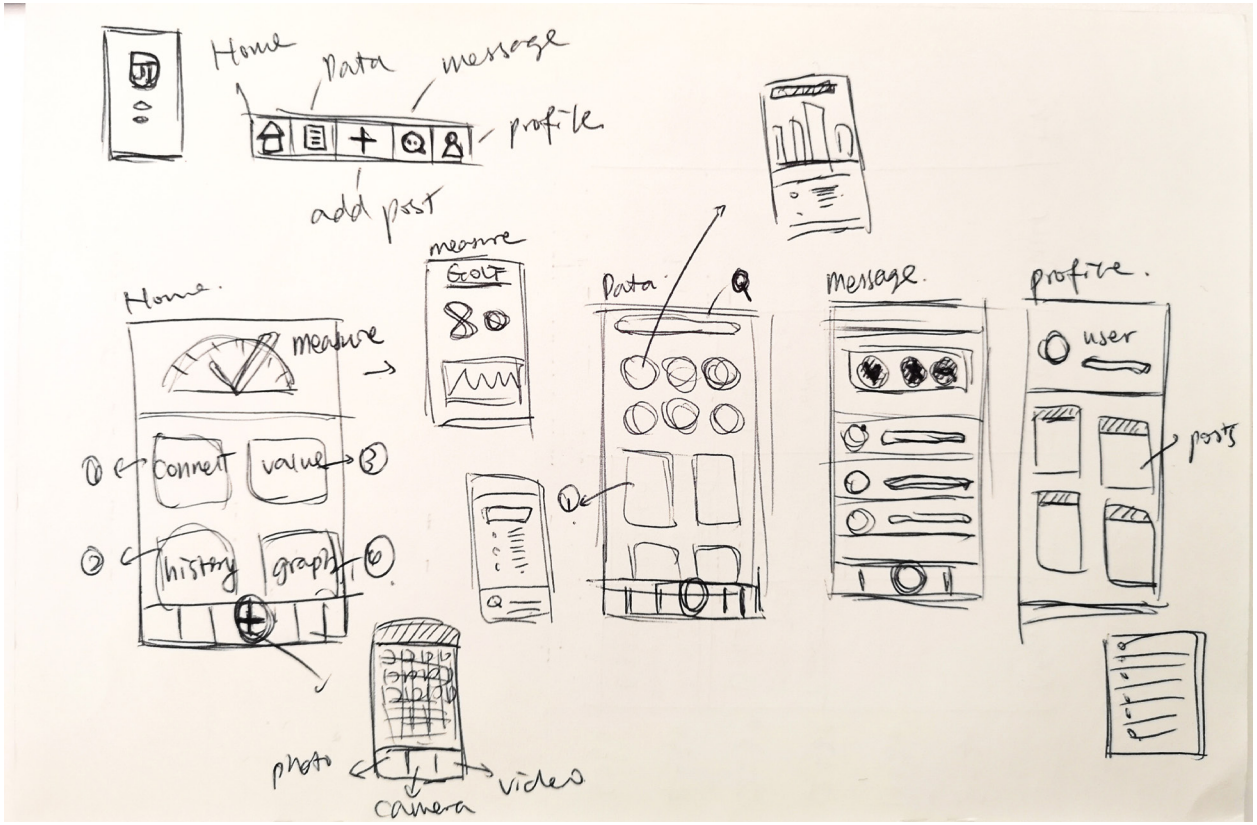
To having an app connected to the product, it allows users to access the databases of each activity and communicate with other patients or doctors to help to fasten their recovery.

Features Including:

- Reading the measure
- Viewing history
- Browsing data
- Connecting doctor
- Writing a post
- Building Community

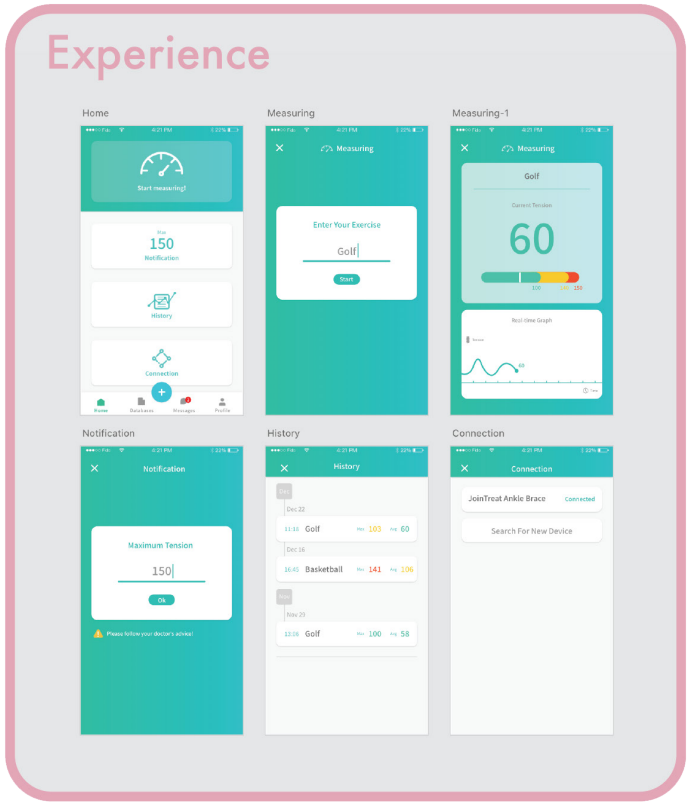
Sections:

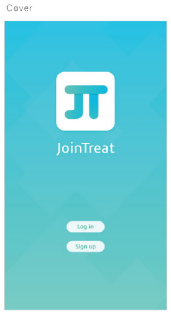
- Home/Measure
- Database
- Message/Community
- Profile
- Add post

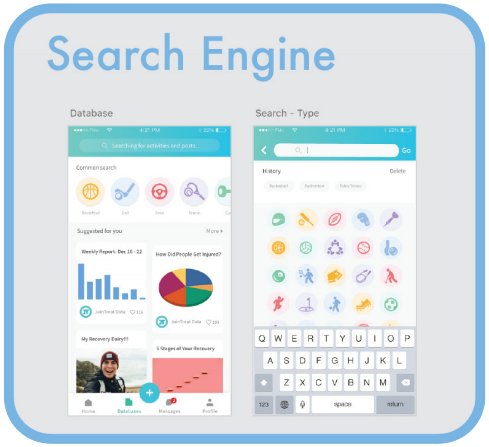


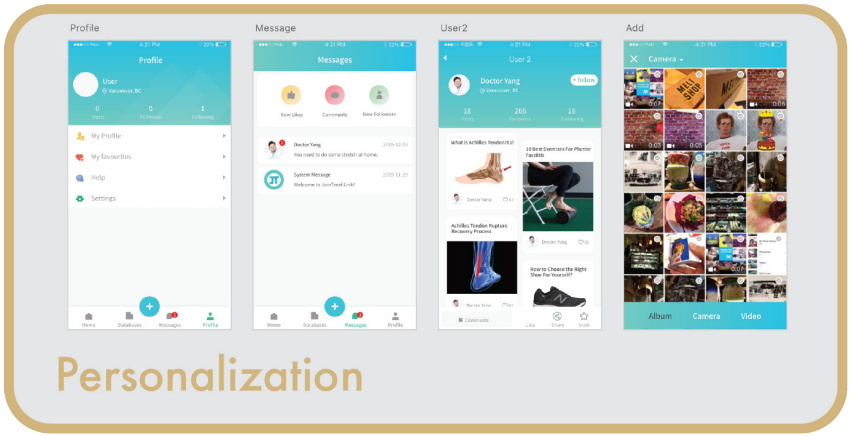
App Development

System Map



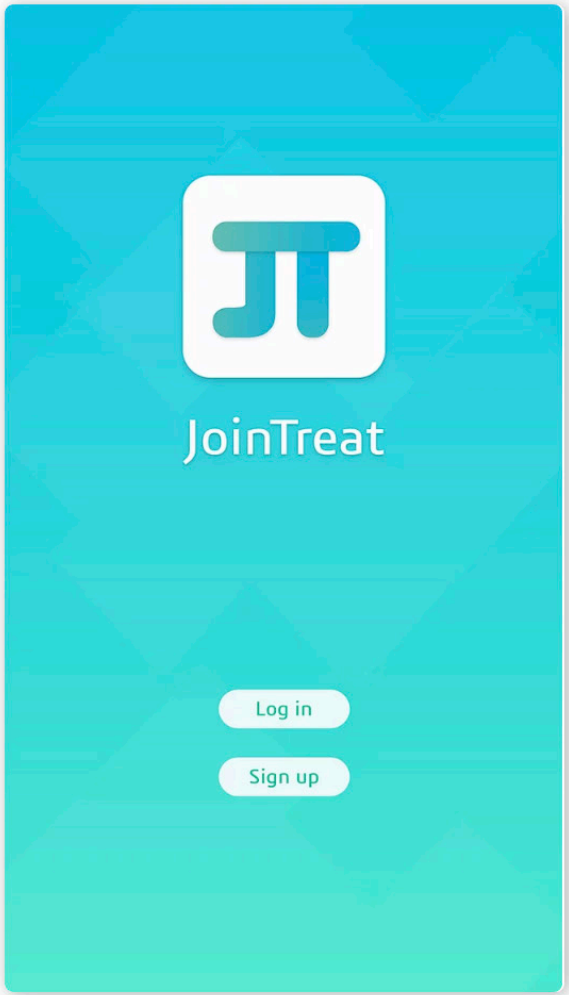




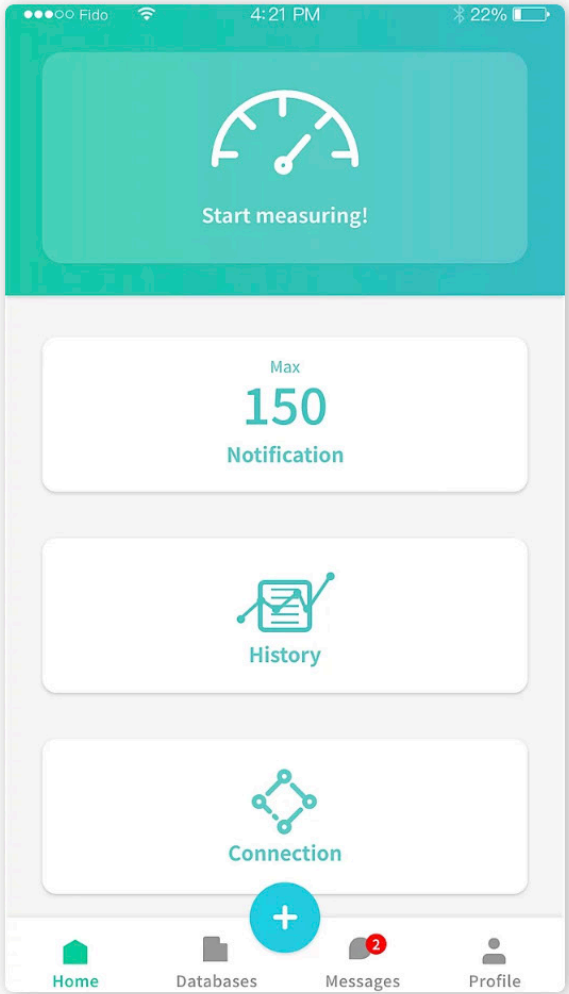


1 Home (Function)

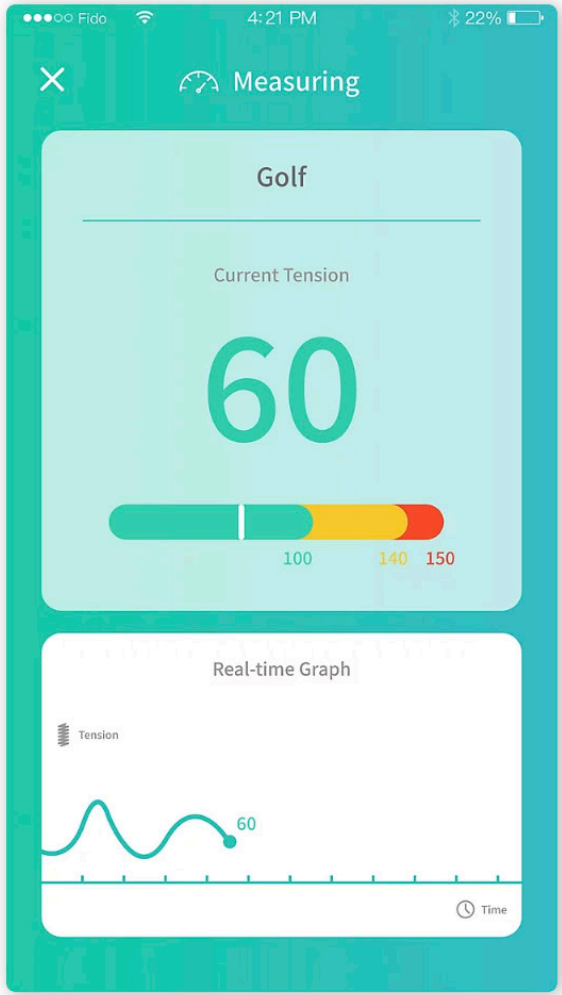
Login Page



Home page: provides easy access

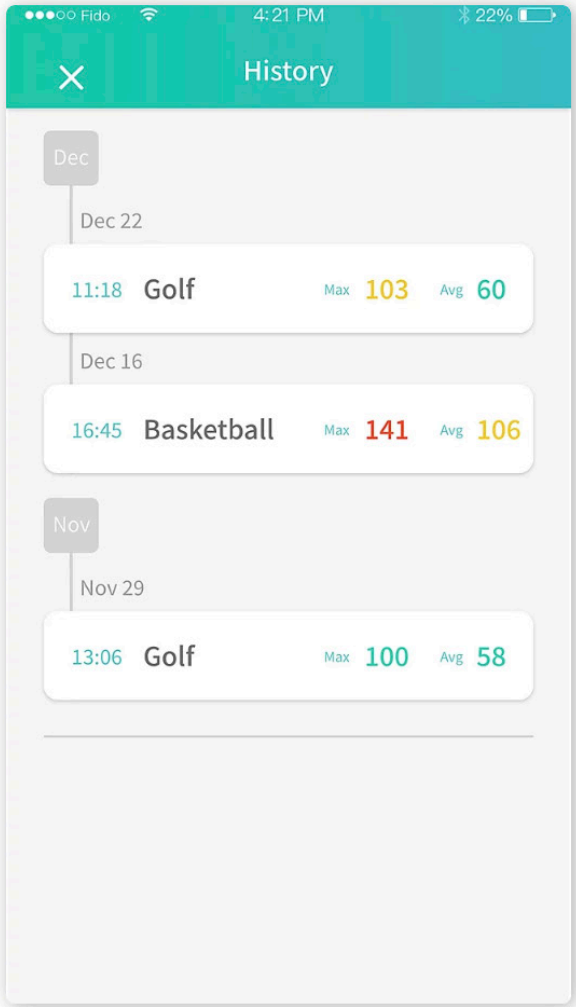


Real-time measuring tension values of the Achilles Tendon with graphic

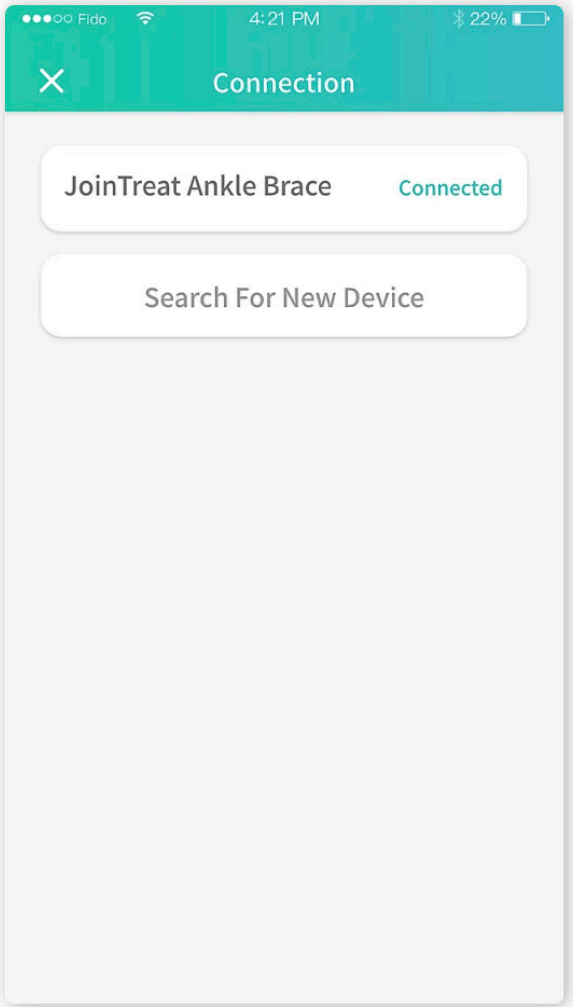


Change max tension notification value to fit different self-conditions

Record measuring histories to track user's recovery progress

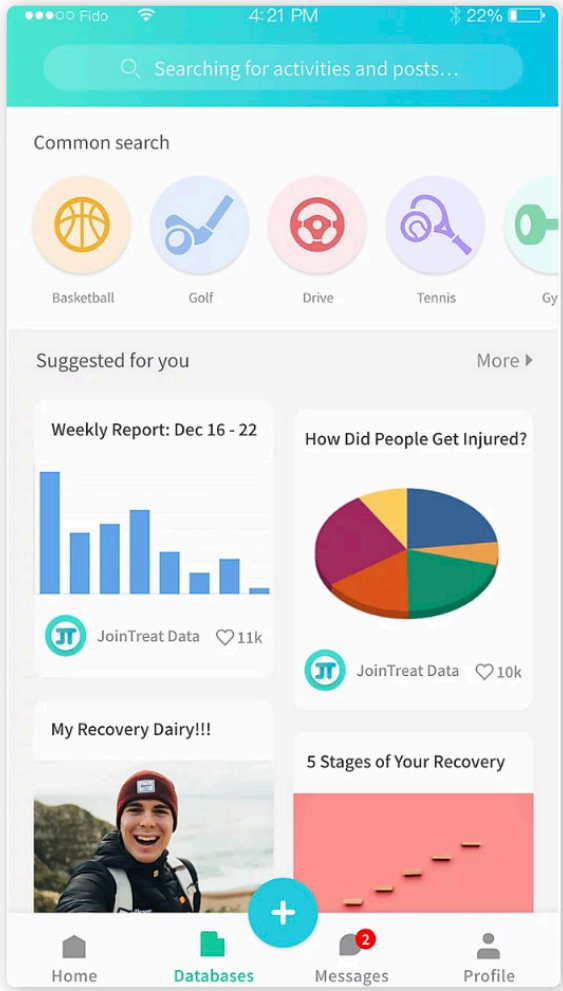


Modify Bluetooth connections

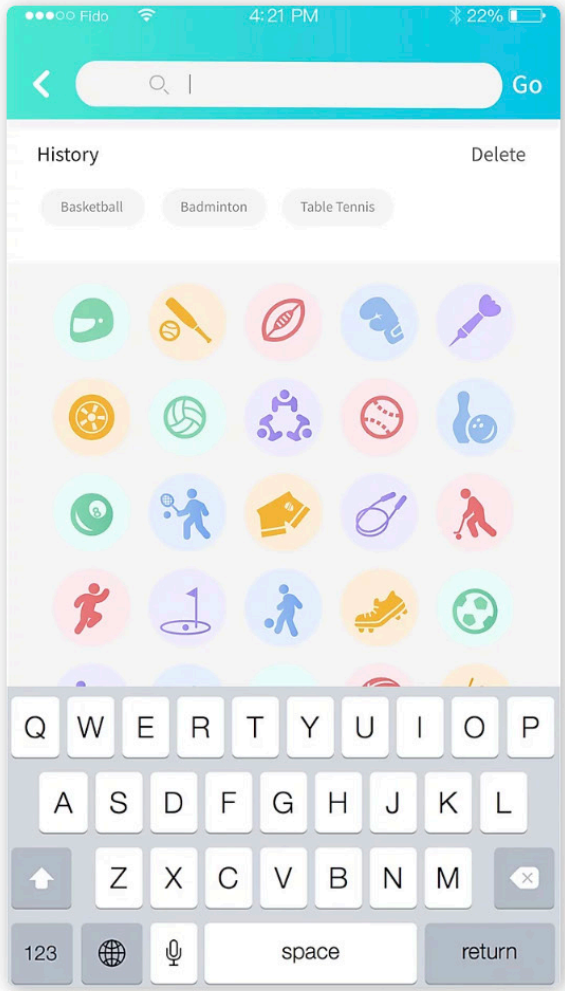


2 Database

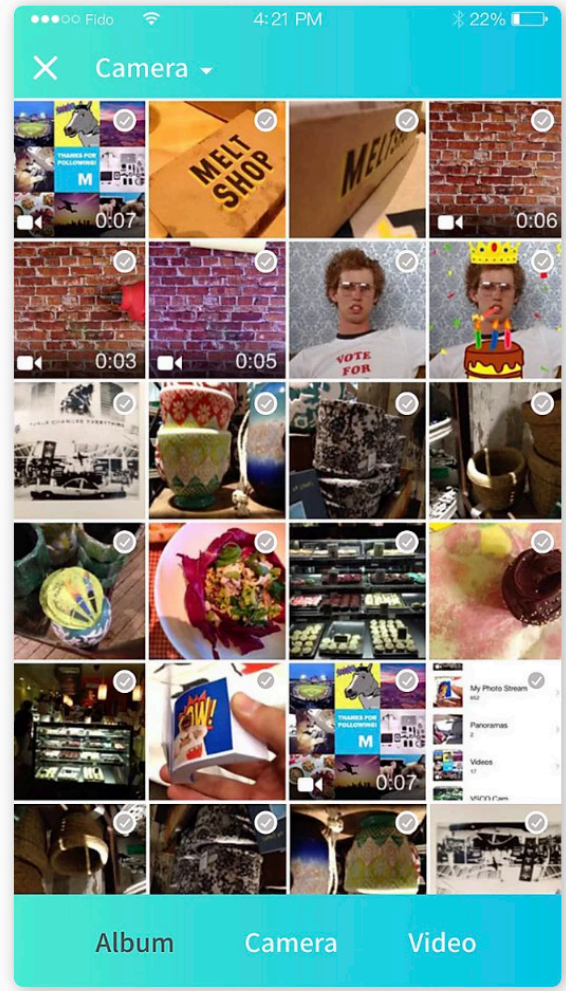
Search for information about different sports and posts from other users



Sport icons for quicker access

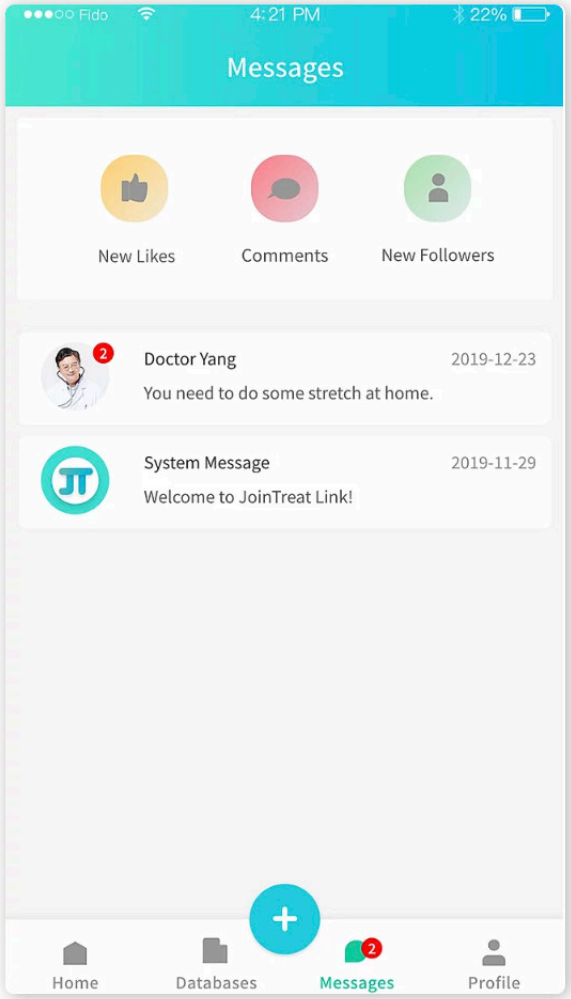


Post and share your own story and experiences with the community



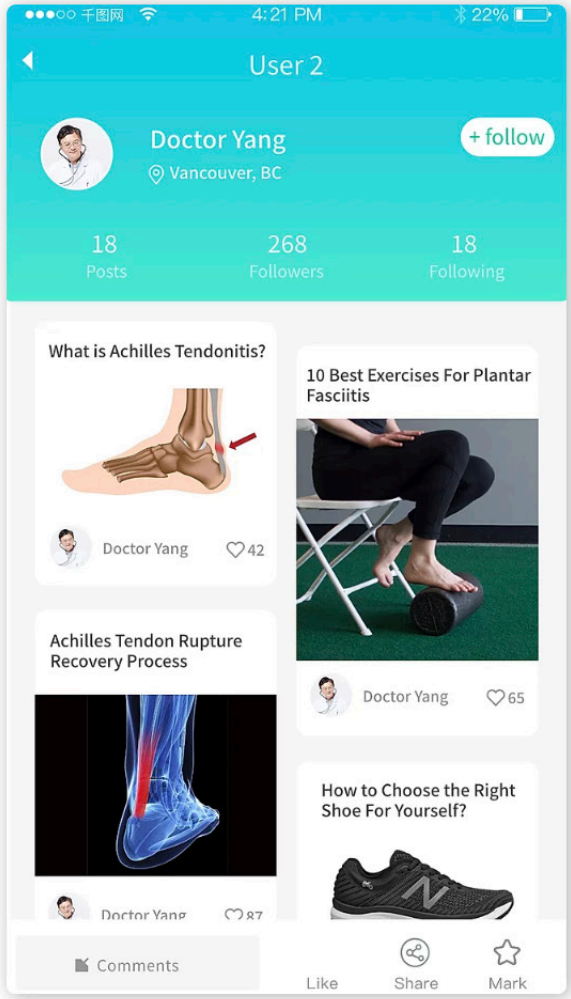
3 Messages

Contact your doctor directly online

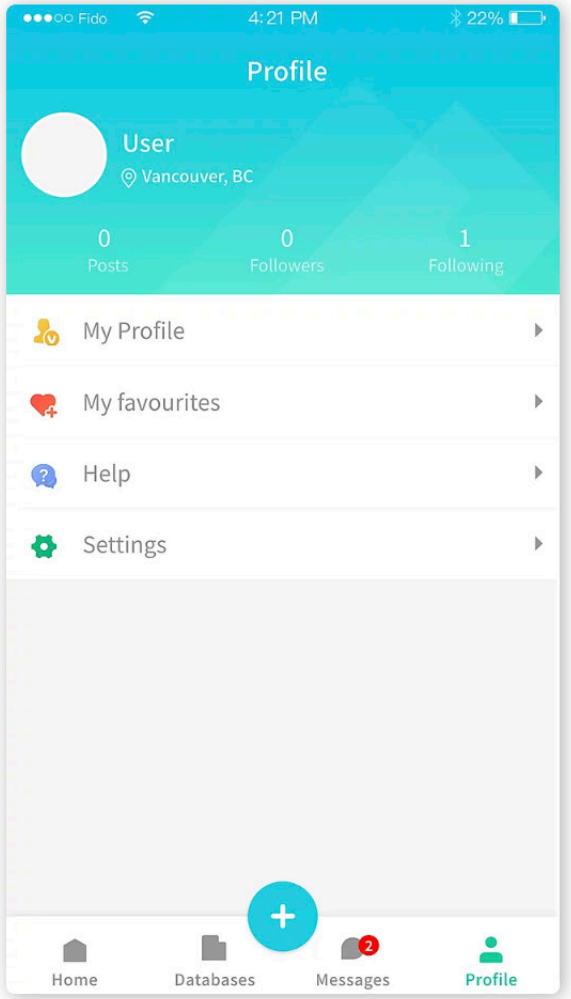


4 Profile

Browsing your doctor's profile



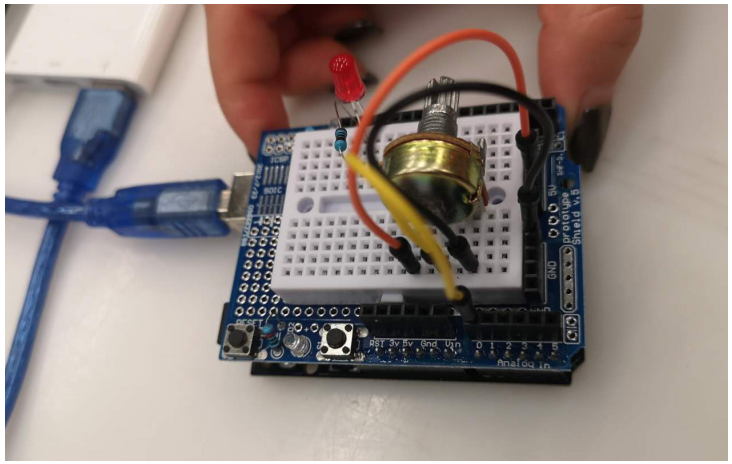
Personal profile and settings

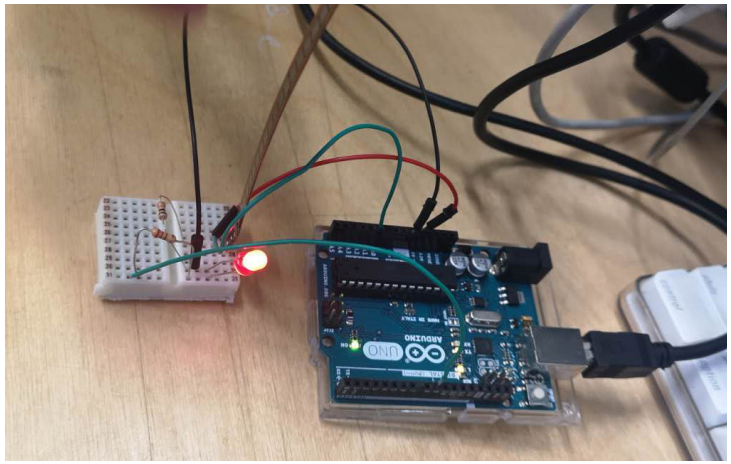


Electronic Exploration

I first explored the circuit with simple components, simplify and simulate the situation, and then adding more things that I need such as sensor and motor, and make change to the Arduino program.

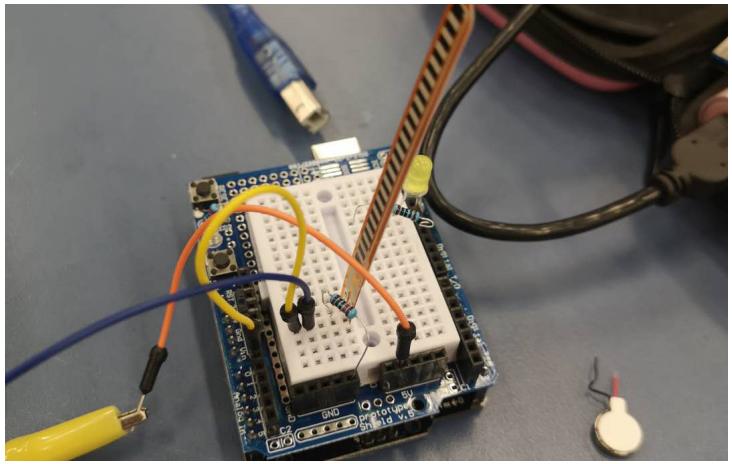
Stage 1

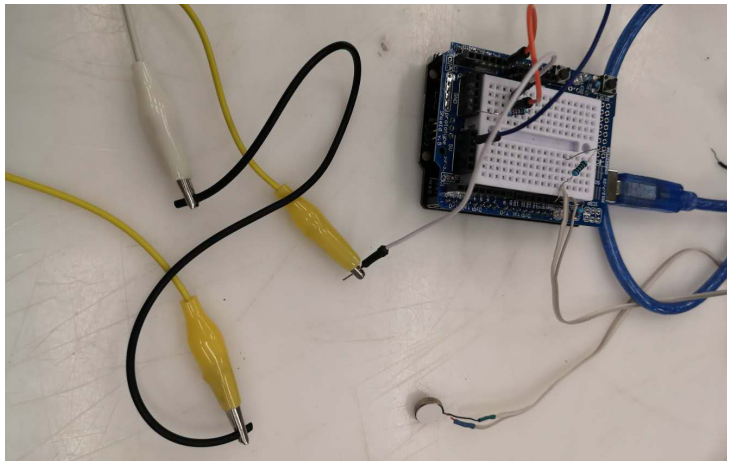




Stage 2

Stage 3

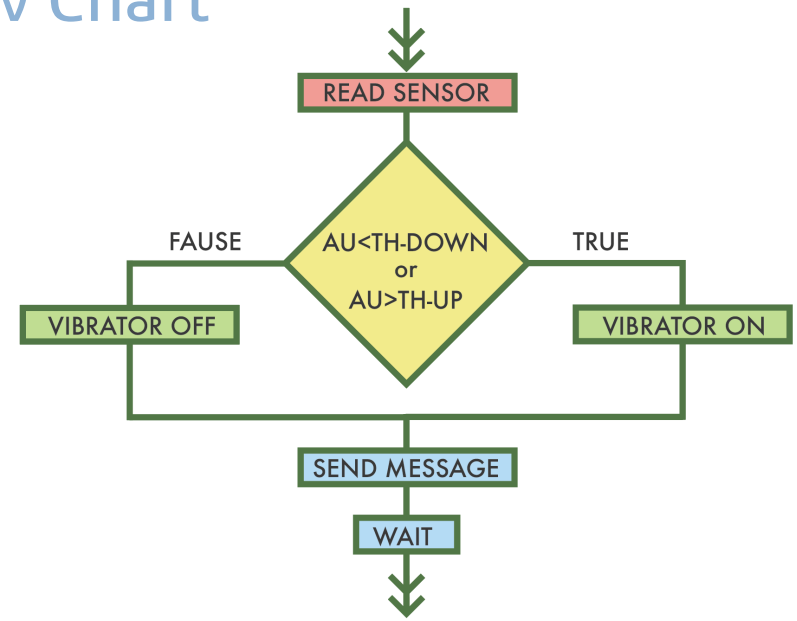




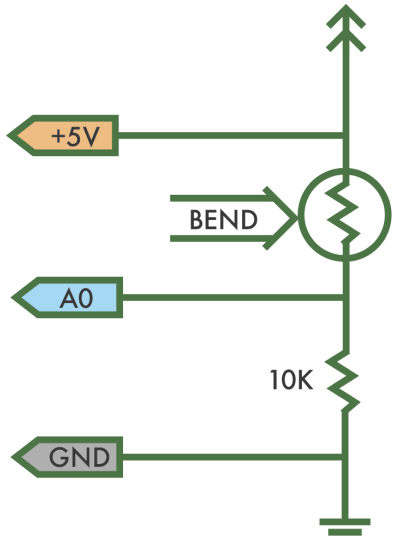
Stage 4

Electronic Exploration

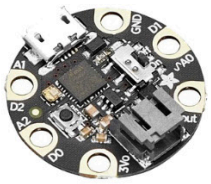
Flow Chart



Circuit Map

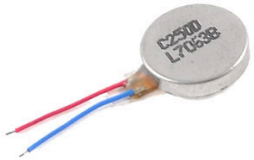


Components

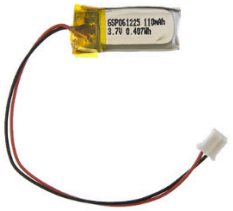


Main Board

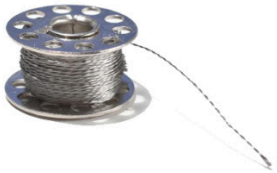
Stretch Sensor



Vibrator



Battery



Conductive Thread

Electronic Exploration

Arduino Code

```
// These constants won't change:
const int analogPin = A0;    // pin that the sensor is attached to
const int motorPin = 2;       // pin that the motor is attached to
const int threshold = 600;   // an arbitrary threshold level that's in the range of the analog input

void setup() {
  // initialize the motor pin as an output:
  pinMode(motorPin, OUTPUT);
  // initialize serial communications:
  Serial.begin(9600);
}

void loop() {
  // read the value of the potentiometer:
  int analogValue = analogRead(analogPin);

  // if the analog value is high enough, turn on the motor:
  if (analogValue < threshold) {
    digitalWrite(motorPin, HIGH);
  } else {
    digitalWrite(motorPin, LOW);
  }

  // print the analog value:
  Serial.println(analogValue);
  delay(1);        // delay in between reads for stability
}
```

I used Adafruit Gemma M0 for my final prototype so I have to down-load the board format which took me a long time to figure out.

Windy Wen

JoinTreat

Smart protective ankle brace embedded with sensors to measure the tension of the Achilles Tendon and collect data.

USERS: Designed for Achilles tendon rupture or Tendonitis patients to help with their recovery and prevent secondary injury.

OBJECTIVES

Support

Maximize ankle stability and keep warm

Smart

Detect tension and give instant feedback

Share

Build up databases for communities

DESIGN CRITERIA

Functional

- Give real-time notifications and feedback for each movement
- Collect data and analyze
- Provide communication platform

Experiential

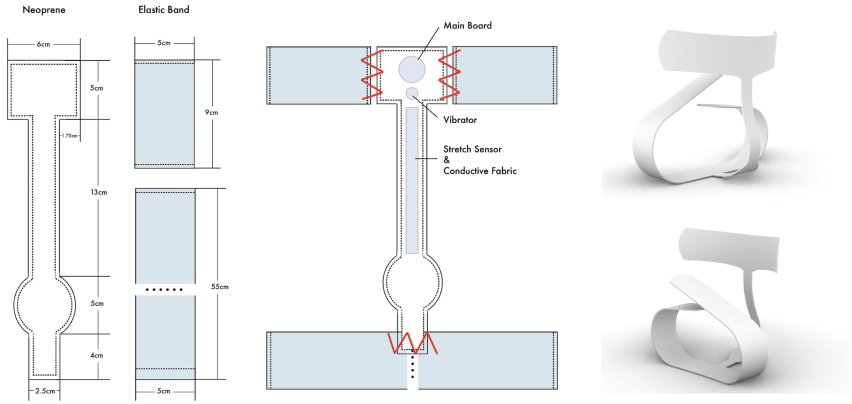
- Make it easier for patients to tract their recovery stages
- Limit motion to prevent injury
- Directly contact with doctors in the App

Emotive

- Let patients feel more secure while doing sports
- Be able to get in touch with other pacients and be connected

1 SUPPORT: Brace design

PATTERN



MATERIALS

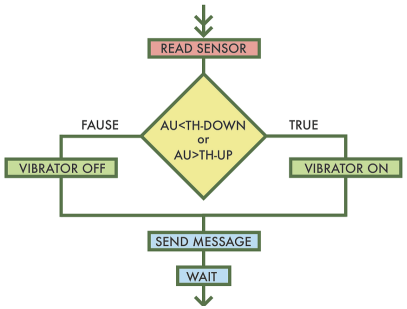
Neoprene | Conductive Fabric | Elastic Band | Velcro

ELECTRONIC COMPONENTS

Main Board | Stretch Sensor | Vibrator | Battery | Conductive Thread

2 SMART: Arduino Mock-up

FLOW CHART

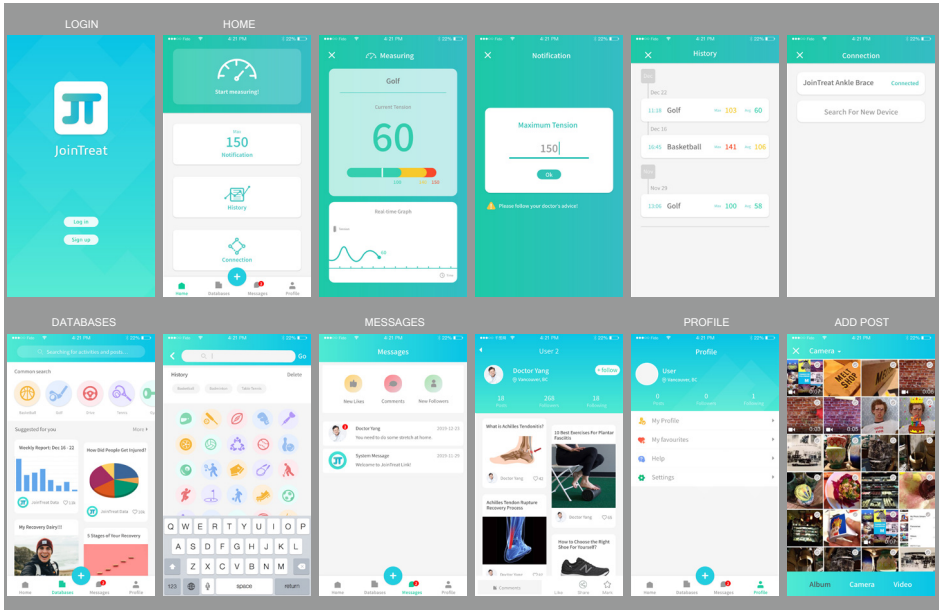


3 SHARE: App design

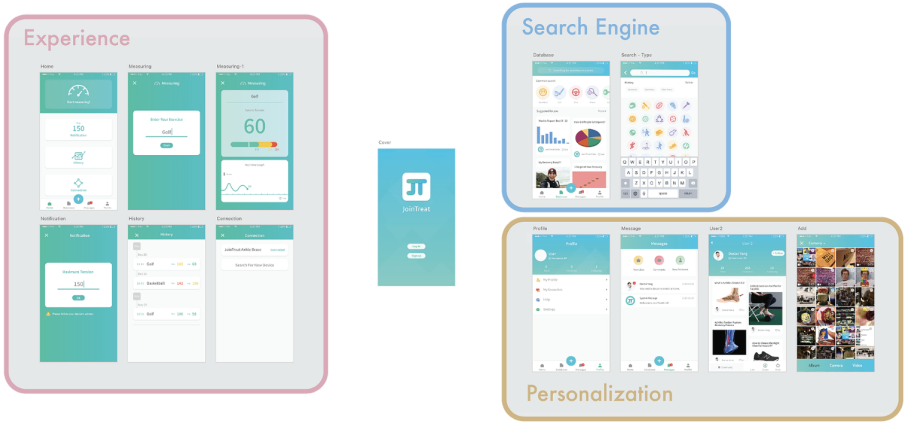
The app allows users to access the databases of each activity and communicate with other patients or doctors to help to fasten their recovery.

- Viewing history
- Browsing data
- Connecting doctor
- Writing a post

APP PAGES



SYSTEM MAP




Scenario 3
AND MORE...

Engagement Summary

JoinTreat

Purpose of Research

To find out if the prototype of the ankle brace is comfortable enough to wear during exercises. Determine the average range of motion of the Achilles Tendon and the tension in normal condition. Then explore different sports to see how the tension has changed.

Testing Intentions

To refine the pattern of the brace in order to make it safe and comfortable for the user to wear, and find the form that is most stable for the Achilles Tendon tension testing and collecting. Also, know the average range of motion to make sure the reading of the electronic component to be more precise.

Key Users

The key users are people who are Achilles Tendon rupture or Achilles Tendonitis patients. Users also include people have regular exercise who likely to have Achilles Tendon injury or elderly people who have difficulties walking.

User Goals

- Have more control of the status of the Achilles Tendon while doing sports, especially high intensity exercises.
- Know the average range of motion and their own limitation of the Achilles Tendon.
- Have access to information and data of specific sports.
- Learn more about each excercise/sport and make changes to exercise plan according to the data.
- Be able to directly contact with other patients and learn from the expirences, or get in touch with the doctor directly for better recovery.

Potential benifits

- Know the mobility of the Achilles Tendon and learn the intensity of different sports.
- Learn more about the Achilles Tendon injury, then more likely to prevent one in the future.

Potential risks

- Participants might feel uncomfortable wearing the ankle brace because of the sizing or improper design.
- Participants might overstretch the Achilles Tendon or hurt during the exercises.

Engagement Summary

JoinTreat

Research Methods

- Interviews (in person)
- Secondary Data
- Photo/Video Recording
- Non-invasive physical measurement

Scenario

The prototype will focus on discovering how the users feel about the product both physically and emotionally.

- Scenario 1: Asking participants to stretch their Achilles Tendons at their best at any location without shoes.

- Scenario 2: Base on scenario 1, read the tension value on the brace while moving to make sure the reading has significant changes between stretch and unstretched conditions.

- Scenario 3: Asking participants to wear the brace for a period of time, approximately 10-30 minutes, and give feedback on the comfort level of the brace.

- Scenario 4: Base on scenario 3, wear the brace while doing sports, and give feedback on the comfort level and support level.

- Scenario 5: Asking about how participants emotionally feel about the brace while wearing it, whether feel protected or discouraged.

Measures

What is the difference in the results between age groups?

Did the user find the brace:
- accessible?
- comfortable?
- discouraging?
- engaging?
- useful?
- necessary?

If the brace had mass-produced would the participants want to buy it?

Result

The research result might be various, even contrary to people since the different body structure of each person. However generally popular opinions will be adopted, and individual opinions will be adjusted slightly according to the situation.

Refinement

- Refine the brace design and pattern to make it more comfortable and ergonomic.

- Adjust the way of connecting the electronic components to make the reading more stable and accurate.

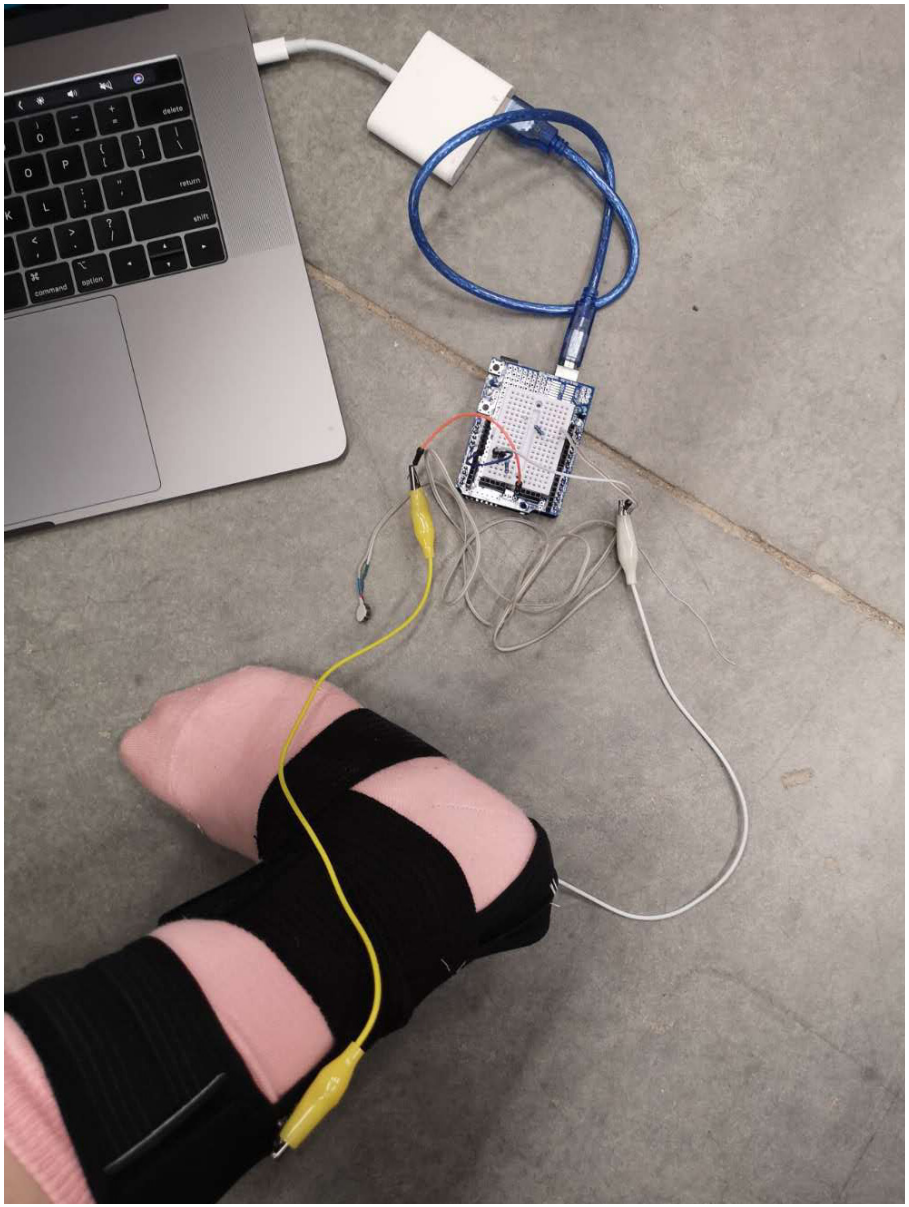
- Adjust the reading values and Arduino coding based on the result.

- Based on the feedback think about how to make the ankle brace more sustainable and emotionally durable.

3rd Prototype

Made this prototype to try out if the electronics are working as I wished.

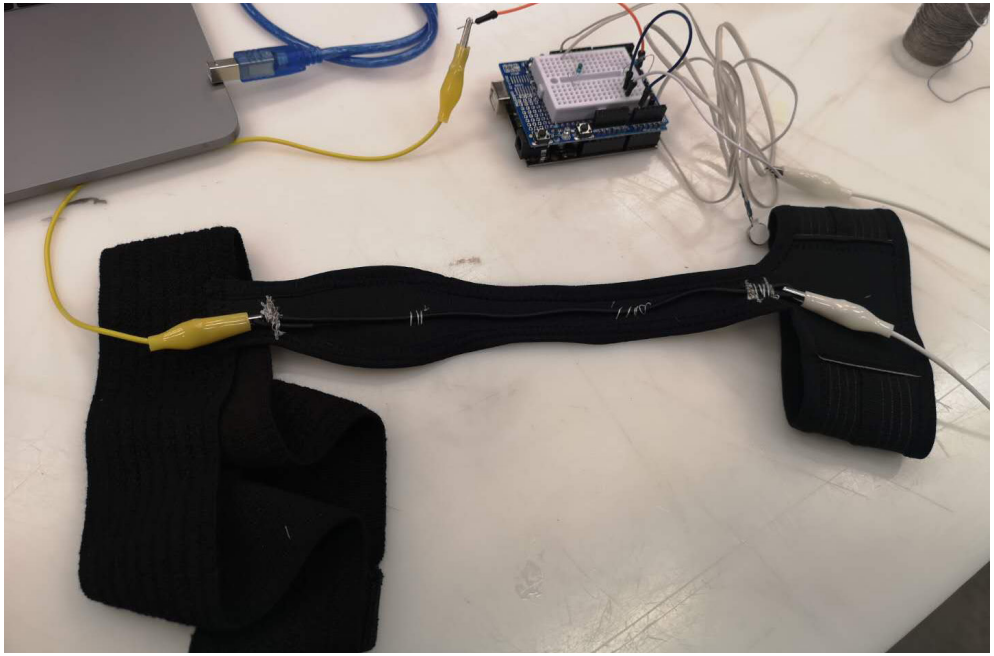
Hand sew two ends of the conductive rubber and use home sewing machine to sew the conductive thread onto the rubber.



It was working very well








User Testing








User Testing






Feedbacks

Cons:

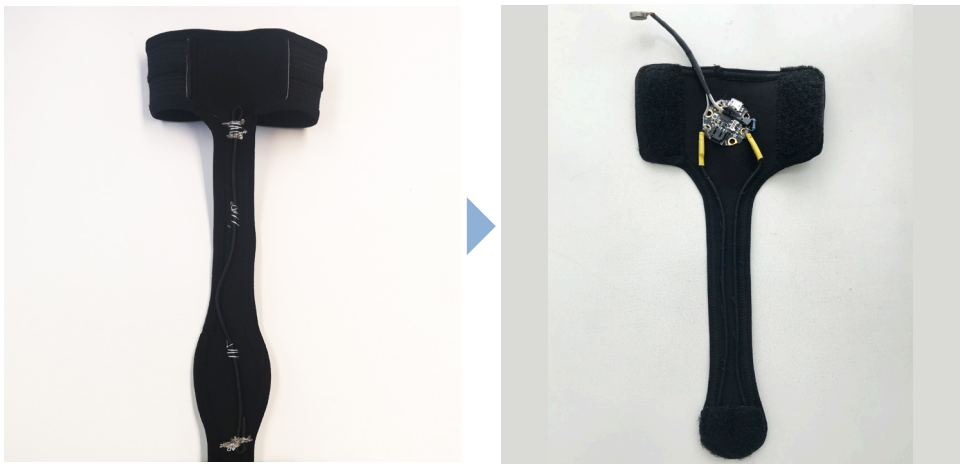
- Sizing: change to adjustable elastic band velcro
- Not washable: separate electronics
- Fitting not stable: make a hole at the heel
- Reading accurate: double the rubber to make the reading more significant
- Sensor: stop at the heel, too thick to step on

Pros:

- rubber band works well to keep the top stable
- fabric is comfortable
- good flexibility

Final Prototype

Replaced the normal elastic band to a special one that the velcro can be stick to the band itself so that the user can adjust the size according to their conditions.

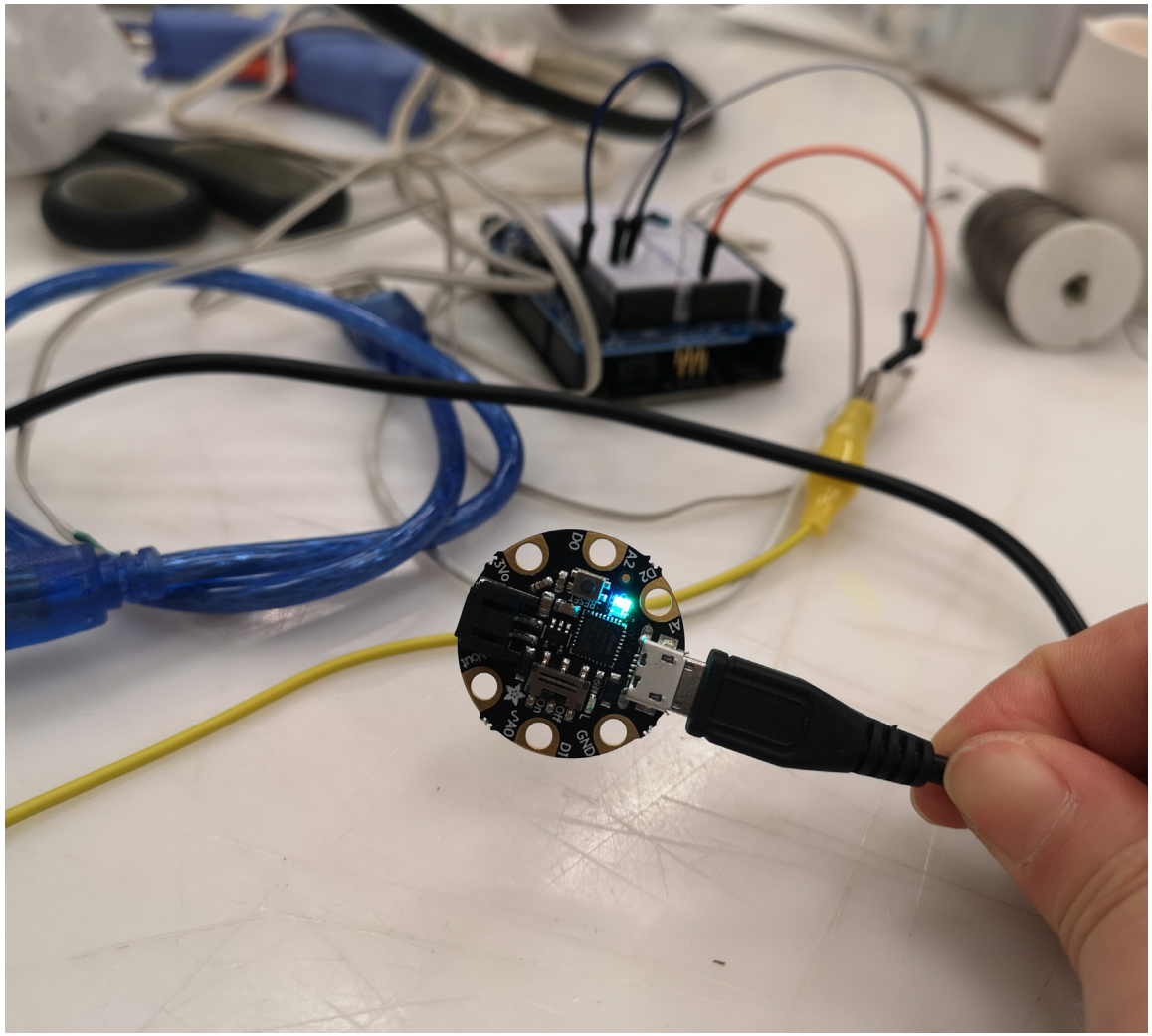


To make the ankle brace washable, I separated the electronic components from the main body to make it more durable and sustainable.

Added a hole to at the heel to make the brace more fitted to the foot ergonomically even bending foot down.

Moved the rubber upwards to the end of the Achilles Tendon to make it comfortable, and doubled the rubber to make the reading more significant.

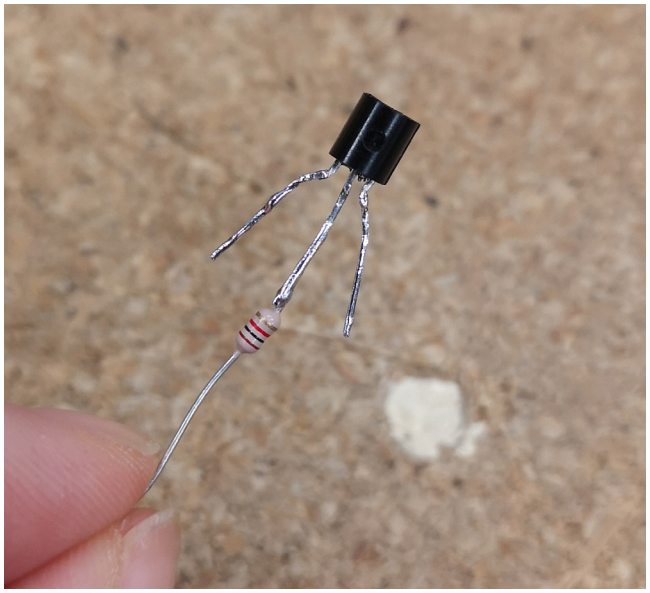
Final - Making



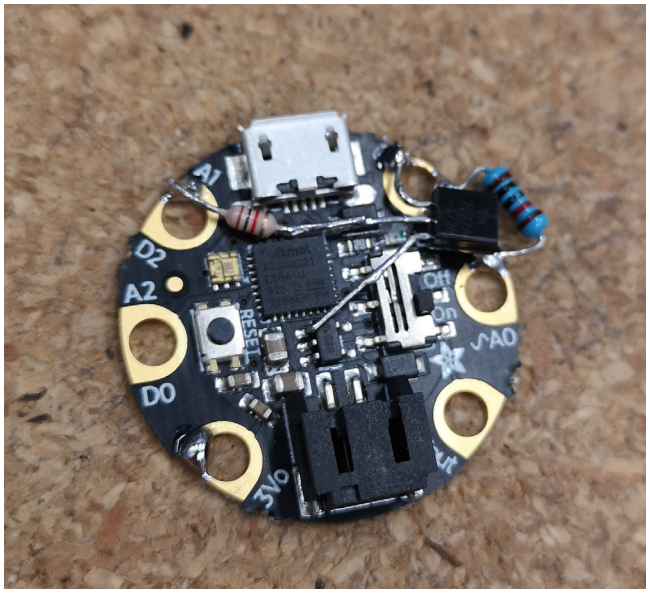
Translating code for Arduino Uno to Adafruit Gemma M0.

During the process, I realized I need to add an extra transistor to make the motor work because the current that the port gives was too low to run the motor.

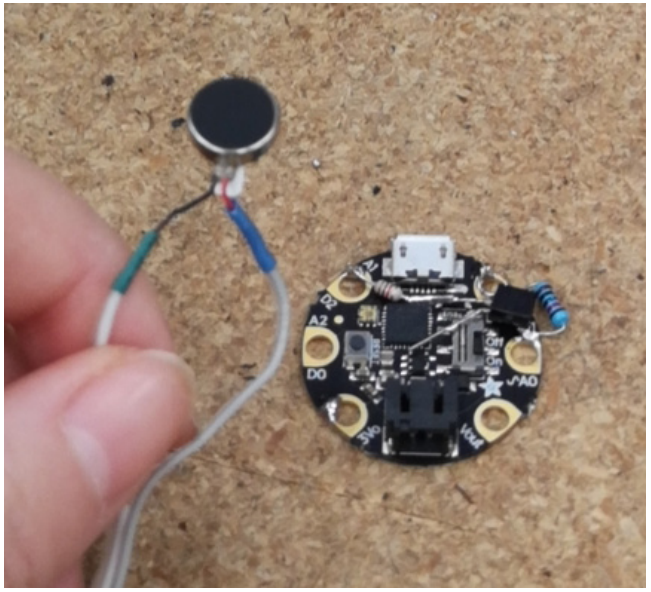
Solder the 10k resistor between port A0 and ground.



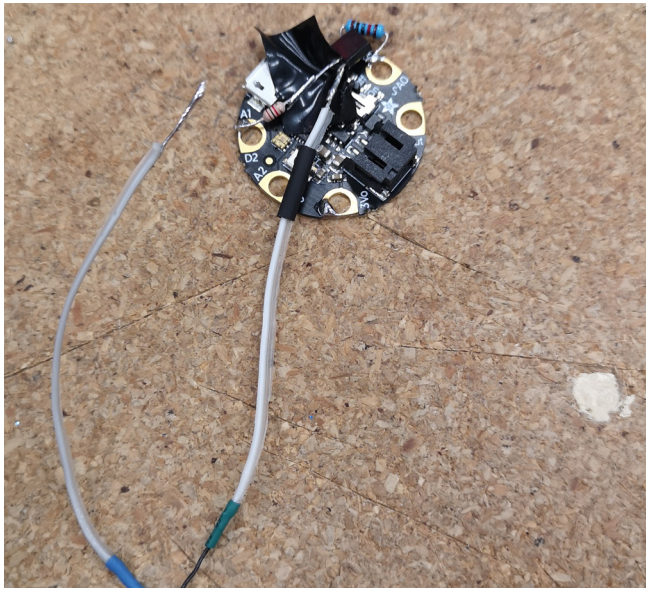
Solder the 1k resistor to the transistor.



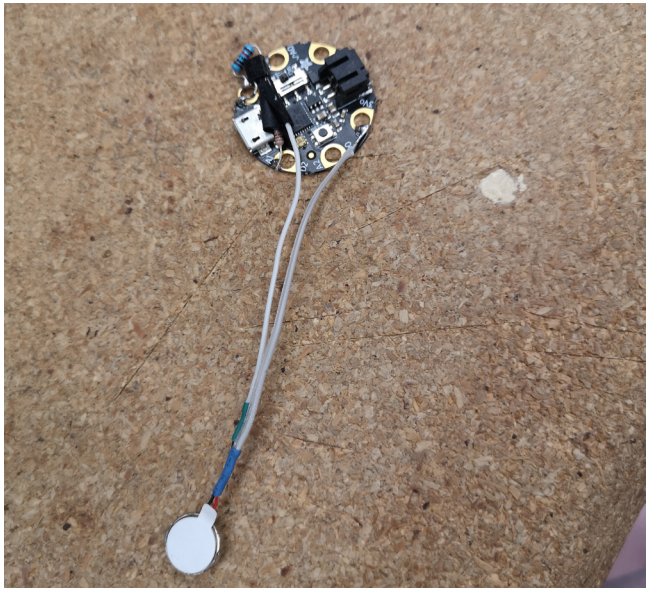
Solder the transistor one foot to the ground.



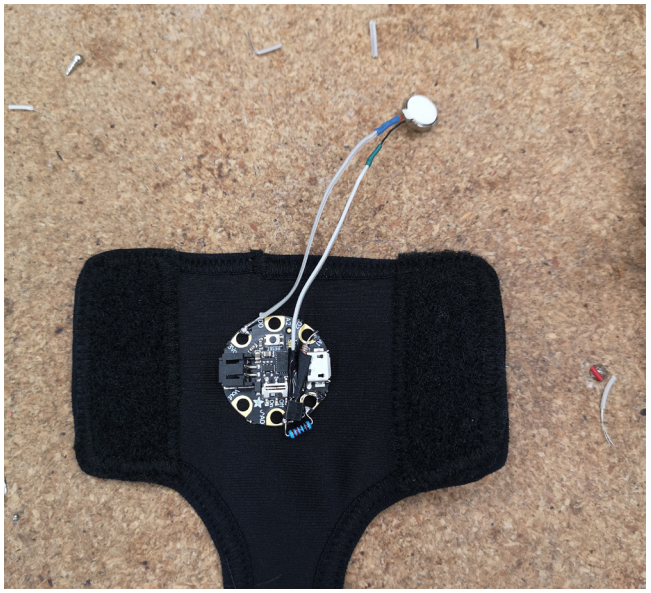
Extend the wires of the motor, use heat-shrink tube for reinforcement.



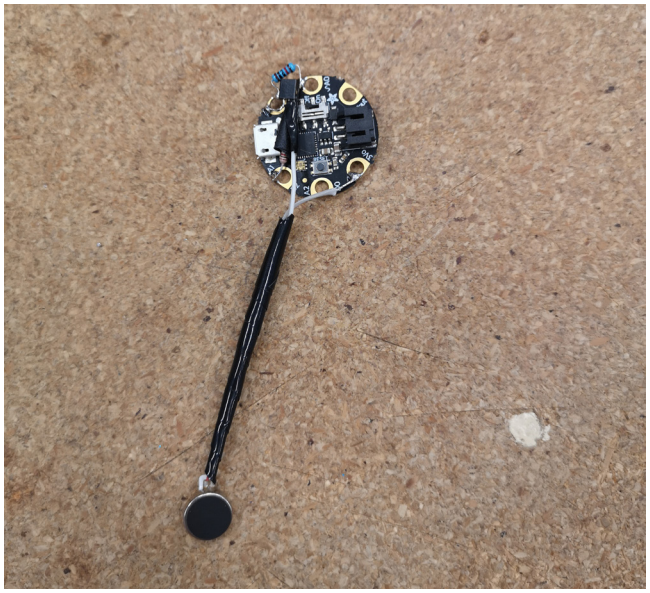
Solder the ground foot to the transistor put tape underneath to prevent wires touching.



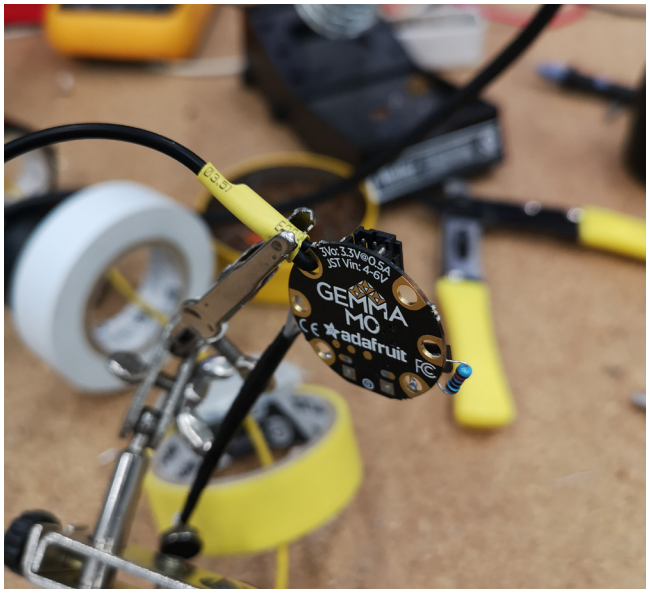
Solder the red foot to 3V.



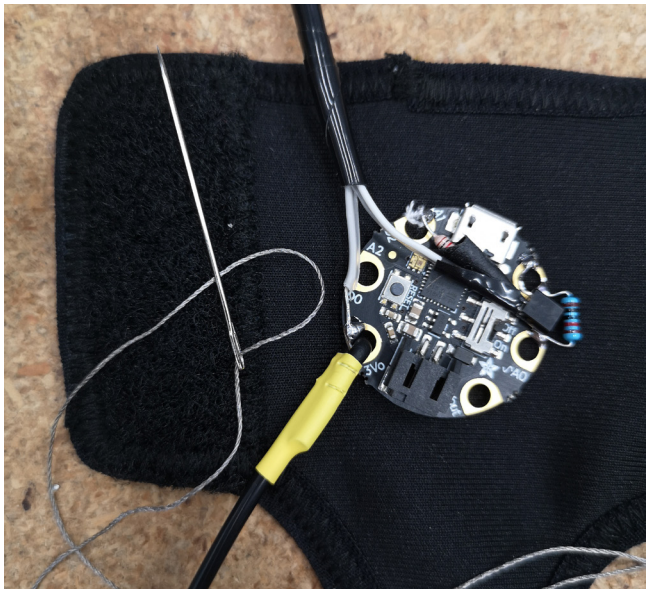
Decide the placement and angle of the board.



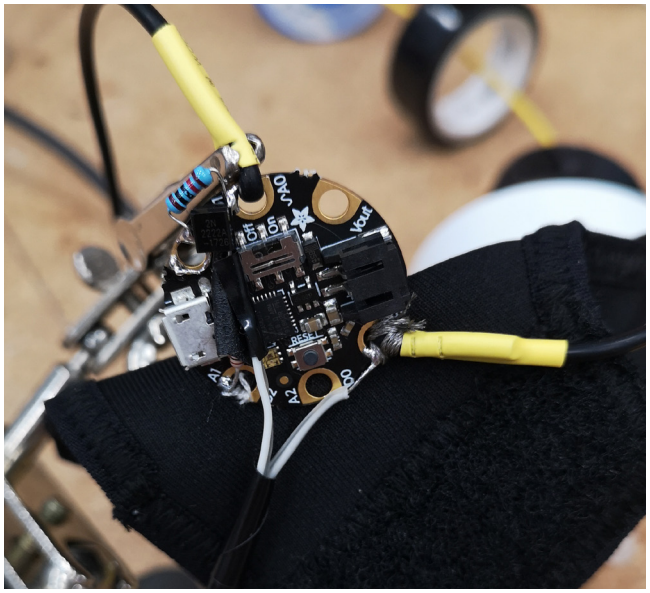
Use tape to group two wires. (Should've use heat-shrinks but too late)



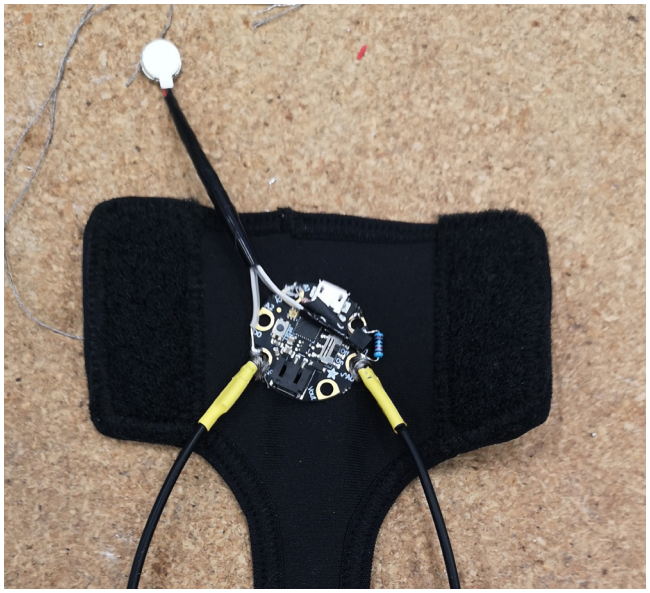
Connect the conductive rubber to port A0 and 3V.



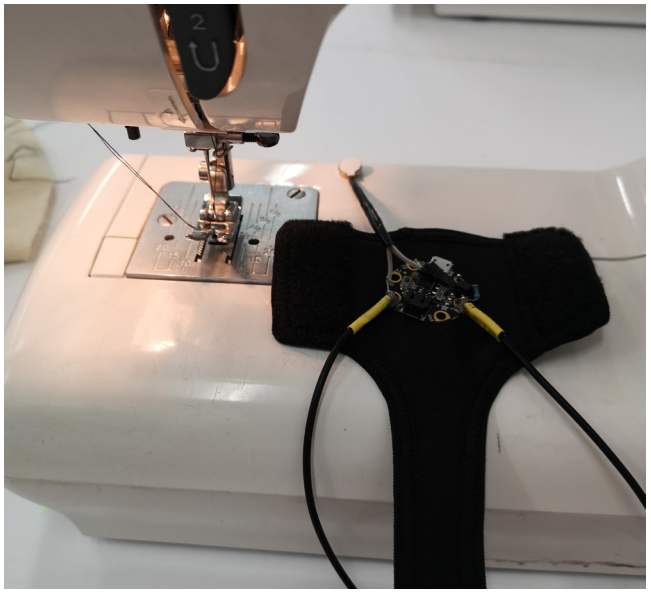
Hand sew the conductive thread between the port and the rubber.



Connect the other end.



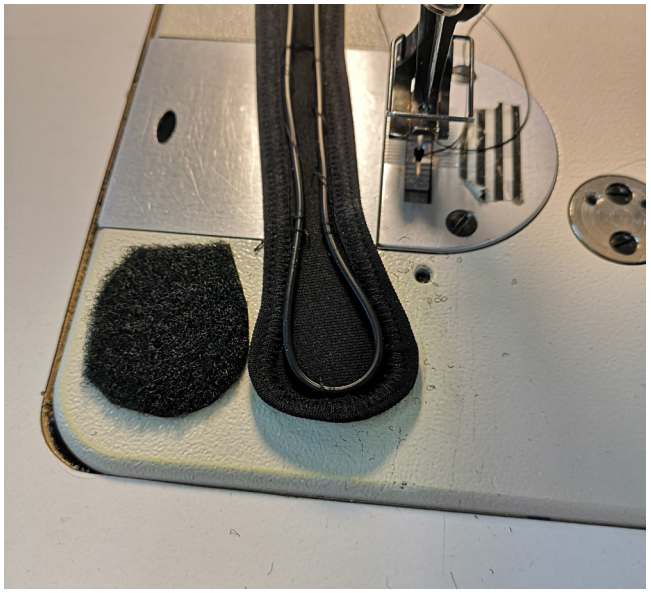
Electronic parts done!



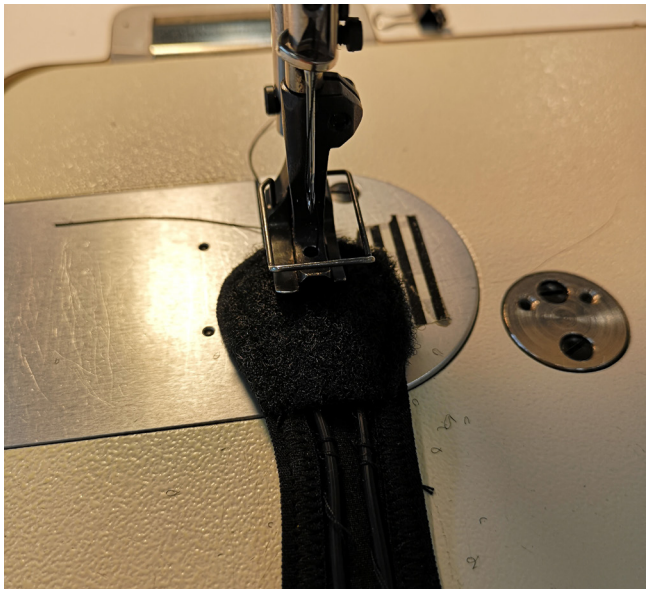
Use home sewing machine to keep the rubber two ends in place.

Hand sew loose lines to keep the rubber in place.

The loose lines prevent the rubber from touching togther but save the elasity.



Using industrial sewing machine to sew the velcro on top of the rubber.



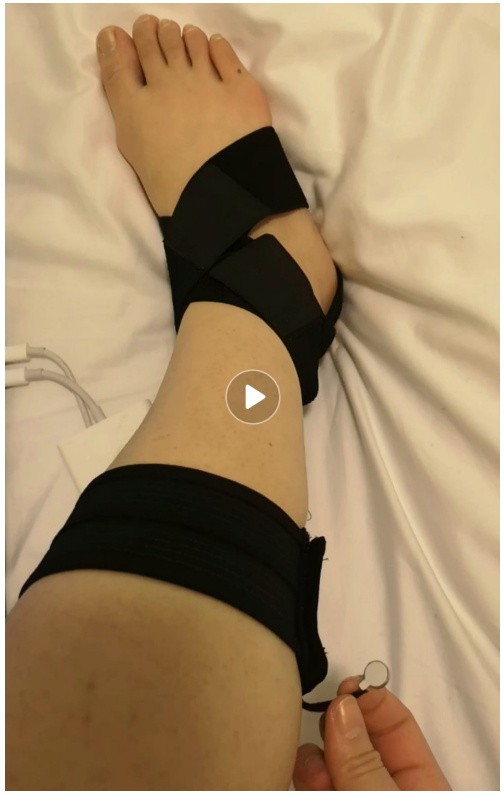
Sew lines at the middle to prevent rubbers touching each other.

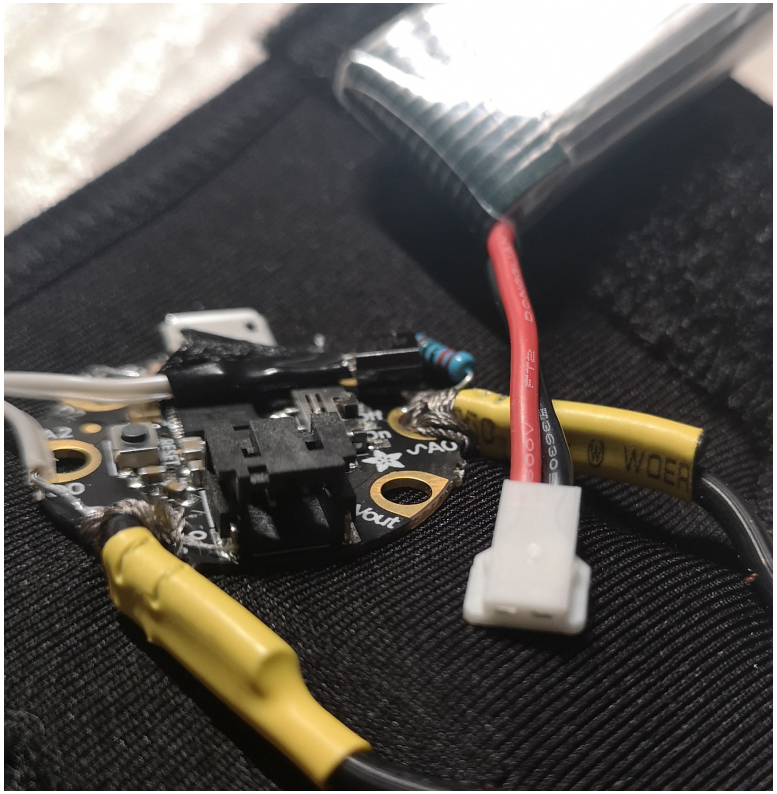
Done!

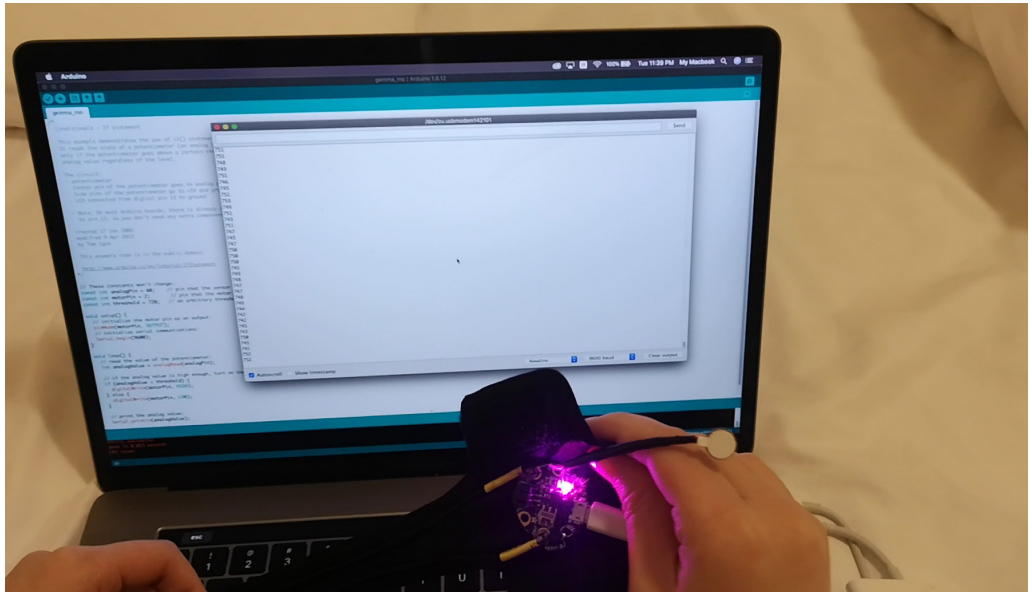
Final - Testing

I measured the reading, changed the value of the threshold to a proper number since I doubled the length of the rubber, and uploaded it to the board.
It worked well and turned out very successful!

*The threshold was designed to be able to change as the recovery progressed or according to the user's self-condition.



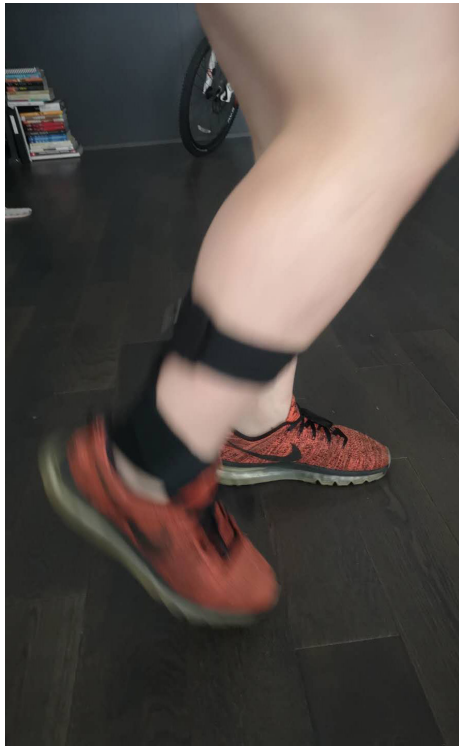




Screenshots from the testing video

Unfortunately, the port of the battery I bought does not match the port of the board so I am not able to test it without a wire connected to my computer, but I will buy a proper one after the Coronavirus to test it out for sure.

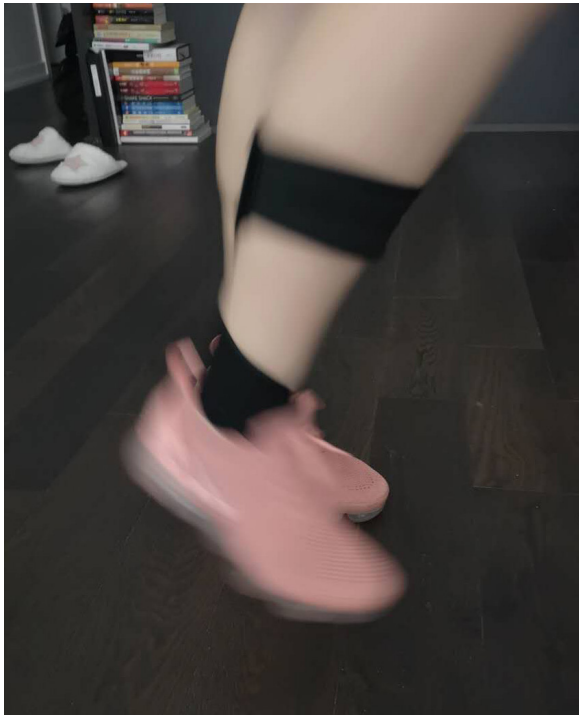
Final - Testing




I tested the brace with running shoes and applied a small range of motion. The brace held in its place pretty well.








Final - Details








Reflection

Sustainability

JoinTreat can not only adjust the tightness of the elastic band but also the value of tension to set personal reminders to suit different users. The brace is designed for post-injury care but it can also be used for recovered people and normal people while doing exercises, to keep the stability and prevent injury to a certain extend. One brace can work for all families.

The electronics are separated from the body of the brace so it is easier for repair and does not have to change the whole brace. Even without the electronics, the brace itself can still work as a normal brace. Neoprene is not the most eco-friendly material out there, but it is still the most material for braces because of its warmth, strength, elasticity, thickness, and durability. Fortunately, it is easily recyclable, and there are Green Neoprene coming out which using natural rubber, reducing 80% of the CO2, and solution-dyed linings that save 86% of the water and reduce 96% of CO2 in the manufacturing process.

Improvement

I can only find one kind of neoprene in all fabric stores so there are two different colors, black and white, on each side. I would like them to be all black since the white does not mean anything special as a symbol or reminder. Also, the neoprene was a little bit too thick, and I think it could be 20% thinner. I did not finish the cover layer of the electronics, did not punch holes on the neoprene, and missing a small bag for the brace because currently we do not have access to the soft shop and the zig-zag machine which needs to be operated during technician hours.

Reflection

Further Development

For further development JoinTreat could use the material called Neogreene, the company GreenSmart has introduced. It abandoned the chloroprene chemistry of neoprene entirely. It is a neoprene-like material made with water-based chemistry allowing for less toxic adhesives to be used. It also uses 25% less electricity and 25% less petroleum to produce. The material of the brace can also be changed to knitted fabric so it would be more fitted to human body.

The electronic components are also can be changed to more advanced ones. The board should be wireless, rechargeable, and waterproof. The conductive thread can also be changed to conductive fabric and threads, with conductive ink on top for reinforcement, and apply plastisol ink for protection. There is an essay doing research on washable conductive materials, so it is possible to make it entirely washable with current technology.

It would be great if it can be used in professional medical service and cooperate with doctors as recovery equipment to contribute to the patient. It can also be used among athletes to test and improve their performance. If adding a gravity sensor at the bottom, it could be used by elderly people to ensure their security, monitor whether if they fall down or injured.

References

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https://www.zhihu.com/question/19658136
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