DEGREE PROJECT

Voet : A foot comfort solution for pregnant women

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Volume : 1 of 1

STUDENT : NUTI VATSAL MODY

PROGRAMME : Bachelor of Design (B. Des)

GUIDE : MOHAMMED NAIM SHAIKH

2020

INDUSTRIAL DESIGN FACULTY (PRODUCT DESIGN)

राष्ट्रीय डिज़ाइन संस्थान
NATIONAL INSTITUTE OF DESIGN

The Evaluation Jury recommends NUTI VATSAL MODY for the

Degree of the National Institute of Design

IN INDUSTRIAL DESIGN (PRODUCT DESIGN)

Herewith, for the project titled "Voet : A foot comfort solution for pregnant women"

on fulfilling the further requirements by*

_____ _____ _____

Chairman

Members :

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

Jury Grade : _____

*Subsequent remarks regarding fulfilling the requirements :

This Project has been completed in _____ weeks.

Activity Chairperson, Education _____

Preface

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Prologue

Acknowledgment

The Nudge

Design Education & NID Ahmedabad

Product Design at NID Ahmedabad

Graduation Project at NID Ahmedabad

Methodology and Timeline

Acknowledgment

The work presented in this document would not have been possible single-handedly if not for the steady, cohesive efforts and guidance of My Faculty Mh. Naim Shaikh. I want to extend my gratitude to him for putting faith in me and my project, suggesting a way ahead when I couldn't see it for myself, and guiding me during the entire tenure of the project. Every discussion with you added an enhancing layer to my project and helped me complete it smoothly.

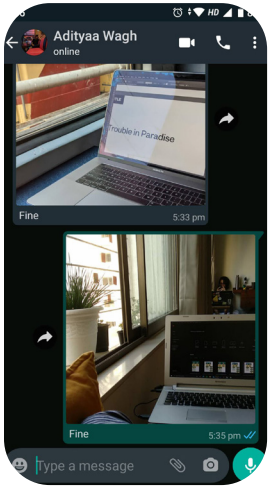
I would like to extend my gratitude to Dr Parag Parikh, Dr Rupal Shah, and Dr Shashikanta Prushty for take time out of their busy schedules and providing their invaluable inputs throughout this project. I want to also acknowledge Mr Pareshbhai Soni and Mr Bhautik Dudhwala who were ready to deliver the 3D printed mock-ups on time.

To Dhyani Parekh, Adityaa Wagh, Anushree Joshi, Ajay Sapkale, and the Mission2021 team, I want to say thank you - for their constant support and for making sure that no man was left behind. I will be forever grateful to have had the opportunity to learn and grow with you during and after my years at NID. I want to thank my Product design family, Jayneel Shah, Subhrajit Ghosal and Aditya Vora for constantly sharing their experiences and learnings during my education.

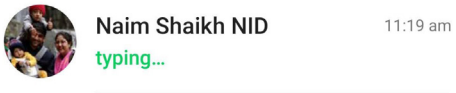
To Dr Mukul Choksi and Dr Bhavna Raja, for making sure I was in the right mindset and motivated to produce my best work. I want to thank Karan Shah- with whom, I could cross my barriers with electronics and personal constraints, and build the circuit in no time; Thank you for helping me get over my creative block. Thank you Parnavi, Swayam, Suhani, Tiruja - for giving me much-needed coffee breaks when I was stressed the most.

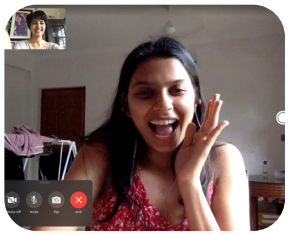


















My mom and dad made sure I had all the resources and a comfortable environment to produce sufficient work during a pandemic situation. Aayushi Mody, my sister, who made sure I follow my schedule and consider all the aspects of the design process as I move forward.

I convey my sincere gratitude to NID, for providing me with a nourishing and resourceful environment, campus life, and faculties that helped me flourish into the individual that I am today.

The Nudge

I was first introduced to the topic of designing specific footwear for a group of users when I started with my internship at Ducere Technologies Pvt. Ltd., Hyderabad. The company was founded in 2011 with their first product- interactive haptic footwear - for the user group of blind people. Due to the Covid related crisis, I was unable to continue my internship after 2 months of joining. Then I handed over my work done there to my superior and got back in a conversation with my college guide.

Afterwhich at home, I started searching for a brief for my graduation project. Due to covid, the on-field research sources were limited but not unfeasible. I started contacting relatives, friends, who all belong to different professions and age groups. During this, I was able to see a pattern forming which was pushing me to work with pregnant ladies around me.

A major conflict here personally was - whether I want to look at physiological issues faced by them and focus on making a tangible product or Do I want to look at Postpartum Depression and take up a route that may or may not turn into a research-driven project.

As a design student, I have noticed a part of me that was always ready to dive into research. This was my chance to step outside the comfort zone and pick up there pieces of a puzzle that were staring right back into me.

All three proceedings brought me to one single thought. “You have to try this while you are in college!” and I decided to look into physiological issues faced by pregnant females around me. Eventually, I was lucky enough to connect the findings from my earlier internship to my (then) current research. and that is how I landed myself with a project of designing a footwear accessory eventually clubbed with a footwear product.

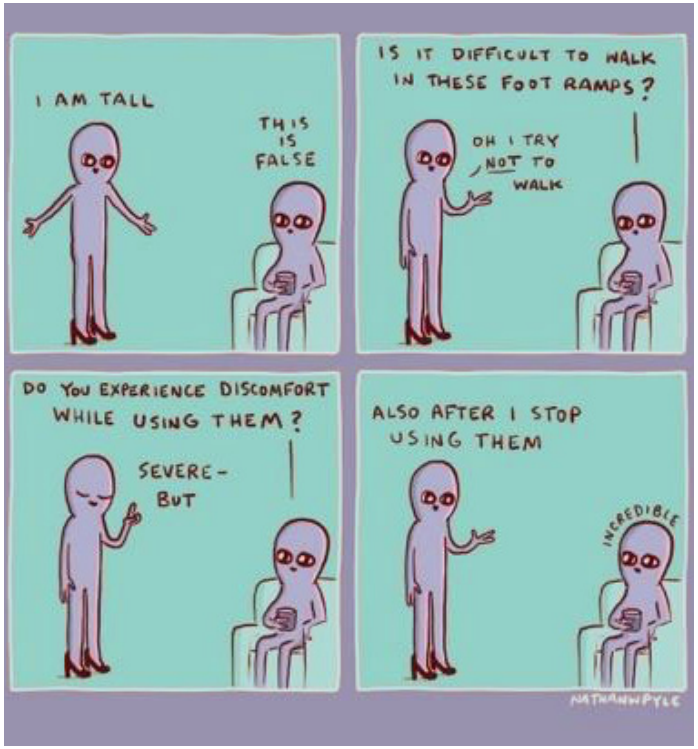

I AM TALL
THIS IS FALSE
IS IT DIFFICULT TO WALK IN THESE FOOT RAMPS?
OH I TRY NOT TO WALK
DO YOU EXPERIENCE DISCOMFORT WHILE USING THEM?
SEVERE - BUT
ALSO AFTER I STOP USING THEM
INCREDIBLE
NATHANWPYLE

Diagram 1.1

Design Education &
NID Ahmedabad

राष्ट्रीय डीज़ाइन संस्थान

In 1955 Pupul Jayaker, the noted writer on Indian craft traditions and the founder of the Indian Hand-looms and Handicrafts Export Council (HHEC) met the renowned American designer Charles Eames at the Museum of Modern Art in New York. The Museum had organized a unique exhibition titled The Textiles and Ornamental Arts of India. This would be the beginning of a lifelong dialogue between these two eminent individuals.

The 1950s were a decade of rapid industrialization in India and clearly, the need for such an institute grew stronger. In 1957 the Government of India requested the Ford Foundation to invite Charles and Ray Eames to visit India. Charles and Ray Eames travelled to all parts of the country, meeting and talking to writers, craftspeople, architects, scientists, industrialists, educators and philosophers. They took hundreds of photographs of their travels.

On April 7, 1958, the Eameses presented the India Report to the Government of India. The Eames Report defined the underlying spirit that would lead to the founding of



Image 1.1



NID and the beginning of design education in India. The Report recommended a problem-solving design consciousness that linked learning with experience and suggested that the designer could be a bridge between tradition and modernity. The Report called upon future designers to re-examine the alternatives of growth available to the country at that time. The preliminary report was that of a creative genius and philosopher who had delved deep to discover and pinpoint the crises in the field of the form, function, and way of life. The detailed notes that followed it spelt out the technological hardware necessary to build the workshops that formed the integral structure of the institute and provided facilities for training research and service in the field of design, in its widest sense. The National Institute of Design was born. . . .

Since its genesis, the National Institute of Design has been the front-runner for higher design education in India, with currently 6 institutes in different parts of the country, offering education in varied fields of design on undergraduate, post-graduate and doctorate levels. It is an autonomous institution under the aegis of the Ministry of Commerce and Industry, Government of India. NID has been declared ‘Institution of National Importance by the Act of Parliament, by virtue of the National Institute of Design Act 2014. It is also recognized by the Department of Scientific and Industrial Research, Government of India as a Scientific and Industrial Research Organization.

Product Design at **NID Ahmedabad**

The product design programme at NID inculcates user-centric approach and processes. The courses are developed in order to align with the perennial ideology of NID's teachings, that is 'Learning By Doing'. The design practices lay emphasis on a designer's social, ecological and ethical responsibilities. Responsibility and concern towards the social, physical and ecological environments is emphasized in the process of developing innovative ideas.

The product design programme assimilates inputs in diverse domains such as human factors, cognitive ergonomics, form studies, studio skills, advance cad, research methodology, design management, materials & manufacturing processes and social sciences. Emphasis is on process centric approach which shapes a student's education through participation and teamwork. The semester ends with a jury, where a student is expected to defend their projects done over the course of the semester, in front of a highly experienced panel comprising of internal and external members.

Design projects from the core of a product designer's education, with gradual increase in level of complexity and cover broad areas that product designers are likely to encounter in their professional careers.



Image 1.2

Graduation Project at
NID Ahmedabad

The end of the students' academic tenure at NID is marked by the culmination of a substantial investigation in the field of design on a topic that is closely allied to their discipline of study. It is through the graduation project and subsequent documentation of the same that this investigation takes place. This is the final academic project for the student.

A jury comprising faculty members evaluates the students' performance in the graduation project, after which, students are awarded NID's professional education programme final graduation.

The graduation project is an opportunity for students to demonstrate their expertise and must be done with academic rigour incorporating systematic inquiry and informed design decisions. The graduation project should reflect the thought leadership manifested through creativity and innovation. The project should lead to new knowledge creation and should align with the broader objectives of the institute.

There should be structure and order in the representation of the project carried out by the student. The project must display systemic inquiry while exposing different informed design decisions undertaken by the student throughout the project. The project marks the conclusion of the student's academic life at NID, and hence must be carried out with a responsibility to spread knowledge and insights.



Image 1.3

Foundation year, Group A, 2016



Image 1.4

Semester 3, PDUG16, 2018



Image 1.5

Semester 7, Systems Design, 2019

Graduation Project

Methodology and Timeline



Brief Introduction

Secondary Research

- Competitor analysis
- Market study
- Technological advancements
- Material Study

- Mapping, Scenarios generation
- Opportunities,
- Defining Problem Setting,
- Outline for Context

Primary Research

- User interviews
- Experts interviews
- User persona
- Synthesis

Interviewed Dr. Rupal Shah

Interviewed Dr. Parag Parikh

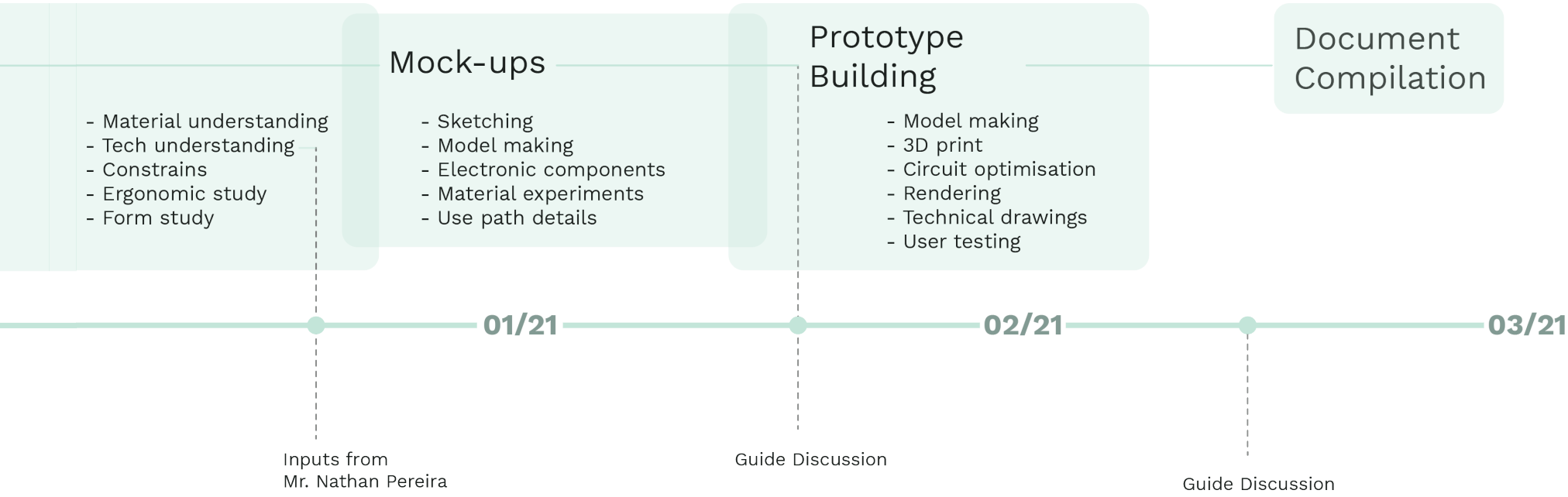
Interviewed Mr. Sashikanta Prusty

11/20

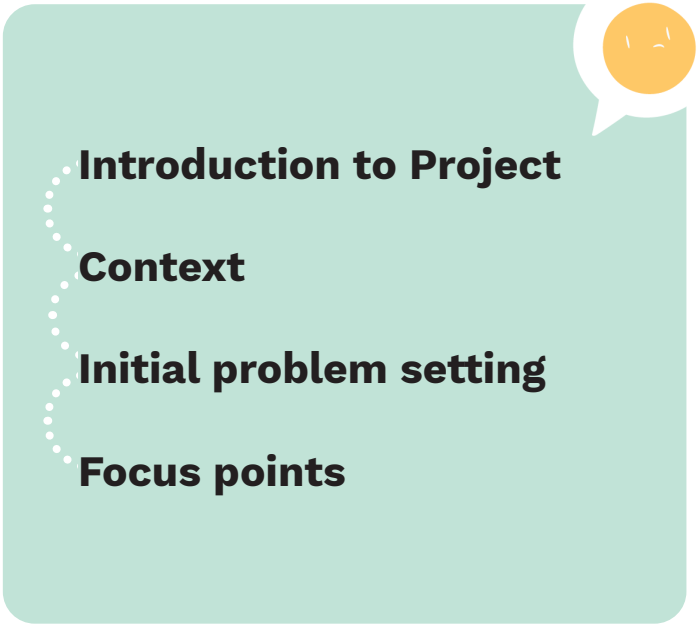
Guide Discussion

Ideation

12/20


- Material understanding
- Tech understanding
- Constrains
- Ergonomic study
- Form study
Mock-ups
- Sketching
- Model making
- Electronic components
- Material experiments
- Use path details
Prototype Building
- Model making
- 3D print
- Circuit optimisation
- Rendering
- Technical drawings
- User testing
Document Compilation
01/21
02/21
03/21
Inputs from Mr. Nathan Pereira
Guide Discussion
Guide Discussion

Proposition





Introduction to Project

Every foot is unique, providing a solution to each foot is a pervasive form of wellness and alignment recovery. Personalized insole at a go (add-on to existing footwear), with accuracy and effectiveness, opens up many solutions for foot health and improvements, establishing improved stance and gait, natural pronation (stability, neutral) balanced walking, running, training, supporting, foot shapes, that results in better performances.

Pronation, gait change, imbalanced walking are a few issues faced by pregnant ladies that are often neglected.

Every foot's feature points are unique and theoretically act as a barbed fluke for the standard parameter building process, resulting in interesting challenges to address in space of insole customization.

Context

According to Marybeth Crane, DPM, FACFAS, a Dallas Area foot and ankle surgeon, women often experience foot pain during pregnancy because of increased weight, foot instability and swelling. “In the last five years, I’ve seen an increase in pregnant women with foot pain because more women than ever before are active, even running marathons, during their pregnancies,” Dr Crane says.
Every foot is unique, providing a solution to each foot is a pervasive form of wellness and alignment recovery.

This opens a scope for product development in the area of lifestyle with thorough research study, interviews, experts’ insights, value hypothesis, opportunity identification.

Initial problem setting

Design a product-based solution to ease down foot pain during pregnancy by researching Technologies and innovative materials. The purpose of the project is to understand users behaviour in everyday experiences that indicate effective adoption of new technologies, that aim to supplant existing solutions. The goal is to develop tangible product solutions to form a product to support and improve foot shape, suggest improvements for their gait and balance while retaining the familiarity of the user environment.

Currently, the offered solutions to these problems are light exercises, stretching, physiotherapy, orthotic solutions, correction of footwear, increasing blood flow, hydration, increased blood circulation, balancing diet, massaging with olive oil, wearing cotton socks, or compression stocking. These are simpler products that can be effective in some cases. Upon creating a matrix, a window to introduce a product in the area of technology and familiarity opens up.

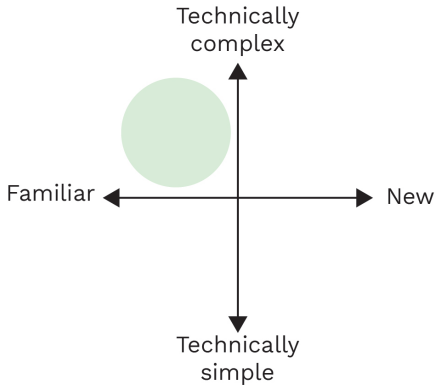


Diagram 2.1

Focus points

- Additional comfort to foot (or the entire leg) muscles
- Support and improvement of foot shape
- Relaxation of muscles
- May/May not be an improvement of existing product
- A familiar solution for easy adaptation by the user-group
- Users should not seek external help to use the product.

3. Research



Pregnancy and Foot-pain
- Causes of foot change
- Plantar foot pressure
- Current market solutions

Phases of Gait cycle
- Biomechanical analysis of Gait during pregnancy
- Pronation/Supination + Gait

Interview with,
- Pregnant females
- Gynecologist
  (Dr Rupal N. Shah
  OB/Gynecologist at Rupal hospital)

Pronation and the effects

Market Solutions

Importance of Arch in foot

Interview with,
- Podiatrist
  (Sashikanta Prusty
  Centre manager at India
  ottobock, Hyderabad)
- Orthopedic
  (Dr Parag Parikh
  MD Orthopedic
  at parag hospital, Surat)

Secondary Data Analysis

Footwear vs. Insole market

Footwear consumption

Waste generation of Footwear market

User and Customization
Comfort
Technology

Redefined Design Brief

Material Study
- Preferable material
- Market and Manufacturing
- Processes
- Structural Innovations

Survey data on Foot-pain area
- Case studies
- Scenario

What are different causes that lead to changes in foot during pregnancy?

During pregnancy, the female body produces hormones that are new in quantity. Some of these hormones, such as Prolactin, help relax ligaments and other structures to allow a vaginal birth. These same hormones can also relax the ligaments in your feet, leading to flat feet (fallen arches) and overpronation.

It is not uncommon for pregnant women to develop heel pain (plantar fasciitis) because of the extra weight and stress on the arches.

Loosening of ligaments can also increase your shoe size during pregnancy—you may have to wear a half or whole size larger after you give birth.

Pregnancy hormones can also cause changes in the blood vessels, which may lead to swelling. All of this extra fluid needs a place to go, and gravity usually pulls it down to your feet and ankles. Increases in foot size that are due to swelling are common and temporary.

Varicose veins are veins that have become enlarged and usually stick out above the surface of the skin. Varicose veins are also a result of the weight of your growing womb and baby putting pressure on blood vessels.

Suggested prevention and treatment:

1. Walking gets your calf muscles working, which helps **pump some of the extra fluid out of your legs and feet.** That said, be sure to rest several times a day, elevating your feet as much as possible when sitting down.
2. Wear compression stockings to help decrease the swelling.
3. Drink plenty of water throughout the day. Try to avoid foods that contain large amounts of salt, **to decrease fluid retention.**
4. Wear the correct shoe size for your foot.
5. Stretch and massage the muscles in your legs and feet.

Plantar-foot pressures in pregnancy

Below are a few research papers that discuss the change in foot structure during the pregnancy period and the major foot pain area that is affected.

1. According to the study [1],

   In the static measurements, the pregnant women had significantly lower maximal forefoot pressures and higher hind-foot pressures than the non-pregnant women. The area of the foot in contact with the measuring pressure plate was greater in the pregnant women than in the non-pregnant women. In a brief explanation, The pregnant woman **has a different pattern of gait.**
   There is an increase of load on the lateral side of the foot and the hind-foot.

[1] Nyska M;Sofer D;Porat A;Howard CB;Levi A;Meizner I; “Planter Foot Pressures in Pregnant Women.” Israel Journal of Medical Sciences, U.S. National Library of Medicine, pubmed.ncbi.nlm.nih.gov/9254877/.

2. Plantar Pressure and Foot Pain in the Last Trimester [2]

   Conclusion: This data suggests that forefoot pressures increase in the last trimester of pregnancy during standing & walking. There is prominent increased postural sway in anterior-posterior direction in this period.

   Clinical Relevance: We believe that based on the observed pressure changes, foot pain in pregnancy due to changes in body mass and distribution may be relieved by exercise and shoe wear modifications.

[2] Evrim Karadag-Saygi, Feyza Unlu-Ozkan. “Plantar Pressure and Foot Pain in the Last Trimester of Pregnancy - Evrim Karadag-Saygi, Feyza Unlu-Ozkan, Alin Basgul, 2010.” SAGE Journals, journals.sagepub.com/doi/abs/10.3113/FAI.2010.0153#articleCitationDownloadContainer.

3. Anthropometric Foot Changes During Pregnancy [3]

- Women's feet change during pregnancy owing to hormonal and anatomical changes, thus having a strong influence on the decrease in their quality of life during pregnancy.
- The most significant finding, with a reliability rate of 95%, is the decrease in internal arch height, which descends 0.65 mm (0.0394 inches) on average at the final stage of the pregnancy period. This change happened in 18 of the feet analyzed, tending toward pronation according to the measure provided by the Foot Posture Index, with a change of 3.78 points on this scale.
- **Conclusions** - The foot of the pregnant woman tends to flatten during gestational weeks 12 to 34, taking a more pronated posture, and the anthropometric changes in late pregnancy result in increases in foot length and forefoot width, changes that seem to be moderate.

[3] Gijon-Nogueron, Gabriel A., et al. "Anthropometric Foot Changes During PregnancyA Pilot Study." Journal of the American Podiatric Medical Association, Allen Press, 1 July 2013, meridian.allenpress.com/japma/article-abstract/103/4/314/184308.

4. Pregnancy Leads to Lasting Changes in Foot Structure [4]

The results of this study showed a significant decrease in arch height and arch rigidity index, with concomitant increases in foot length and arch drop. During pregnancy, women's foot size increased, whereas the height of arch decreased.
The results indicate that the women subjectively complained that their shoes were too tight, resulting in foot discomfort.
The height of the arch decreased by an average of 0.52 cm (−24.2%)

The prediction model developed in this study can serve as a reference for clinical applications and shoe design to prevent women from experiencing extreme discomfort in their feet during pregnancy.

[4] Chiou, Wen-Ko, et al. "The Influence of Body Mass on Foot Dimensions during Pregnancy." Applied Ergonomics, Elsevier, 29 Aug. 2014, www.sciencedirect.com/science/article/abs/pii/S0003687014001434.

Current solutions for foot pain during pregnancy:

1. Taking a cool shower or bath. Water temperatures between cold and lukewarm can help relieve sore, inflamed muscles and tighten blood vessels. This can improve circulation and lessen pain.
2. Elevate your legs to improve circulation.
3. Perform light exercise to alleviate leg pain during pregnancy.
4. Stretch your legs to keep muscles loose.
5. Massaging sore and tired legs is one of the preferred ways to relieve leg pain during pregnancy. The gentle kneading action increases blood flow, decreases inflammation, loosens sore muscle.



Image 3.1



Image 3.2



Image 3.3



Image 3.4

Inferences:

The main focus of any of these activities is to increase blood circulation in the affected area as well as provide enough activity in muscles to provide moderate comfort.

Phases of gait cycle:

What is gait and stride?

The gait cycle is the time or sequence of events or movements during locomotion in which one-foot contacts the ground to when that same foot contacts the ground again and involves propulsion of the centre of gravity in the direction of motion.
A single gait cycle is also known as a stride.

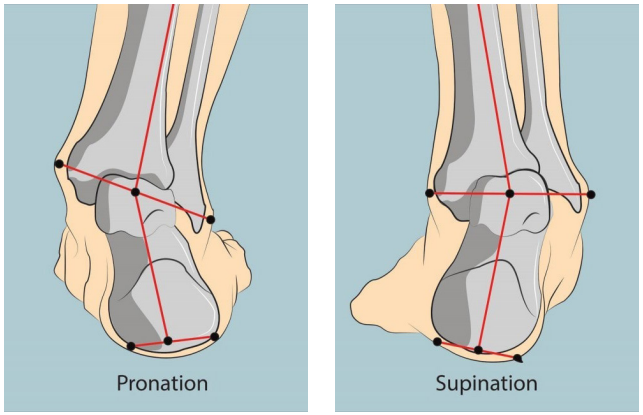


Diagram 3.1

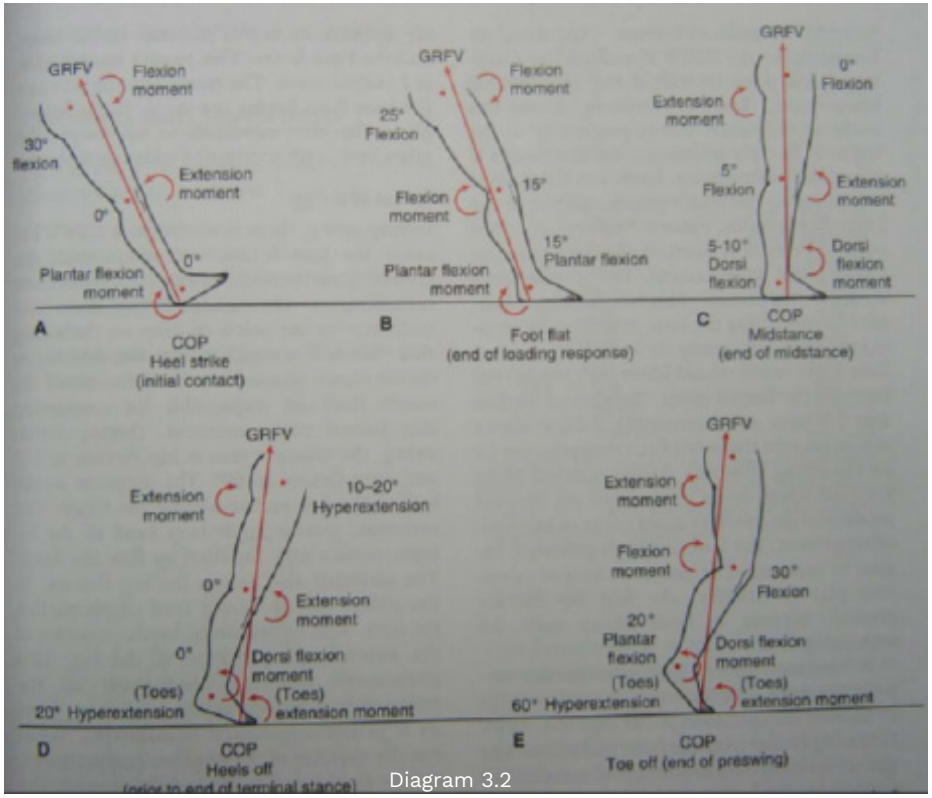


Diagram 3.2

A Bio-mechanical Analysis of Gait During Pregnancy:

According to the study in *The Journal of Bone & Joint Surgery: May 2000 - Volume 82 - Issue 5 - p 625*

Significant increases in kinetic gait parameters during pregnancy ($p < 0.05$) explain how gait motion remained relatively unchanged despite increases in body mass and width as well as changes in mass distribution about the trunk. This finding indicates that during pregnancy there may be an increased demand placed on hip abductor, hip extensor, and ankle plantar flexor muscles during walking. [5]

Leg and joint pain during the second or third trimester may be the result of added weight, changing body shape, and biomechanics. It can also be caused by fluid retention and joint laxity.[6]

[5] Laboratory, †Motion Analysis. "A Bio-mechanical Analysis of Gait During Pregnancy* : JBJS." LWW, journals.lww.com/jbjsjournal/Abstract/2000/05000/A_Biomechanical_Analysis_of_Gait_During_Pregnancy_.3.aspx.

[6] Mei, Qichang, et al. "Alterations of Pregnant Gait during Pregnancy and Post-Partum." Nature News, Nature Publishing Group, 2 Feb. 2018, www.nature.com/articles/s41598-018-20648-y.

Pronation/Supination + Gait

In a study by *J Athl Train. 2005 Jan-Mar; 40(1): 41–46. Comparison of Different Structural Foot Types for Measures of Standing Postural Control*
It shows that,

Individuals in the **supinated** group had **significantly greater centre-of-pressure average speed,** greater maximum displacement in the anterior-posterior direction, and greater SD and maximum displacement in the medial-lateral direction than individuals in the neutral group. The individuals in the **pronated** group had significantly greater SD and **maximum displacement** in the anterior-posterior direction used more trials to complete force plate testing and had **shorter single-limb stance duration** than those in the neutral group. [7]

The research concludes that Individuals with pronated feet or supinated feet have poorer postural control than individuals with neutral feet, but perhaps through different mechanisms.

[7] Cote, Karen P, et al. “Effects of Pronated and Supinated Foot Postures on Static and Dynamic Postural Stability.” Journal of Athletic Training, National Athletic Trainers Association, Mar. 2005, www.ncbi.nlm.nih.gov/pmc/articles/PMC1088344/.

Interview with pregnant females:

During the time of the pandemic, it was highly unsafe to meet with pregnant women for interviews and increase the risk of transmitting the Covid-19 virus to them. For this reason, I contacted the patients through their gynaecologist and interviewed them via a video call or a voice call. In addition to this, I contacted my relatives and neighbours, who were comfortable sharing their current/ past experiences with me.

After interviewing at least 20 women, I was able to segregate the data provided by them into 3 different personas.

The crucial input from this step was that even though enough secondary research data implied the severity of foot pain and gait shift during pregnancy, not many women considered this to be an issue to be bothered by. For further clarity, I met with a renowned gynaecologist of the city and understood the relevance of the problem.



Persona 1:

Age: 27
No. of pregnancy: 1

Experience with foot-related issue:
Little swelling on top of foot area
no shift in footwear size.
Swelling at the ankle.
walking pattern slightly changed.



Persona 2:

Age: 30
No. of pregnancy: 2

Experience with foot-related issue:
No foot pain, no change in stride/gait,
No swelling was experienced.
no gait change was noted.



Persona 3:

Age: 27
No. of pregnancy: 2

Experience with foot-related issue:
The only pain in the bottom of the foot in the morning, iterated gait noticed. Occasional pain in calf and thigh muscles.

Interview with gynecologist:



Image 3.5

Dr. Rupal N. Shah
Obstetrician & Gynecologist

Q: How common is the pain in the foot area?
A: Almost 30% of patients have complaints about overall leg pain, swelling in their 3rd trimester.

Q: What causes a change in foot shape?
A: The change in gait, lordosis, supination is more obvious and common due to weight gain in the last trimester.

Q: What do you recommend to your patients to alleviate foot pain?
A: Rest, leg elevation, increase blood circulation, salt-free diet, vitamin E, B12, D3 supplements.

Q: Is obesity a common factor for women who face foot pain?
A: Yes

Q: How effective are footwear solutions?
A: Something that focuses on the entire leg like compression stockings increase blood circulation. This brings relaxation to muscles. Using flat footwear and avoiding heels helps.

Q: How often do you hear this complaint regarding foot pain?
A: Only during the last trimester for the entire foot, less than 30% of patients have the complaint.

Inferences:

After the interaction with the gynaecologist, I was advised to meet with an orthopaedic doctor to gather more data and understand foot structure. We found some common issues like gait change, pronation/supination, foot comfort which is not only limited to pregnant women but affects a larger group of the audience too. After this insight, I went forward to find more data around the topic.

Guide meeting

A pandemic certainly took a toll on me and my batchmates' projects. Guide meetings looked different now. We couldn't meet our faculties in person or catch up with old friends while sipping tea at laalu's. With Covid-19 risk, and different rules in different states, the institute required everyone to meet with their guides Online, via platforms such as zoom and Google meet.

After collecting a sufficient amount of data and a certain instinct that this project may be capable to cover a large segment of the audience, it was necessary to talk about this with my project guide, Mh. Naim Shaikh, and take a decision that is beneficial to the project.

After the discussion, I received further clarity onto similar lines and we decided to interview orthopaedic doctors and podiatrists as well. Before which I had to gather some basic data through secondary research.

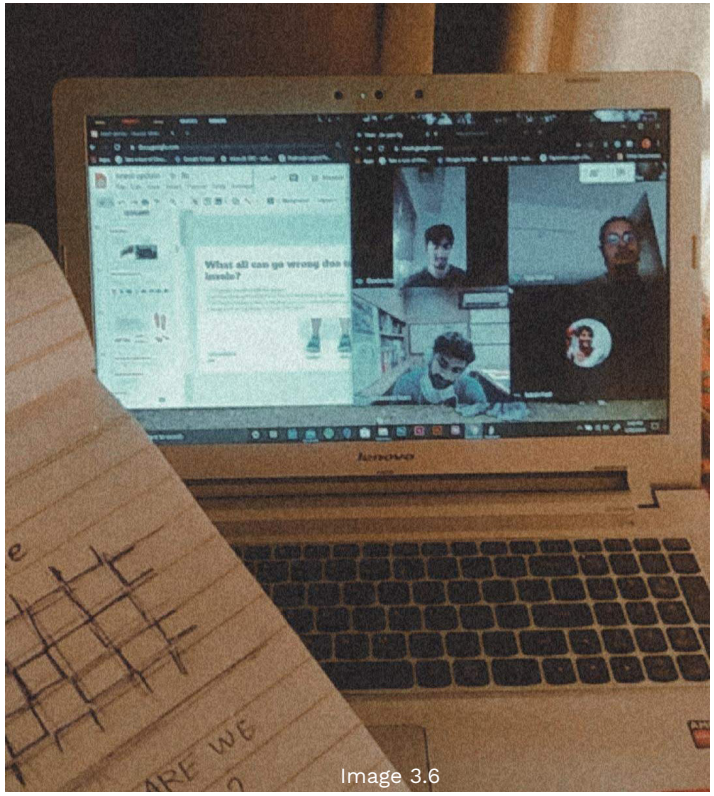


Image 3.6



Current solutions in market to solve pronation/supination related issues:

1. Exercise
2. Insole
3. Massager
4. Food habits

The main focus to alleviate foot pain is on 2 areas, one is to increase blood circulation through varied methods like exercise, massages, acupressure or usage of external supporting devices. Another is an improvement of posture through correction of foot shape, stride and gait improvement.

Why is the arch of the foot the most important part?

The arches of the foot, formed by the tarsal and metatarsal bones, strengthened by ligaments and tendons, allow the foot to support the weight of the body in the erect posture with the least weight.

Arch of the foot accounts for our uniquely human feet's stiffness, which allows us to push off without falling over and distinguishes us from other primates that need a more flexible foot to grasp tree branches.



Diagram 3.3

Interview with Orthotist:

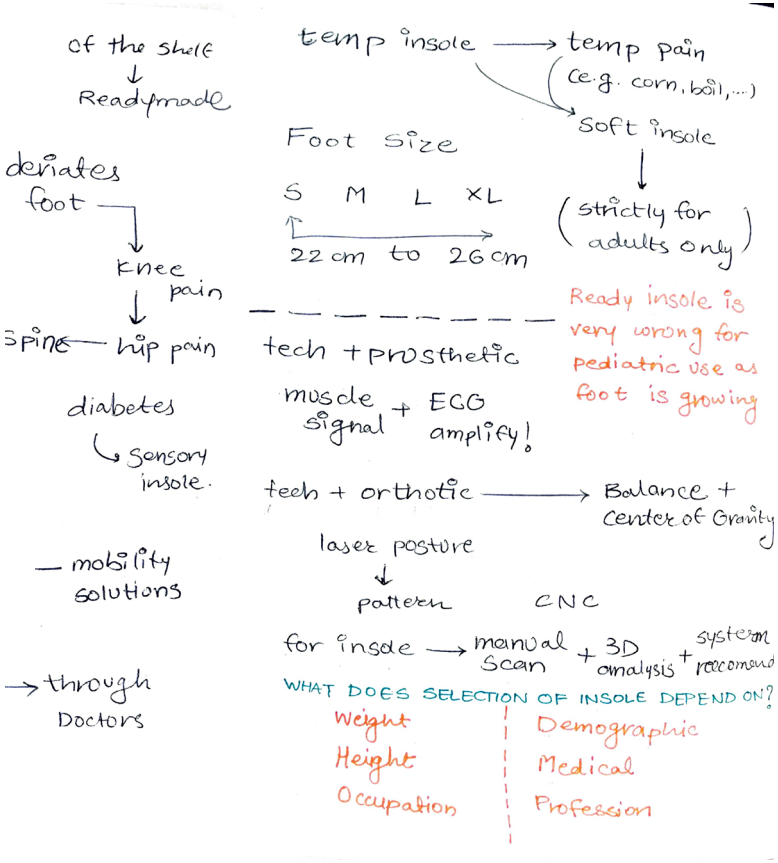


Image 3.7

Sashikanta Prusty
Orthotist
sashikkanta.prusty@indiaottobock.com



Diagram 3.4



Insights:

A primary concern of insole is support especially for flatfoot
Check via footprint and percentage of deformity

Two directions of making an insole:
Corrective/preventive insole
Accommodative insole

When we use the wrong insole, it affects the axial skeleton.
Wrong insole -- deviated foot -- knee pain -- hip pain -- spine -- back pain

Ready-made insoles are Wrong for pediatric use as the foot is growing.
Correction age is 6 to teenage. After that only exercises, therapy, ortho surgery.
Soft insoles are strictly for adults only.

Bilayer or mono-layer material -- Combination of materials is advisable.

Insole making is a 2nd line of treatment.

Selection of insole depends on --
Height, weight, occupation, demographics, medical condition, profession

Interview with Orthopedic:



Image 3.8

Dr. Parag Parikh
MD orthopedic
Surat | +91 261 2325494

Insights:

15-20% problems are related to foot out of which 75% problems are traumatic in young & middle-aged people

How to inspect a foot?
1. Inspection - palpation - movements - neurology
2. **Gait analysis**
3. X-ray, blood test

Sensation on foot is important, lack of it is likely to develop non-healing ulcers, leprosy, more prone to it if already have diabetes

Different directions to consider:
Shape of the foot
Shape+mechanism of the foot
Shape+mechanism+function of the foot
Shape+mechanism+function+neurological problems of the foot

What is a primary foot problem?
When the cause and outlet of pain is the same area of the body, it is considered a primary problem.

What is a referred pain (secondary foot problem)?
When the main problem is in one part of the body, but the outlet /effect of pain is in a different part of the body, it is considered a secondary problem. The specific cause of foot pain must be accurately diagnosed by an appropriately trained physician.

Advantages of insoles and proper fitting of shoes is that it takes care of tender are like heels and medial arch which eventually supports & corrects mechanism of the foot.

The most common material is,
Foam
Rubber (none of these are toxic)
Silicon (choice of material depends upon comfort+cost)

Hard insoles are not for routine purpose. These are usually used when; splint-age, after surgery, after injury, after palsy

Observe the sole of footwear (footprint data)
-- pressure area of the foot -- advice thickness accordingly

What can go wrong when used a wrong insole?
Painful foot, Parastasia, **Altered gait**

"A good insole can add reasonable comfort to a person. Insole tech is helpful and appreciated."

Stance -- Center Of Gravity -- perforated tummy/ varus knees/valgus knees

Criteria to be observed before advising insoles;
1. Shape of legs
2. The lateral stance of a standing person
3. Pressure points of the foot

"Gait can define your personality"

Via insole,
What can we do for a person's gait?

Secondary data analysis chart for understanding medical grade footwear & insole solutions:

	Type of foot problem	Area of foot	Solution in market	Material	Short term /long term	Does it require medical treatement?	Can it be controlled with postural changes?	Can we get any data with pressure sensors?	Does it affect Centre of gravity?	Does it affect Gait cycle?	Front section/ Back section
1.	Heel pain/ Plantar fasciitis	Heel	Heel spur pads 	Soft EVA, medical grade silicon, gel based filling	Both	No	Yes	Yes	Yes	Yes	Back section
2.	Supination	Outer side of foot	Medial flange 	Hard material	Long term effect if not treated in time	in few cases	Yes	Yes	Yes	Yes	Back section
3.	Pronation	Arch	Arch support 	Hard material	Long term effect if not treated in time	in few cases	Yes	Yes	Yes	Yes	Back section
4.	Cuboid syndrome	Outer side of foot	Cuboid pad 	Soft material	Short term	No	Yes	No	No	No	Front section
5.	Morton's syndrome	Below the fingers, Bottom side of foot	Morton exten-tion 	Soft material	Long term	Yes	Yes	No	No	No	Front section
6.	Ball of foot pain/ Metatarsalgia	Ball of foot	 Metatarsal pads	Soft material	Short term	Yes	Yes	No	Yes	No	Front section

Table 3.1

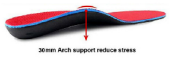
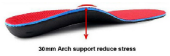
	Type of foot problem	Area of foot	Solution in market	Material	Short term /long term	Does it require medical treatement?	Can it be controlled with postural changes?	Can we get any data with pressure sensors?	Does it affect Centre of gravity?	Does it affect Gait cycle?	Front section/ Back section
7.	Corns/warts	Overall	Tapes 		Short term	No	Yes	No	No	Yes	Front & Back section
8.	Bunions	Under the toe	 Toe sleeves	Soft material	Short term (may cause long term effect)	Yes	No	No	No	No	Front section
9.	High Arch	Arch	 Support insole	Hard material	Long term	Yes	Yes	Yes	Yes	Yes	Back section
10.	Flatfeet	Arch	 Support insole	Soft material	Long term	No	Yes	Yes	Yes	Yes	Back section
11.	Hallux valgus/ Wide feet	Front of foot	Wide forefoot insole	Thin soft material	Long term	Yes	No	No	No	No	Front section

Table 3.2

Inferences: To bring comfort during walking and prevent the foot from pronating and supinating during the last trimester (pg 53, diagram 3.3) the primary focus should be on arch support. As we can see in table 3.1 and table 3.3, foot problems like heel pain, supination, pronation, metatarsalgia, corn/warts, high arch, flatfeet - all affect the COG and Gait cycle. Majority of which is the back area of the foot.

Types of footwear preferred by pregnant women:



Image 3.9

Loafers, Loungers, Sneakers

Usage: Outdoor

Reason: Slip on, Non-skid, Enclosed, Flat



Image 3.10

Crocs

Usage: Outdoor

Reason: Slip-on, Non-skid, Enclosed, Flat



Image 3.11

Belly shoes

Usage: Outdoor

Reason: Trendy, Slip-on, Enclosed, Flat, Lightweight



Image 3.12

Sandals

Usage: Outdoor

Reason: Trendy, Slip-on, Adjustable strap



Image 3.13

Slippers

Usage: Outdoor/ Indoor

Reason: Trendy, Slip-on



Image 3.14

Socks

Usage: Indoor

Reason: Warm, Comfortable, Washable

Inferences:

The main focus of users while choosing this footwear is,
- Comfort,
- Easy to wear,
- Enclosed (for safety)

Some nice to have features include,
- Washability,
- Trendy look

Footwear market

The leather and footwear industry in India is a high employment generating sector, contributing significantly to the country's export earnings and economic growth. India is 2nd largest producer of footwear, 6th largest exporter globally. The footwear industry in India contributes about 2% to India's overall GDP along with employing 2 Mn workers, making the sector one of the top employment generators in the country. Holding an important place in the Prime Minister's drive to Make in India, the footwear segment has been chosen as a Champion Sector. The non-leather footwear industry in India is fragmented and close to 75% of production comes from the unorganized sector, which includes micro, small, and medium enterprises (MSMEs).

The footwear sector in India is now de-licensed and de-reserved, paving the way for the growth of capacities on modern lines with state-of-the-art machinery. To further assist this process, the government has permitted 100 per cent foreign direct investment (FDI) through the automatic route for the footwear sector.

Footwear market growth in India:
India is the 2nd largest producer and consumer of footwear in the world, generating employment for over 2 Mn people. The current market size of the footwear industry is estimated to be at $ 10.6 Bn in 2019, estimated to grow to $ 15.5 Bn by 2024, registering a CAGR of 13 per cent from 2018 to 2019.

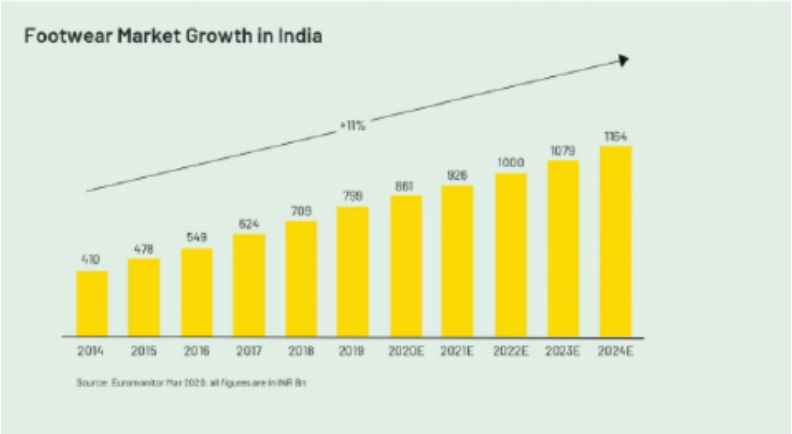


Diagram 3.5

Insole market

Custom insoles:

The smaller manufacturers are targeting different segments of the market, like sporting insoles or therapeutic insoles. The smaller companies concentrate on developing insoles custom fit for their customers. For this, the companies have developed feet scanning equipment and software, which they employ to manufacture one insole at a time. These insoles are high in quality as they are individually manufactured and thus create immense value for the company. Manufacturers also provide liberty to the consumers to design the insoles according to their choice to keep them engaged in the manufacturing process, ultimately building consumer confidence about the company.

Smart insoles:

Consumers like to stay aware of the benefits they receive from their investment in a product, and the companies have put themselves to the task to develop chips and sensors which can provide the insole user with data like impact analysis, stress reduction, and other critical parameters. E.g., Moticon Science launched next-gen insoles using sensors like 3D accelerometer, a 3D gyroscope, and more than 15 pressure sensors which provide the user data about their health through an app on their mobile.

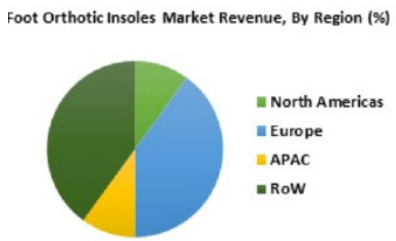


Diagram 3.6

Footwear Consumption

Over the last three years, India has surpassed the US in terms of ‘consumption by volume’. India is the second-largest consumer of footwear globally with a share of 11.7% followed by the US at 10.7% and Indonesia at 4.5%.

The largest growth rate was registered by non-leather footwear with an increase in exports of 13.7%. The overall footwear market in India is pegged to grow at 11 per cent over the next five years propelled by developments in the non-leather footwear segment. Globally, 86% of footwear consumption has become non-leather by volume and India is witnessing a similar trend. This consumption growth has contributed to major growth in revenue generated by the non-leather footwear industry.
As per industry estimates, the synthetic/non-leather footwear market in India is approximately 59% of the total footwear market in India.

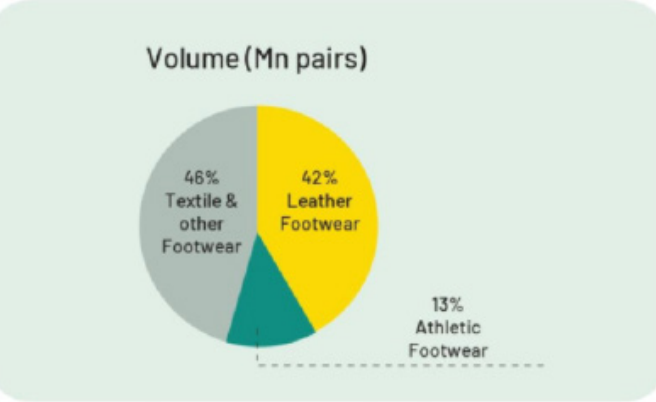


Diagram 3.7

Favourable policy ecosystem and support by the government:

The government of India has approved a special package for employment generation in the leather and footwear sector called Indian Footwear, Leather & Accessories Development Programme (IFL ADP) with an approved expenditure of INR 2600 crore ($ 348 Mn) over three financial years from 2017-18 to 2019-20.
To spur local medium and small enterprises that are involved in the manufacture of footwear, the Union Budget 2020 has pushed to increase the customs duty on footwear from 25% to 35%.
India has a significant transit time advantage for supply to US East Coast and Europe.

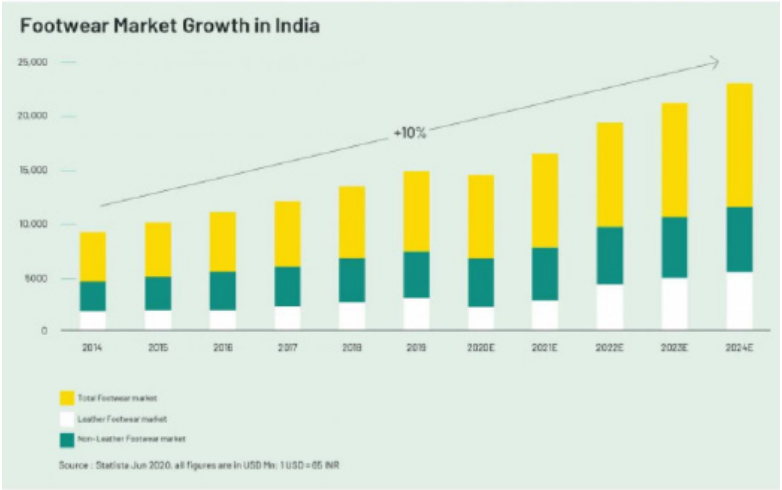


Diagram 3.8

World wide waste generation from the current footwear market

The worldwide footwear consumption has reached 24.2 billion pairs in 2018, raised by 2.7% over 2017 and crossed 23.0 billion pairs in 2015 as per the report of APICCAPS, which is supposed to rise by every year.

Because the material of Foot Orthotics Insoles is soft and deforms easily, they need to be changed every three to six months on average. They may function as shoe deodorizers, provide arch support, or offer targeted relief to the heel, midsole, or ball of the foot (metatarsus).

Polypropylene was the leading segment and it accounted for over 42.24% market share of total revenue generated in 2017. Thus, polypropylene is widely used to manufacture footwear.



Image 3.15

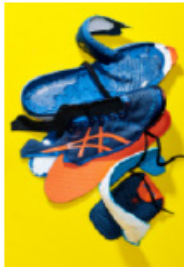


Image 3.16

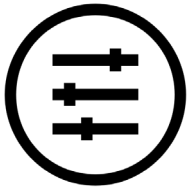


Image 3.17



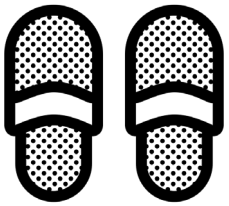
User and customization

- Studies show people are willing to pay about 20% more for a personalized product.
- Builds Customer Loyalty.
- About 55% of millennials indicate they like personalized experiences, especially those associated with a good cause.



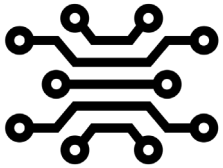
User and comfort

Logitech's Definition of the Role of Comfort in Product Design (n.) 2. Comfort is a critical component of the design process; the value of comfort urges companies to create tailored products designed to fit the unique shape of the human body.



User and technology

- According to the new market data, 55% of U.S. broadband households want to use their smart home devices.
- The wearable market is still growing. Experts believe this space will reach $25 billion by 2019, Link
- Wearable tech is the first step to eating better, reducing stress and adopting a healthier lifestyle.
- Consumers are voting again and again [through their purchases] for devices that offer peace of mind and anticipate their needs.”



Refined design brief:

Aim:

A footwear solution that fits the individual’s foot perfectly and provides comfort to the back of the foot area during the last trimester of pregnancy.

Objective:

- To provide comfort through custom design solutions to each individual's foot contours.
- To make sure the Gait cycles & mobility for pregnant women is not changed.
- To make a product that can be used by pregnant women independently.
- Reduce material layering in footwear manufacturing, for the possible recycling process.

Material study

PU : Polyurethane

PU foam is “blown” into moulds. The liquid compound expands and foam air cells fill the moulds. PU foams are used to make durable mid-soles for hiking boots and can be made into entire sole units, tread, and midsole all in one. Many women’s fashion shoe high heel outsoles are made from high-density PU. Very soft PU is used for foot-beds due to its resistance to compression.

Material property:
Elongation break
Tear strength
Tensile strength
Hardness

Reasons to use:
Comfortable
Long-lasting
Affordable

TPU: Thermoplastic Polyurethane

Thermoplastic polyurethane (TPU) resin has the advantages of high wear resistance, high elasticity, fatigue resistance, chemical corrosion and so on, and is widely used in shoes. Colour TPU foam is expected to replace color EVA foam to use in the high-performance shoe field.

Cork
It is also used in shoes, especially those using welt construction to improve climate control and comfort. It is impermeable and moisture-resistant, Cork is used as a sustainable alternative it has low density. Elasticity + near-impermeability

PCL: Polycaprolactone

Instamorph result is a very strong object that could be used every day and gives you a glossy professional finish. (mouldable plastic) Also called Polymorph.

Heat, mould and use within minutes.
Great for all types of art, hobbies, prototypes, props, modelling, etc.
Tested and Verified By Experts.

- Fabric
- Leather
- EVA foam
- PE foam
- Synthetic
- leather

Ortholite is one of the leading material providers for footwear insoles in a wider range.

Before OrthoLite®, insole materials were just generic commodity foams —a basic filler material that didn't breathe, flattened out quickly and caused sweat and odours to accumulate. Today over 350 brands choose OrthoLite and over half of these industry leaders choose to co-brand with OrthoLite.

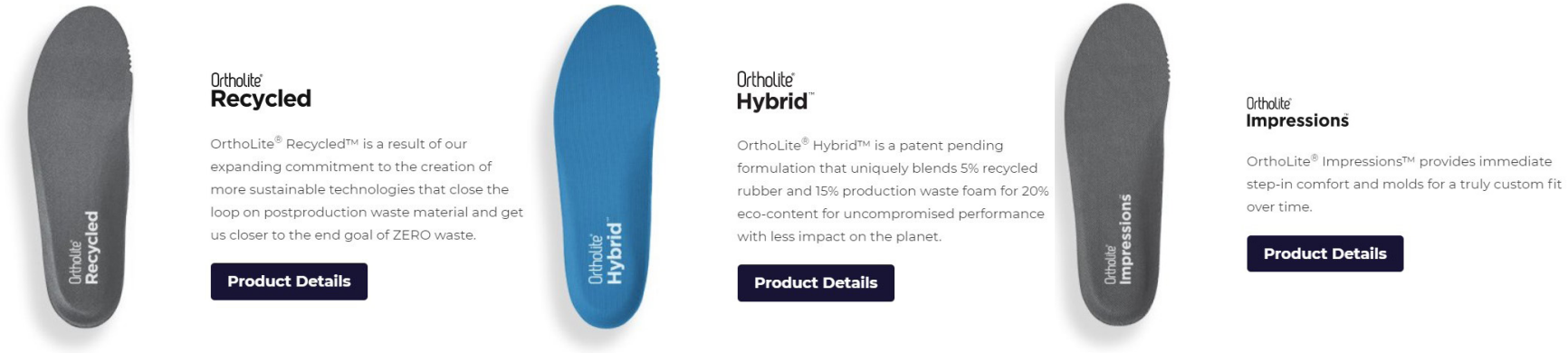


Image 3.18


Ortholite
EcoLT
OrthoLite® Eco LT™ brings innovative eco-upgrades to our original .11D and .13D formulations, replacing a portion of the petroleum with plant-derived bio-oil.
Product Details
Ortholite
Eco
OrthoLite® Eco™ expands on our popular EcoLT™ formulation—more than doubling the bio-oil content to further reduce the use of petroleum.
Product Details

Image 3.19

Preferable material

It was found that [9] static postural stability was not affected by insoles, but cupped insoles improved dynamic postural stability, and rigid insoles were associated with better dynamic postural stability compared to soft insoles. These findings can aid in better understanding the insole design features associated with improved postural stability in older adults.

Typical arch supports known in the arch have a polypropylene shell that is flexible enough to provide comfort, while being rigid enough to properly support the person's arch and to restore foot structure to a natural position during activity.

[9] Qu, Xingda. “Impacts of Different Types of Insoles on Postural Stability in Older Adults.” Applied Ergonomics, Elsevier, 15 July 2014, www.sciencedirect.com/science/article/abs/pii/S0003687014001124/.

Market study of moulding processes for customization

Fibreglass
- Less accurate
- Can be distorted by shrinkage and nonconformity

3D scan
- More efficient with its ease of use and faster processing via email
- Inconsistent
- Non-reproducible

Plaster
- Long turnaround time
- Messy
- More accuracy

Foam crates
- Difficult to maintain the subtalar joint in neutral with any weight-bearing

Structural innovations

1. Auxetic:

Auxetics are structures or materials that have a negative Poisson's ratio. When stretched, they become thicker perpendicular to the applied force. This occurs due to their particular internal structure and the way this deforms when the sample is uniaxially loaded. Auxetics can be single molecules, crystals, or a particular structure of macroscopic matter.
Applications such as body armour, packing material, knee and elbow pads, robust shock-absorbing material, and sponge mops.

Production of auxetic metamaterials through the introduction of patterned micro-structural cuts using direct laser cutting. In footwear, the auxetic design allows the sole to expand in size while walking or running, thereby increasing flexibility.

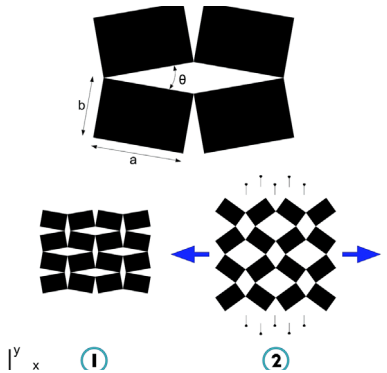


Diagram 3.9



Image 3.20

2. Origami structures:



Image 3.21

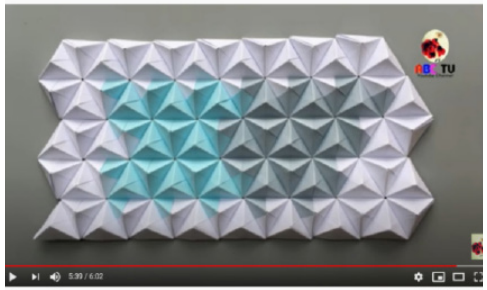


Image 3.22

3. Hexagonal structure:

4. Slits

Survey data on foot-pain area:

Two types of surveys were conducted,

- With 30 pregnant women inquiring about their foot health, major foot pain area, foot care routine, Insole knowledge and general view. The majority of the age group that participated was between the age of 25-35 years.
- With 50 people about their knowledge about insole, general view, customisation, smart products, and foot health. Occupations varied between students, pregnant women, desk jobs, On-field work, housewives, Physical activities.

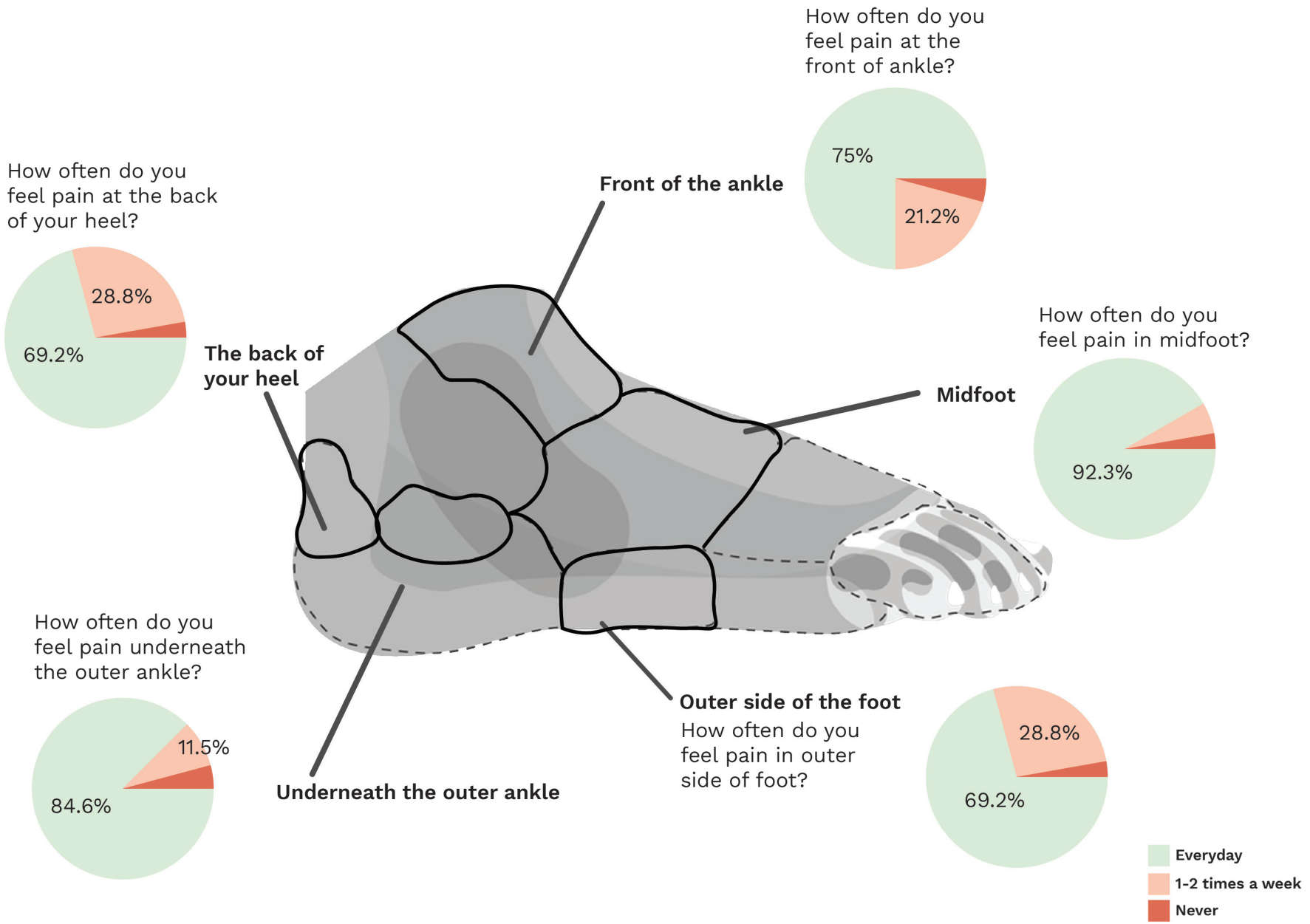

How often do you feel pain at the front of ankle?
75%
21.2%
Front of the ankle
How often do you feel pain at the back of your heel?
28.8%
69.2%
The back of your heel
Midfoot
How often do you feel pain in midfoot?
92.3%
How often do you feel pain underneath the outer ankle?
11.5%
84.6%
Underneath the outer ankle
Outer side of the foot
How often do you feel pain in outer side of foot?
28.8%
69.2%
Everyday
1-2 times a week
Never

Diagram 3.10

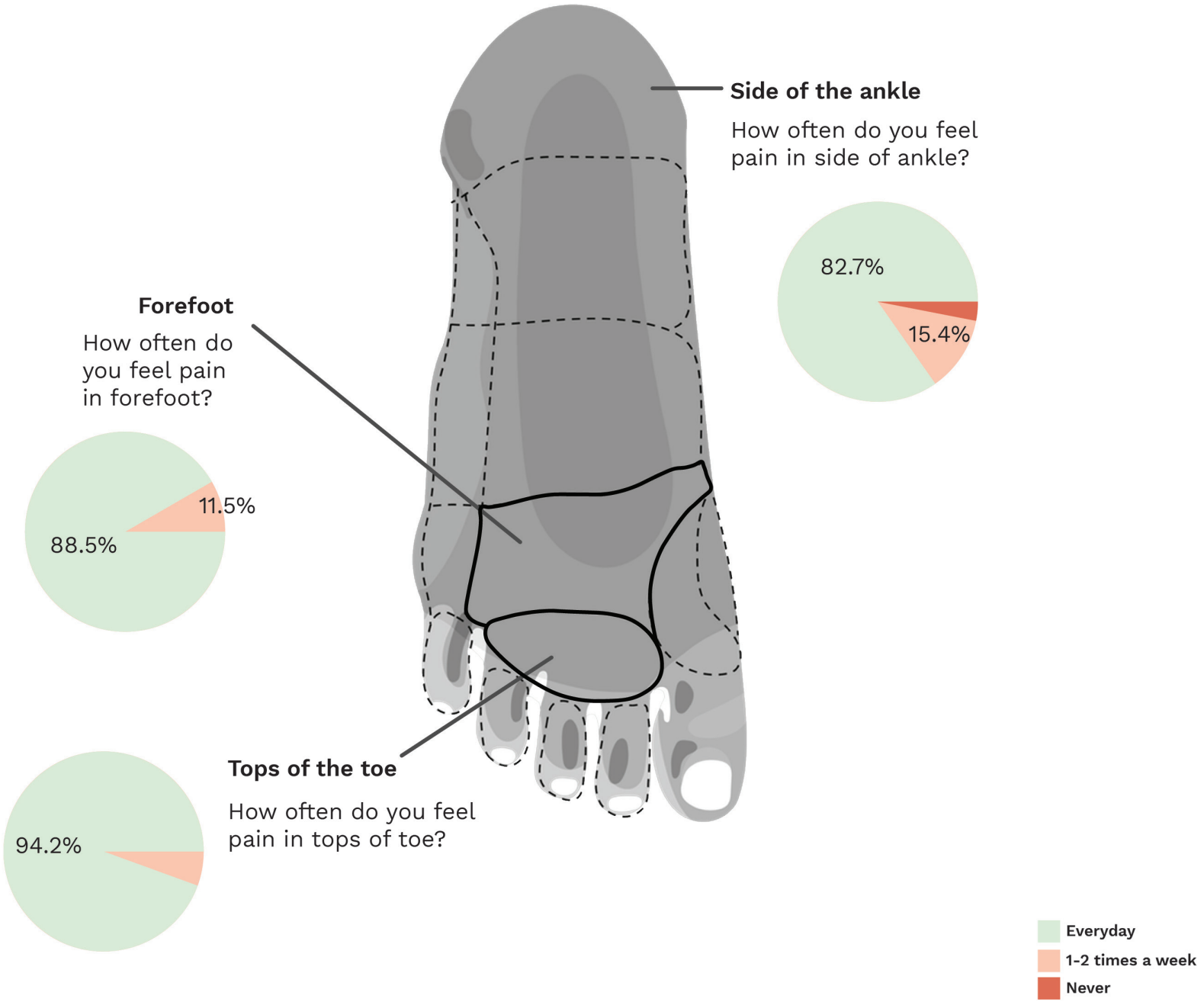

Side of the ankle
How often do you feel pain in side of ankle?
82.7%
15.4%
Forefoot
How often do you feel pain in forefoot?
11.5%
88.5%
Tops of the toe
How often do you feel pain in tops of toe?
94.2%
Everyday
1-2 times a week
Never

Diagram 3.11

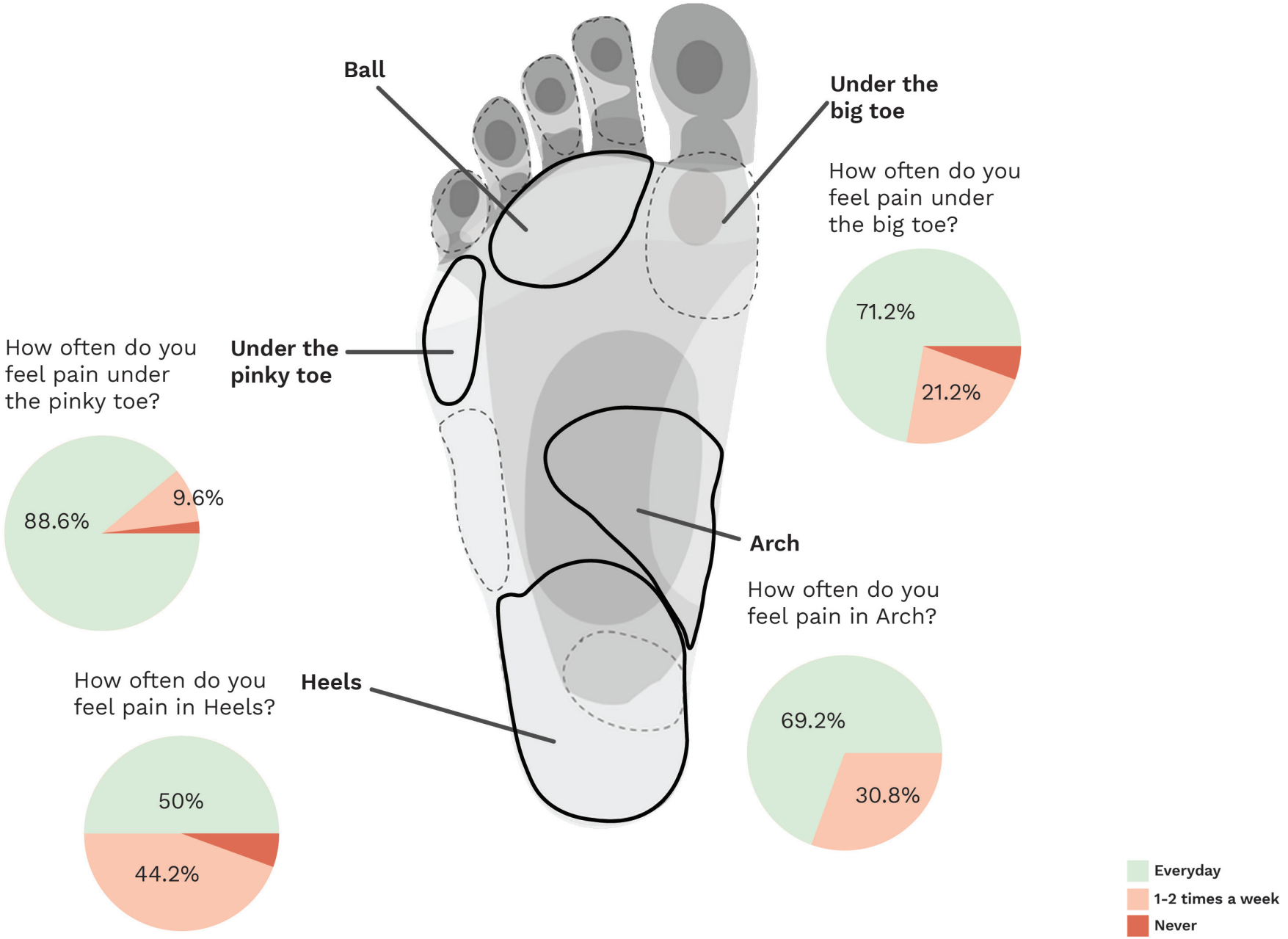

Ball
Under the big toe
How often do you feel pain under the big toe?
71.2%
21.2%
How often do you feel pain under the pinky toe?
Under the pinky toe
88.6%
9.6%
Arch
How often do you feel pain in Arch?
69.2%
30.8%
How often do you feel pain in Heels?
Heels
50%
44.2%
Everyday
1-2 times a week
Never

Diagram 3.12

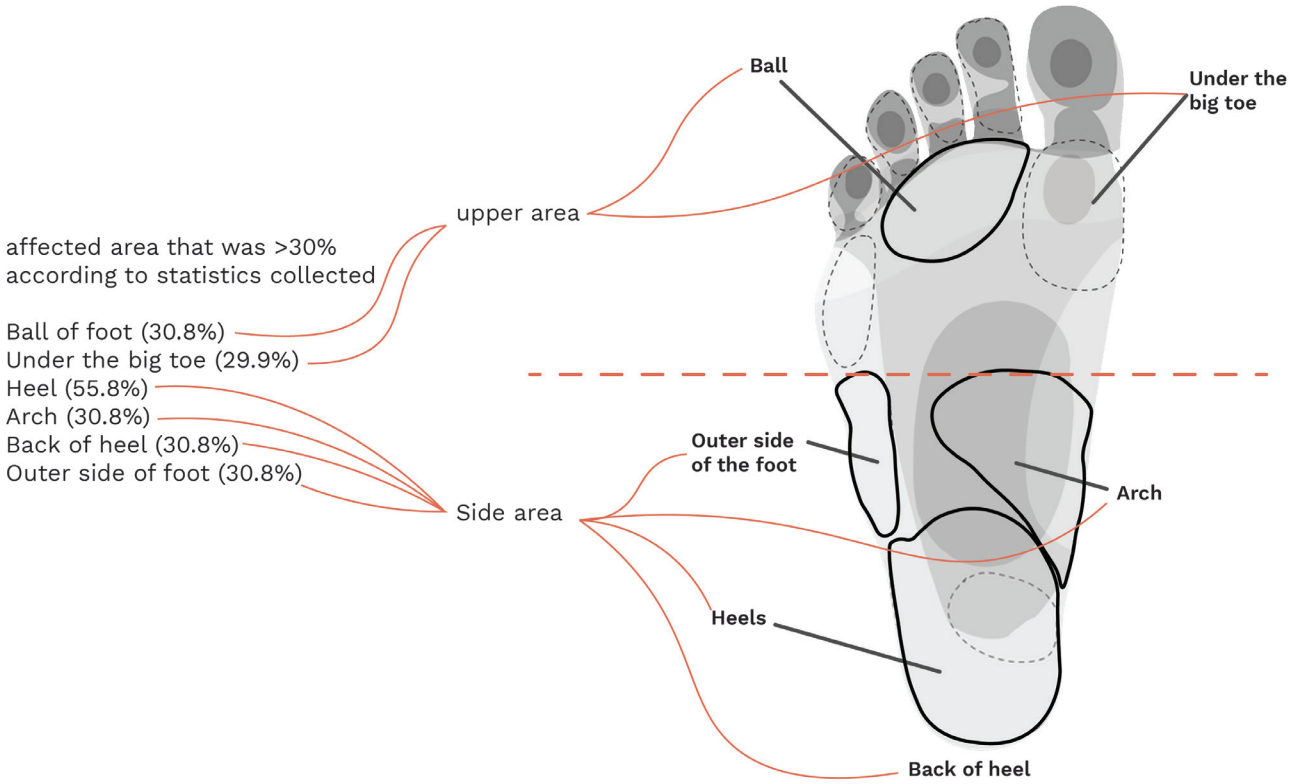


Diagram 3.13

For further elimination, the cases that had a maximum number of combinations of these 6-foot problems were analyzed to understand the intensity rate and occurrence rate of pain.

Case 1 Age: 20- 35
Occupation: Job
Daily Activities: Walking, Sitting, Mild excercises

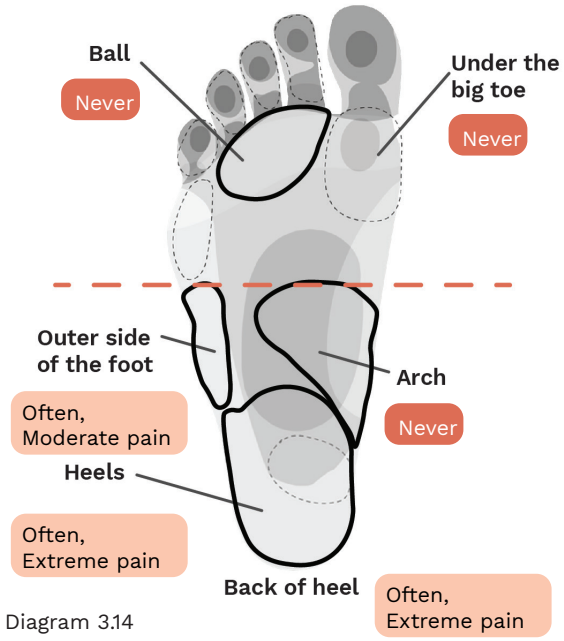


Diagram 3.14

Case 2 Age: 20- 35
Occupation: At home
Daily Activities: Walking, Sitting

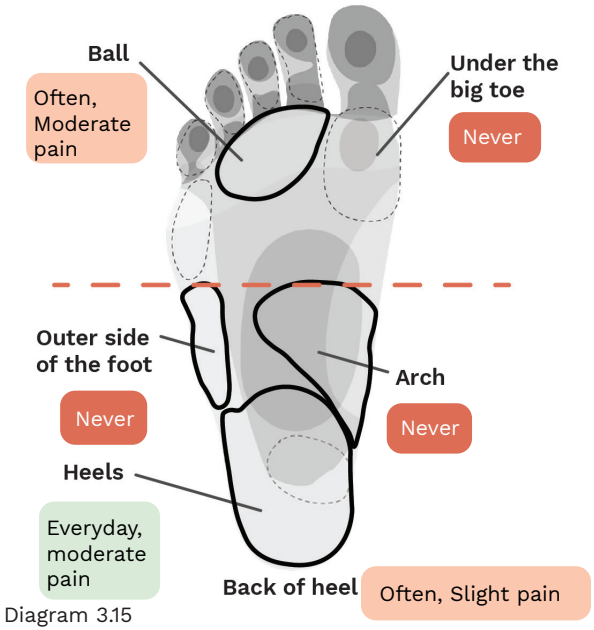


Diagram 3.15

Case 3 Age: 30+
Occupation: At home
Daily Activities: Walking, Standing

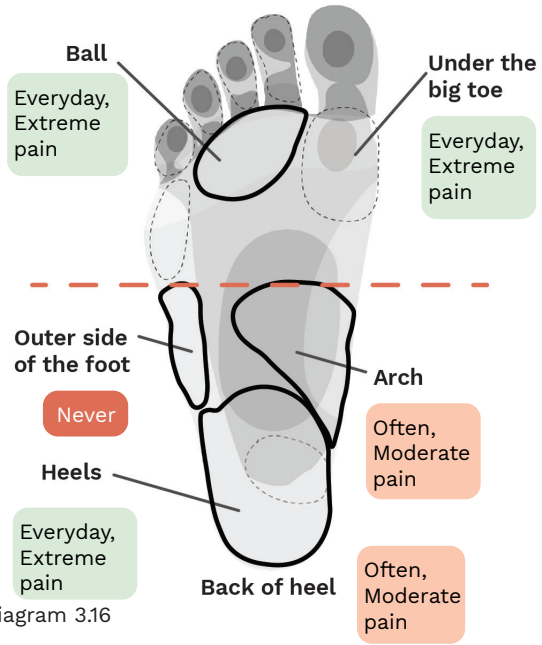


Diagram 3.16

Case 4 Age: 31-40
Occupation: Job
Daily Activities: Walking, Sitting, Standing

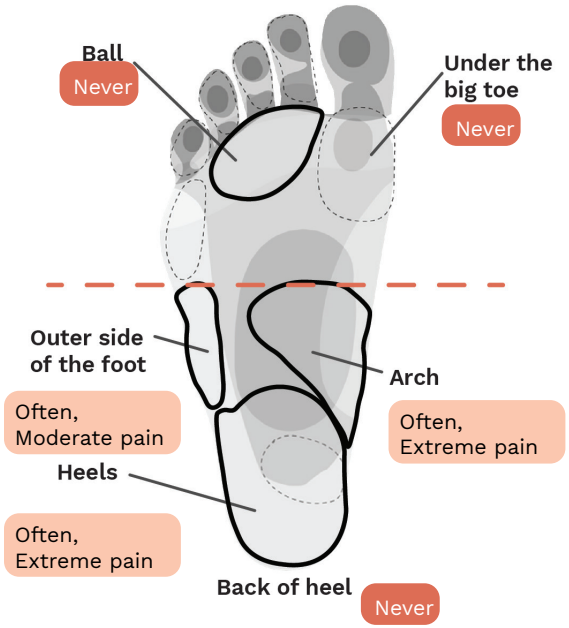


Diagram 3.17

Case 5 Age: 40+
Occupation: Job
Daily Activities: Walking, Sitting

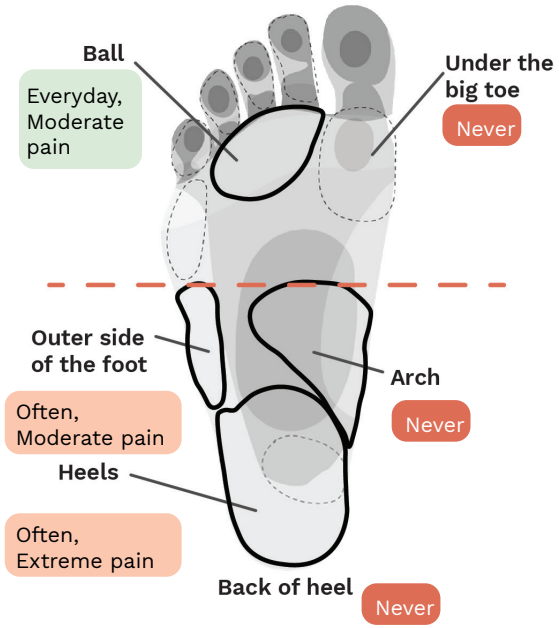


Diagram 3.18

Case 6 Age: 40+
Occupation: Teacher
Daily Activities: Standing, Walking, Sitting

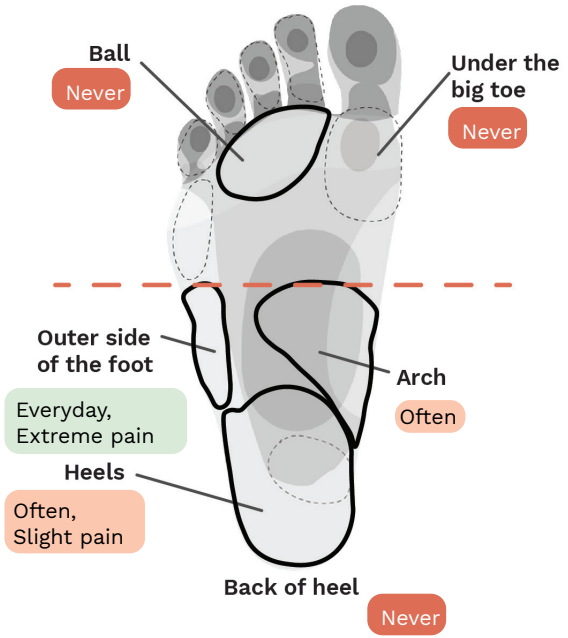


Diagram 3.19

Comparing these cases takes us to a conclusion that,
People of different age groups, with **more standing** time during their routine activities, have **often complained** about pain in the **lower foot area** (especially in the heel area) than upper foot area.

4. Actualization



- **Concept Development**
- **Ideation Sketches**
- **Directions for mock-ups and prototyping**
- **Mockup trials**

Concept Development

At first, all the arbitrary concepts were written on post-its and later segregated according to 4 wide categories. These categories being - Health and lifestyle, help in emergencies, Luxury feature/value addition, miscellaneous.

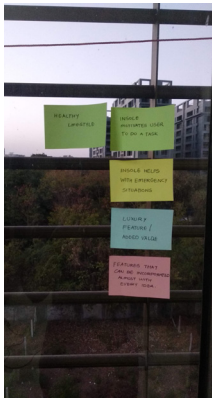


Image 4.1

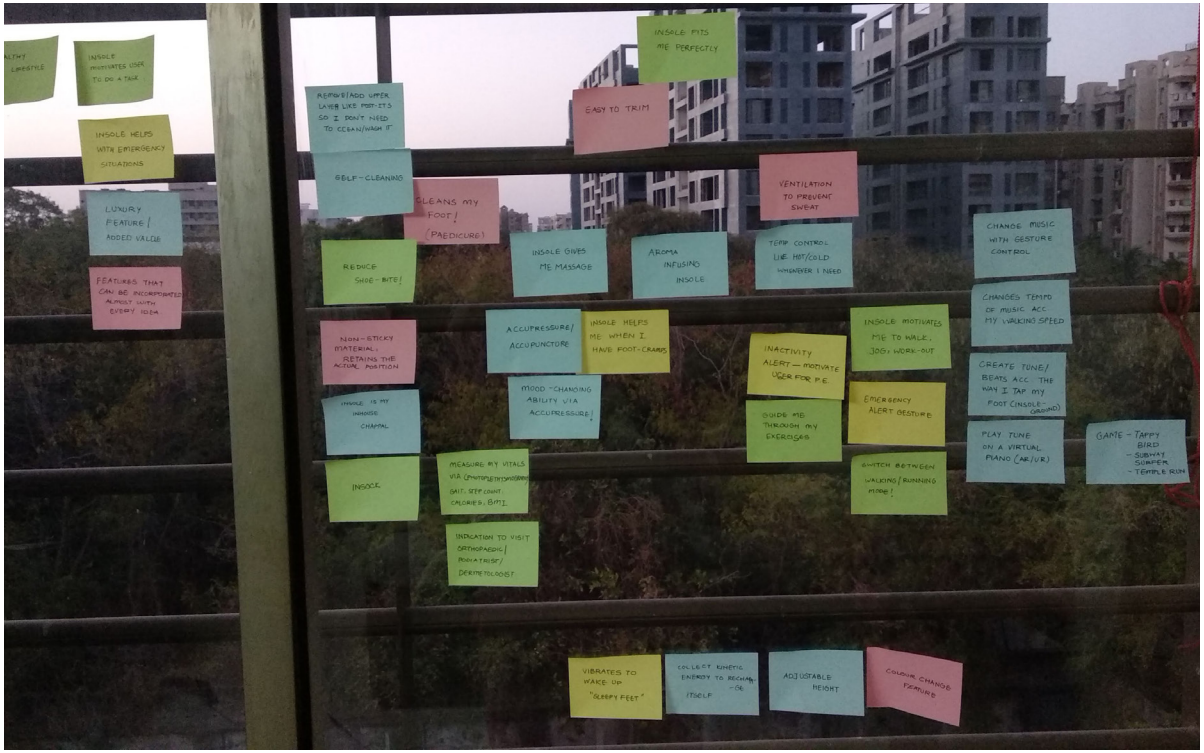


Image 4.2


Categories
Health/Lifestyle
Insole helps with emergency situation
Luxury feature/ added value
Feature that can be incorporated with all of the above
Remove/add upper layer like post-its for washing/cleaning
Insole fits user perfectly
Ventilation to prevent sweat
Aroma infusing insole
Easy to trim
Temperature control hot/cold as per need
Self-cleaning
Cleans my foot/pedicure
Changes music acc to gesture control
Gives me massage
Insole helps when user gets cramps
Reduce shoe bites
Insole motivates user to walk/ jog/ workout
Changes tempo of music acc to walk speed
Acupressure/ Acupuncture
Inactivity alert - motivate user for PE
Non-sticky material + retain the actual posititon in shoe
Emergency alert gesture
Create beats/tunes based on how user taps on floor
Mood changing ability via accupressure
Guide user through my workout
Switch between walking & running mode
Play tune in a virtual piano (AR/VR)
Games- tappy bird, temple run, subway surfer
Insole is my inhouse chappal
Measure user's vitals (via photoplethysmography), gait, step count, calorie burn, BMI and make log
INsock
Indication to visit orthopaedic/podiatrist/ dermatologist
Vibrate to wake up dead feet
Collect kinetic energy to recharge itself
Adjustable height
Colour changing feature

Diagram 4.1

Now the plausible combinations of these ideas were combined & sketched for further visualization, a few with mock-up and trial.

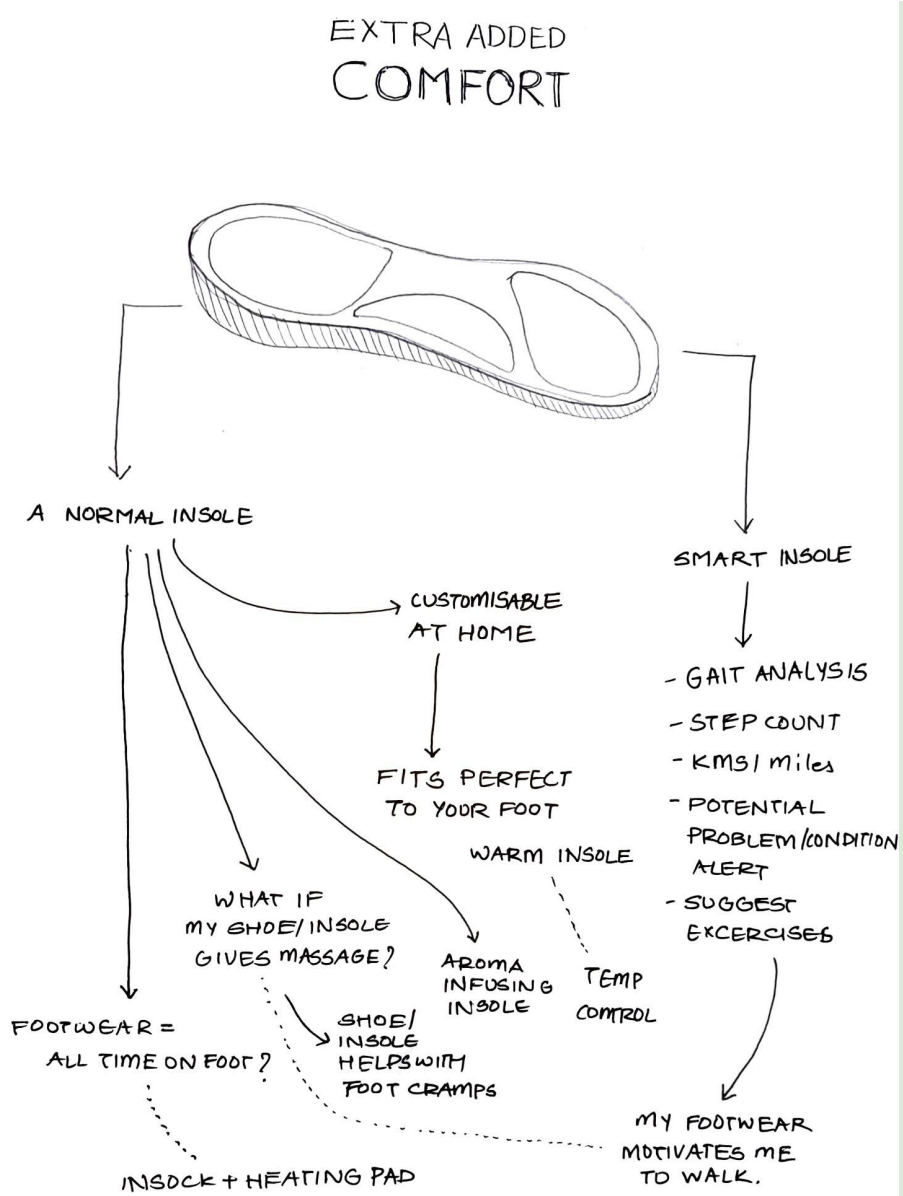


Diagram 4.2

1. Modular insole- was an idea where users can customize according to their needs. According to your foot type and issues face, you can change the material from soft to hard, on a common TPU base, where one can snap-fit each module.

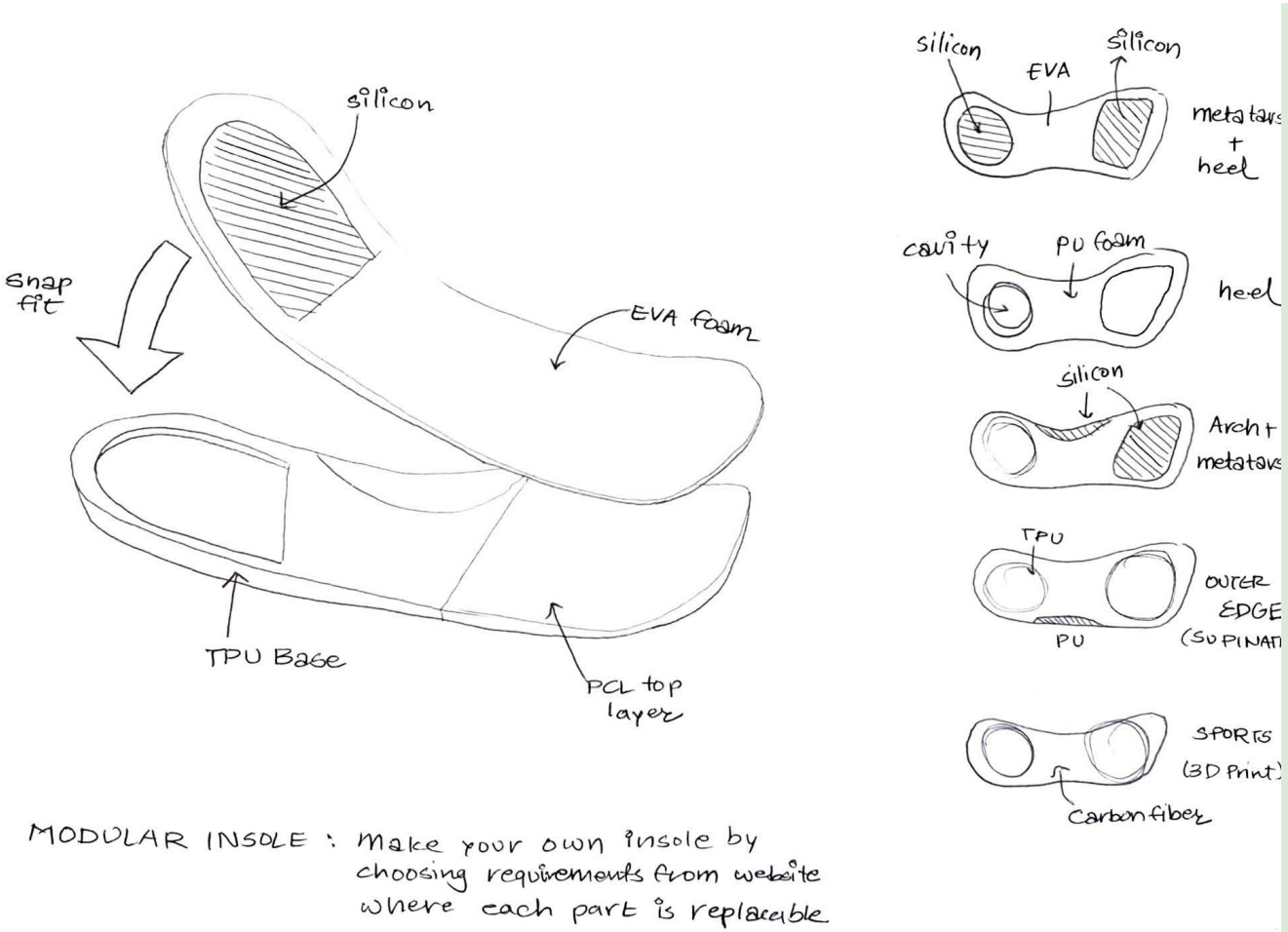


Diagram 4.3

2. Charging:

The shoe every day can be a tedious task. So if the shoe is to include any electronics for haptic feedback, we have to think of various pathways of getting the battery charged.
The options can be,
- With coin cell,
- USB port to the wall
- USB port to the phone
- Self-charging
- Solar-powered
- Kinetic energy
- Wireless charging pod,
- Wireless charging platform

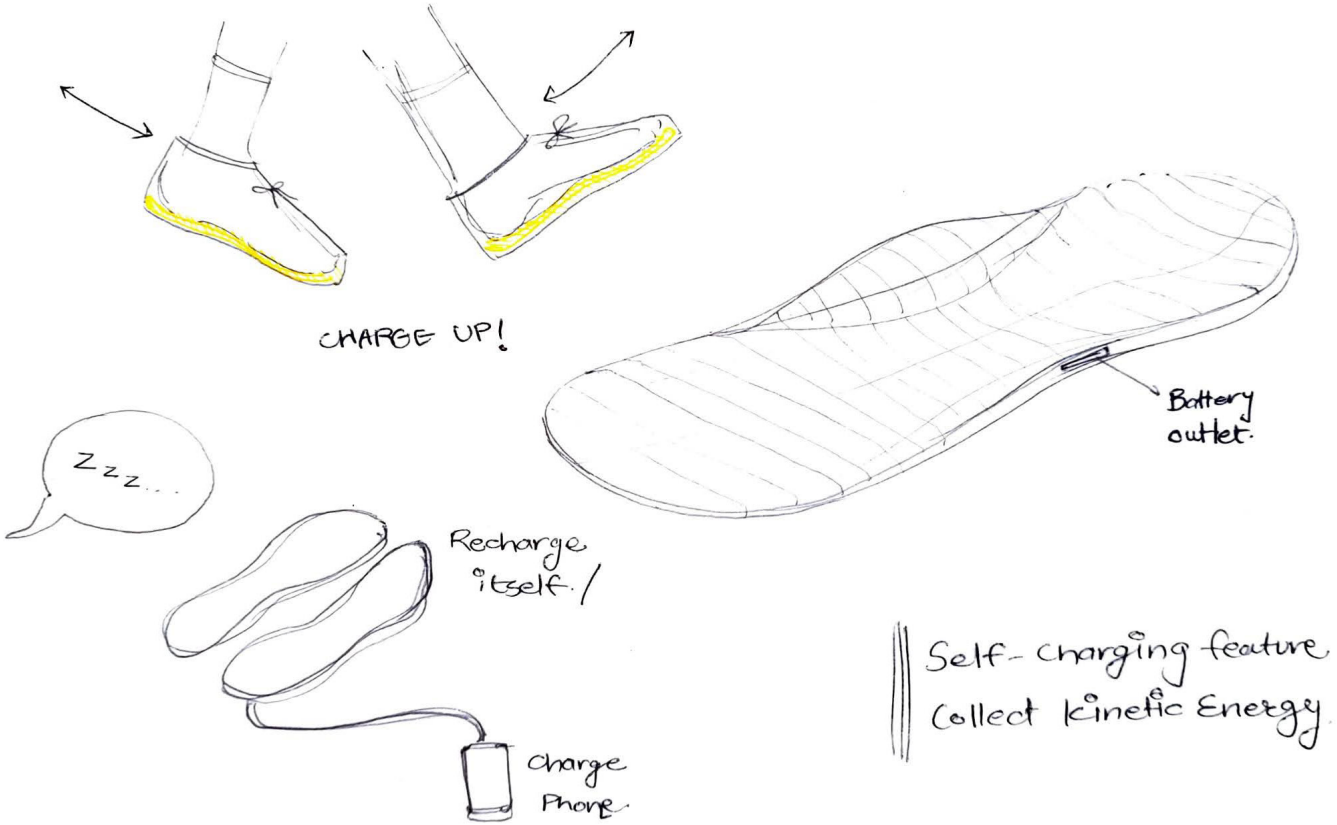


Diagram 4.4

3. Removable upper layer -

is a concept for easy cleaning of hard material footwear, when the EVA foam/soft TPU can make the upper layer, which can be washed in the washing machine on its own.

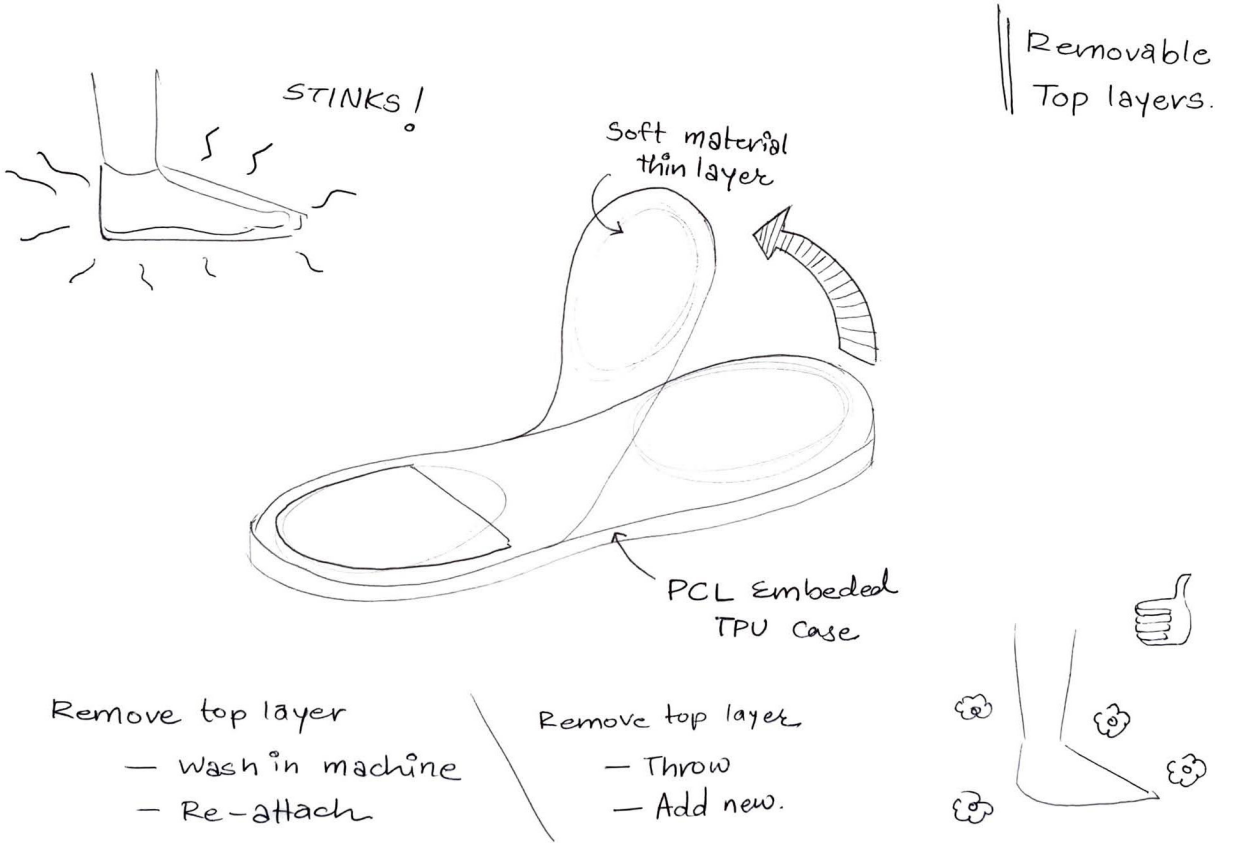


Diagram 4.5

4. Gaming/Playfulness - These were different concepts where the everyday walking was made more fun by using simple everyday gestures. (This concept was thought of as an added feature and does not cater to the main goal of enhancing comfort)

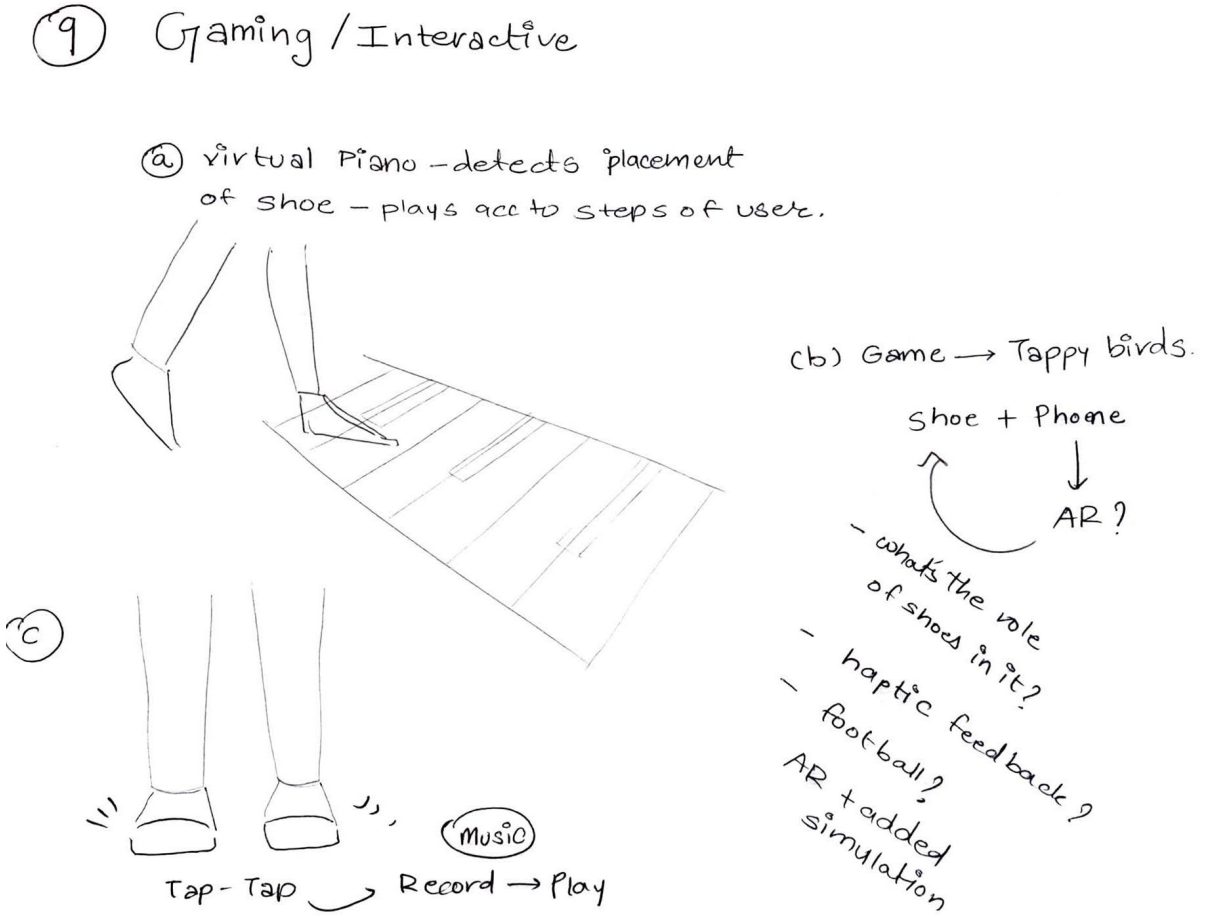


Diagram 4.6

5. Ventilation to prevent sweat- This could be achieved by either material control or structural innovation. Sufficient ventilation can keep the feet feeling fresh throughout the day, adding extra comfort to the product.

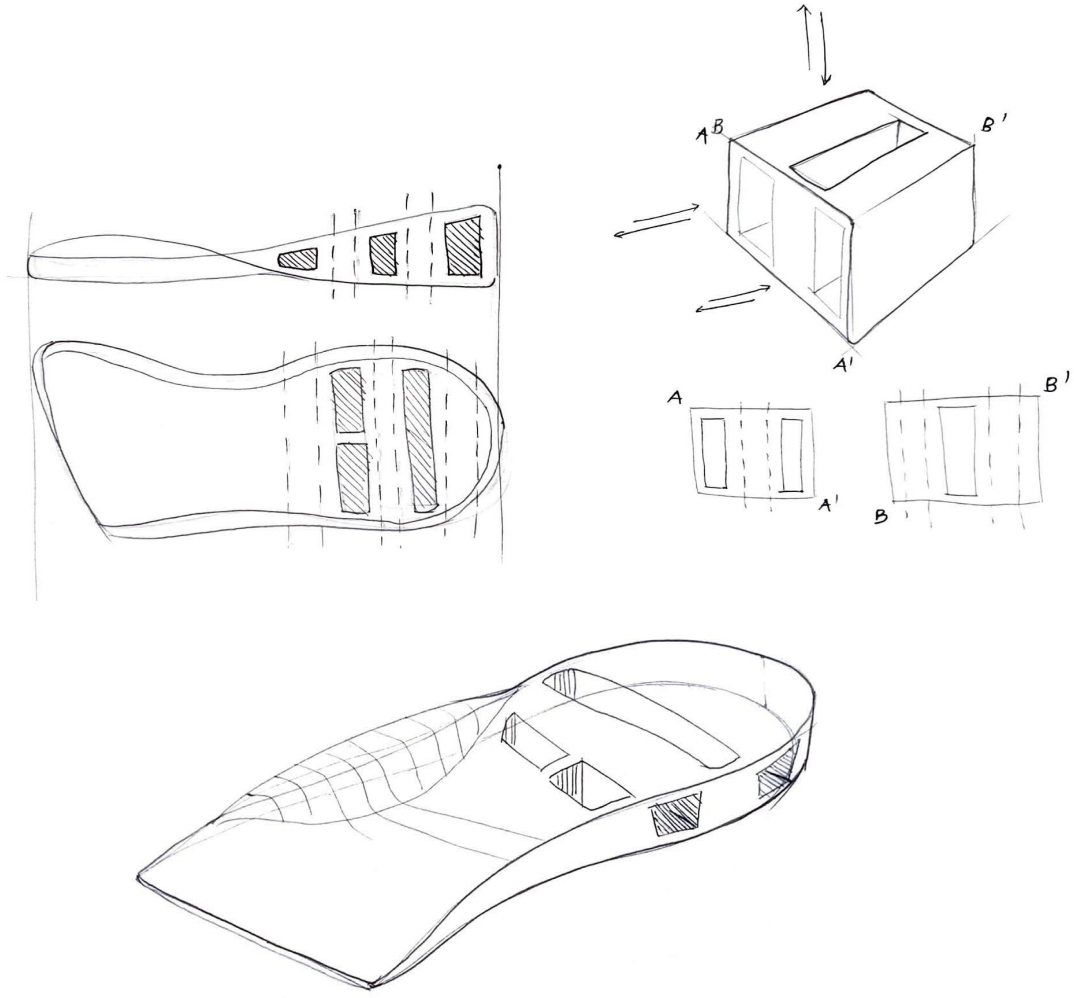


Diagram 4.7

6. Shoe that motivates to walk/run

The idea here is to make a product based on instant gratification and reward systems, where you are motivated to walk more and do the advised physical activity that can eventually give the user a reward or a massage or points to redeem.

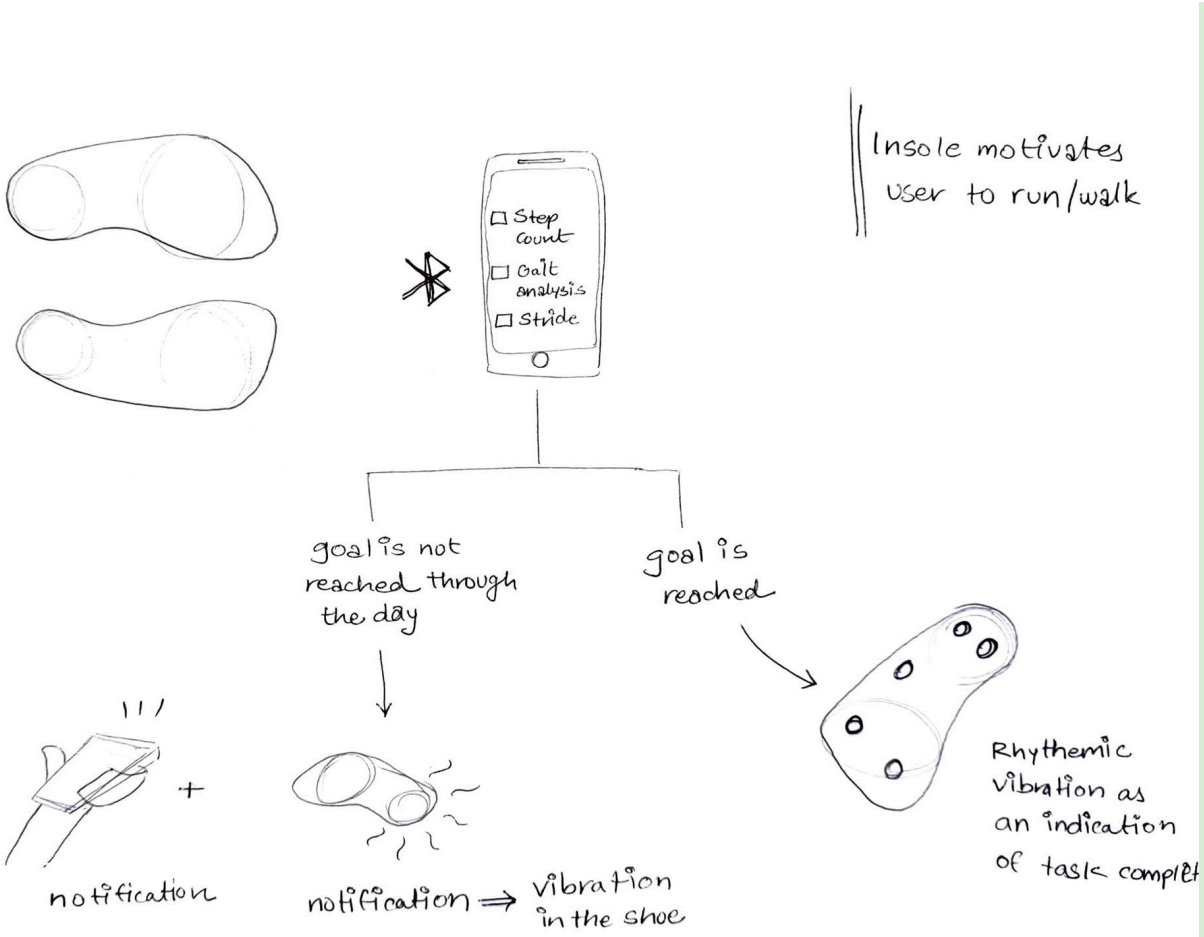


Diagram 4.9

7. Gesture control

This concept was created in general to brainstorm on which gestures will be easier to capture by the tech that is available in the market. The main challenge here was to ideate on something which will not be mistaken by the regular walking/ running and adding false data.
The concept can be combined with any of the other concepts if the user experience requires gesture control.

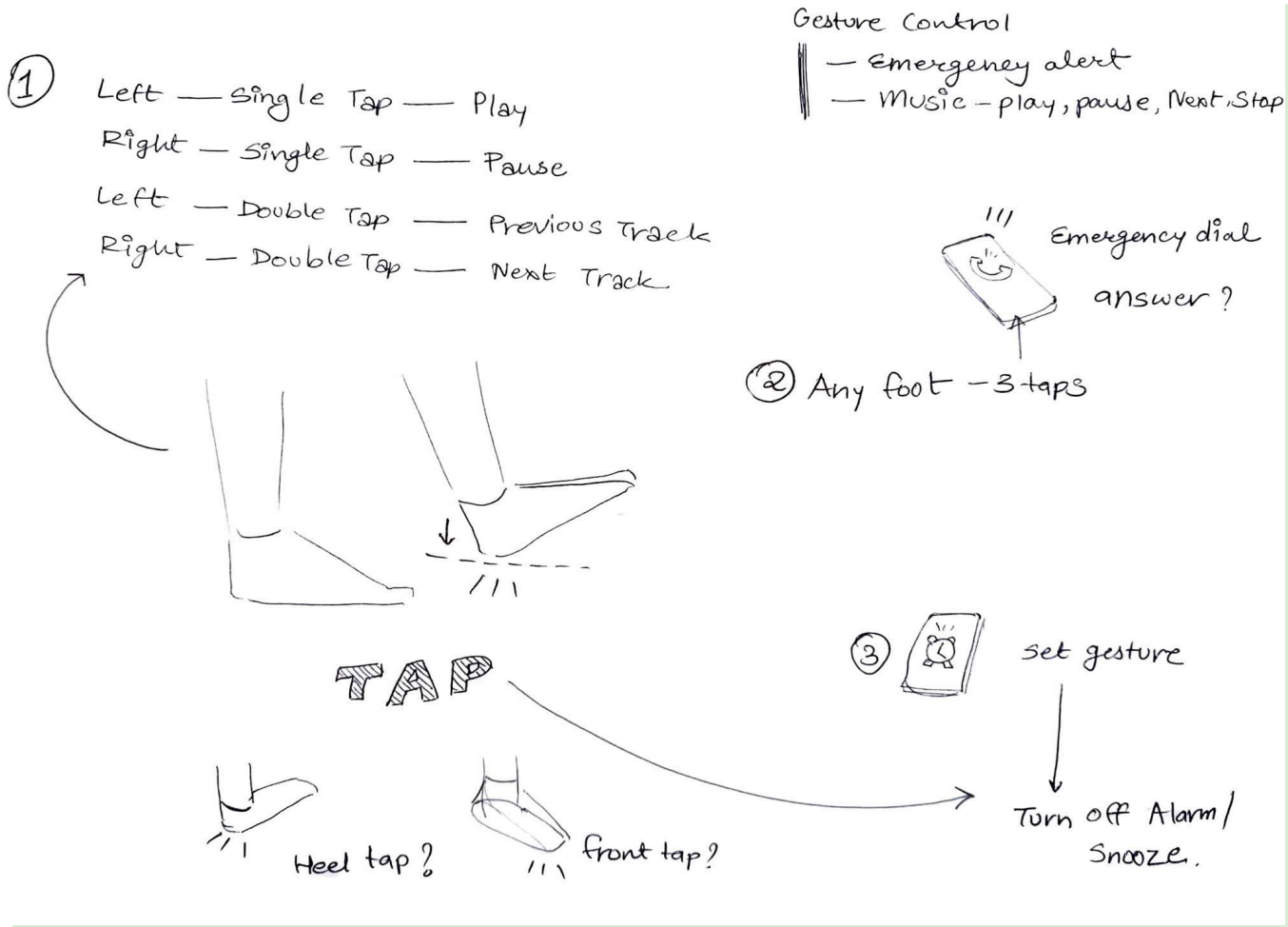


Diagram 4.10

8a) Massaging footwear
-

is a luxury feature to relieve stress in foot muscles which are usually caused by the exertion of the muscles. Mainly with the condition of pronation/supination/flatfeet.

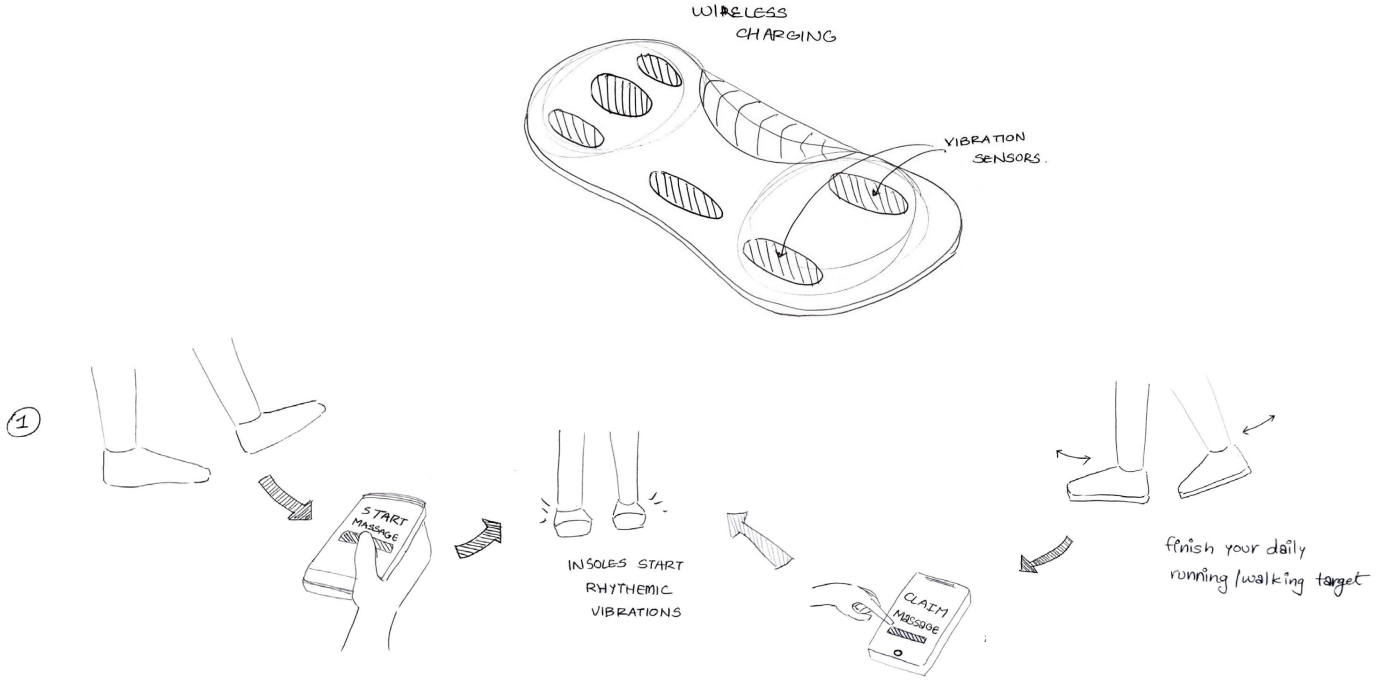


Diagram 4.10

8b) Massaging footwear

A more focused intervention for the condition of experiencing occasional foot cramps. The footwear can have sensors to detect unusual muscle movement of the foot, and can instantly start vibrations to increase the blood flow and provide relief to the user.

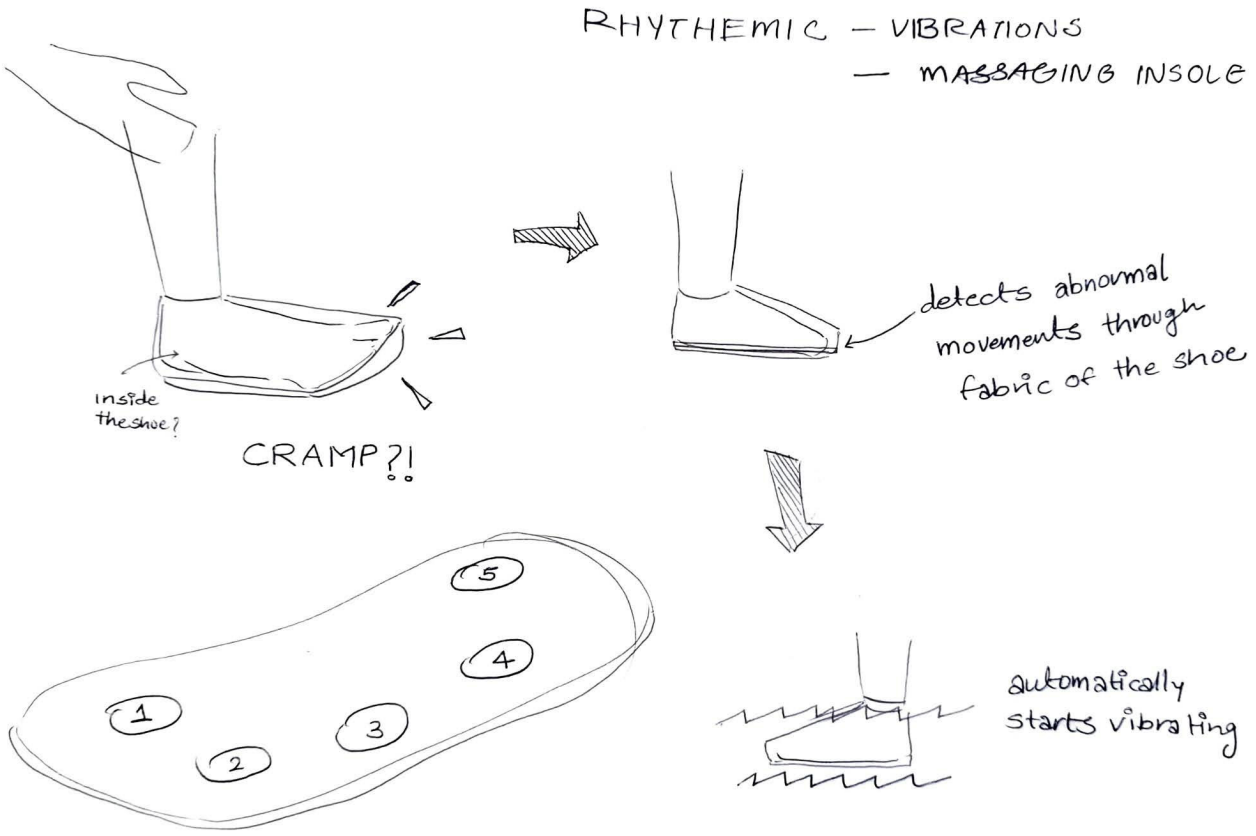


Diagram 4.11

9. New-gen footwear- Insock-

Insock which becomes your permanent footwear. The moulding insole is attached to the sock which you can wear inside your shoe.

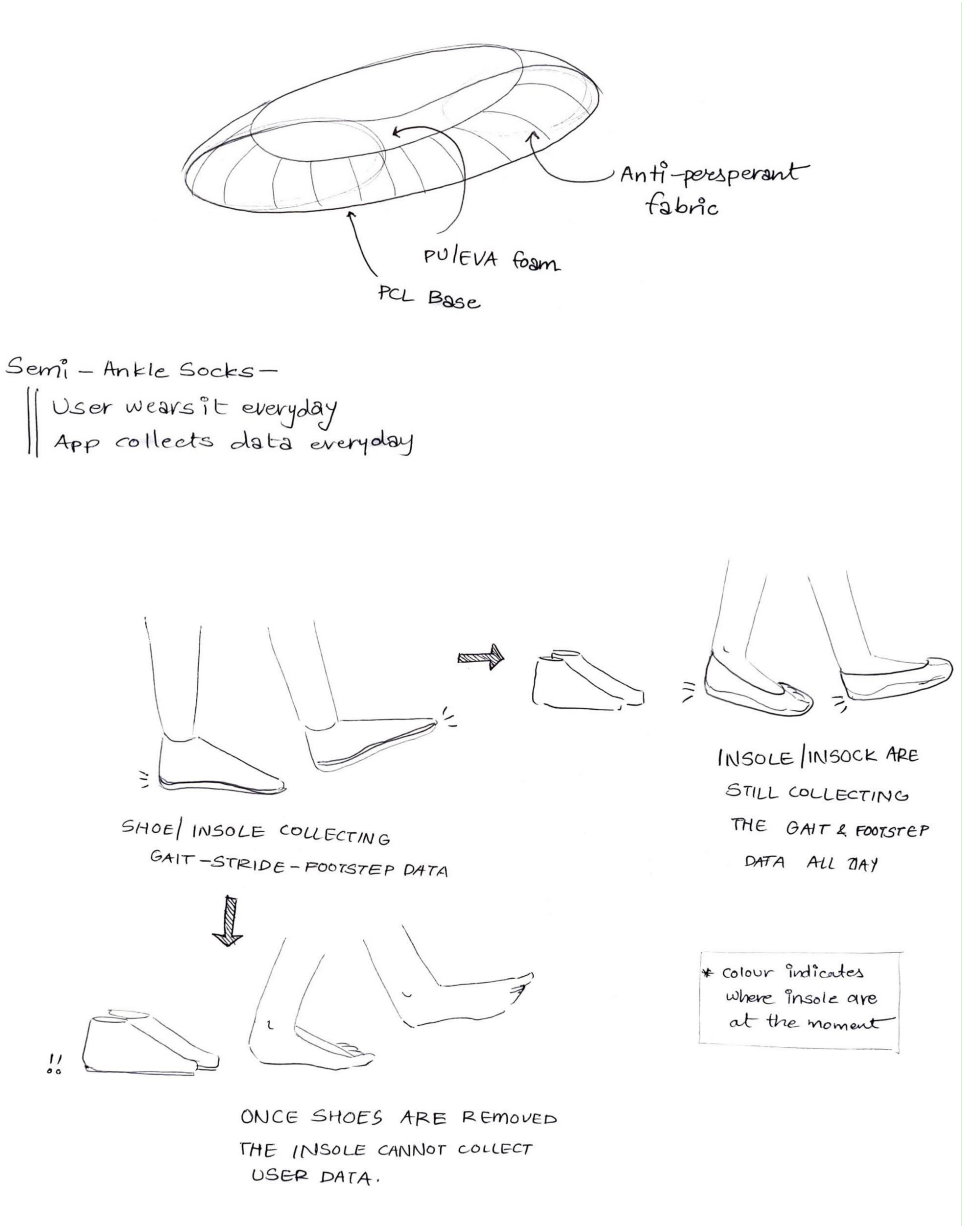


Diagram 4.12

How can I provide a shoe that can push the boundaries of comfort for users?

What legos do when we aren't looking



Directions to be taken forward for mock-ups/prototypes

- Massaging insoles with rhythmic vibrations.
- An insole that conforms to your foot such as mimicking the experience and comfort of walking barefoot.
- Look for ways to heat PCL at home by users.

The mock-up trials started with understanding material properties:

Due to covid restrictions and limited resources, initial mock-ups were made with available material at home which includes, EVA foam, Corkboard, Felt cloth, Jute sheets, PCL mask, and by optimizing electronics.

Now onwards you will be following a journey of two separate processes:

1. **Shape moulding insole**
2. massaging footwear

(Colour coded for easy continuity)

At this stage a discussion with an expert from the field was required. Mr Nathan Pereira is a Product Designer and Materials Engineer. He is currently building a new sneaker brand at Flatheads, Bangalore.

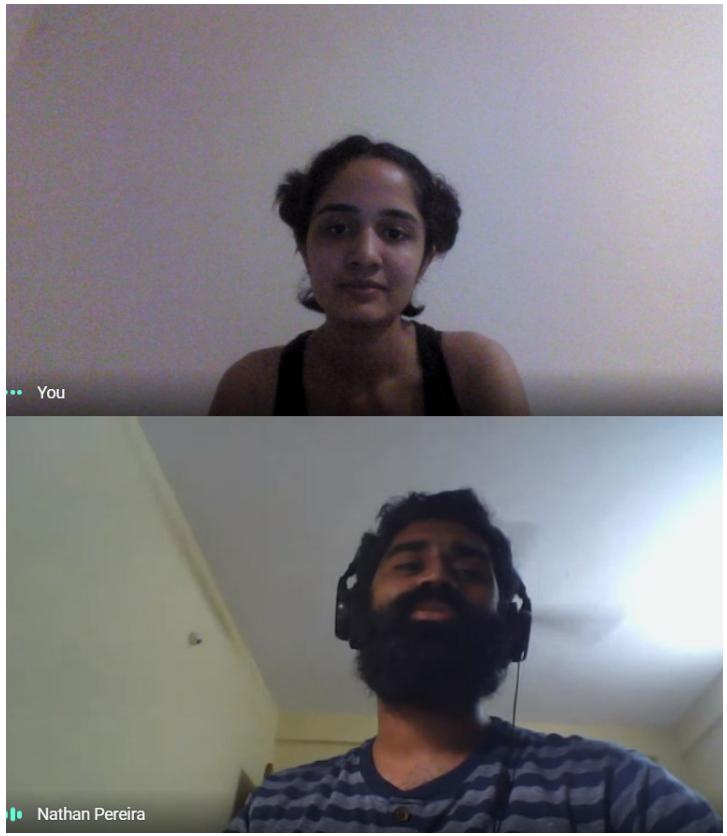


Image 4.3

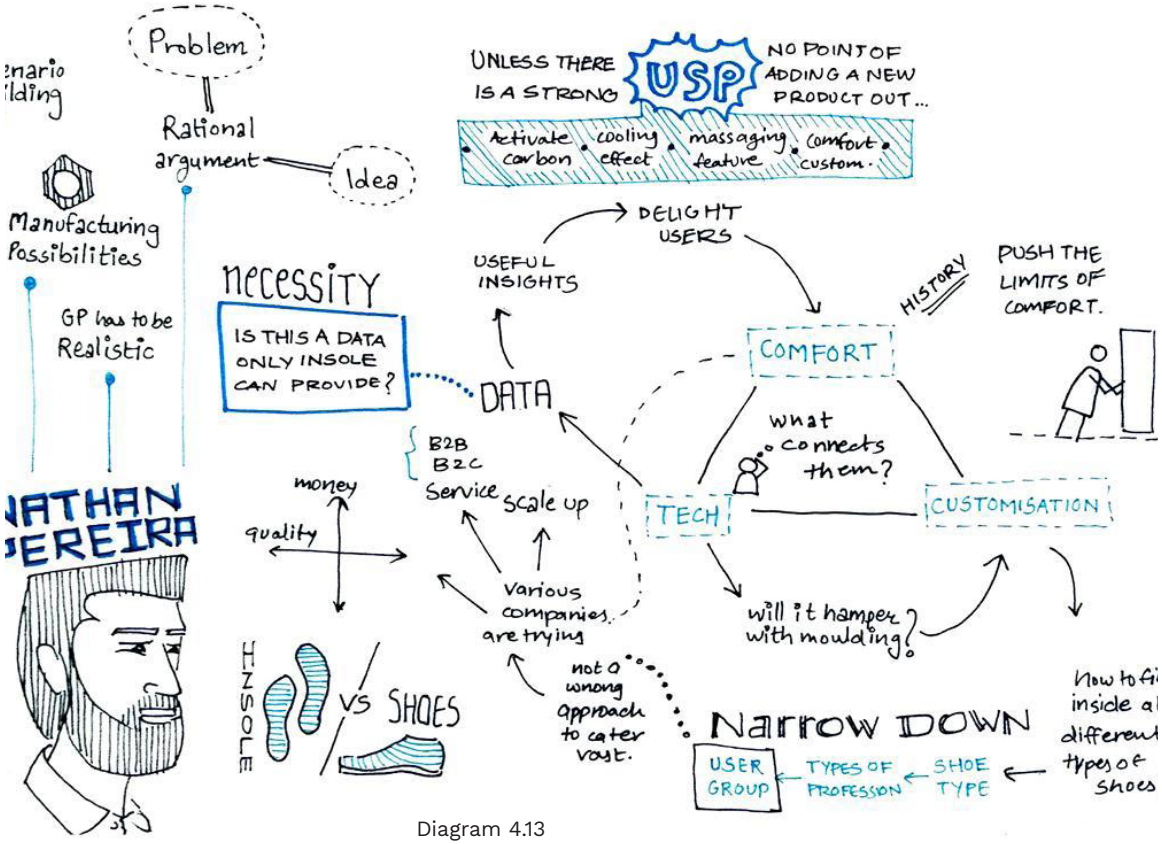


Diagram 4.13

The major inputs from Nathan were,

1. Unless there is a strong USP, there is no point in adding a new product to the market.
2. If you are adding technology, is it the kind of data that only your foot can provide? Can you convert the data to something useful to delight the user?
3. Hierarchy of features: moulding>massage

Form structure :

of the arch will define the form structure of the sole inside the shoe:



Image 4.4

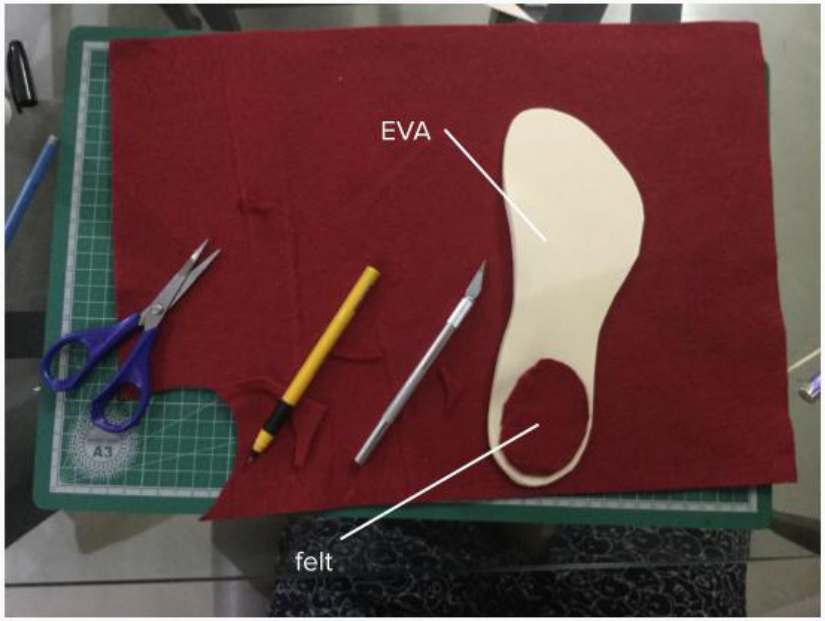


Image 4.5

Notes for measurements of the form:

Foot/footwear size (as followed by the Indian footwear market):

Men's Size Conversions				
US Sizes	Euro Sizes	UK Sizes	Inches	CM
6	39	5.5	9.25"	23.5
6.5	39	6	9.5"	24.1
7	40	6.5	9.625"	24.4
7.5	40-41	7	9.75"	24.8
8	41	7.5	9.9375"	25.4
8.5	41-42	8	10.125"	25.7
9	42	8.5	10.25"	26
9.5	42-43	9	10.4375"	26.7
10	43	9.5	10.5625"	27
10.5	43-44	10	10.75"	27.3
11	44	10.5	10.9375"	27.9
11.5	44-45	11	11.125"	28.3
12	45	11.5	11.25"	28.6
13	46	12.5	11.5625"	29.4
14	47	13.5	11.875"	30.2
15	48	14.5	12.1875"	31
16	49	15.5	12.5"	31.8

Women's Size Conversions				
US Sizes	Euro Sizes	UK Sizes	Inches	CM
4	35	2	8.1875"	20.8
4.5	35	2.5	8.375"	21.3
5	35-36	3	8.5"	21.6
5.5	36	3.5	8.75"	22.2
6	36-37	4	8.875"	22.5
6.5	37	4.5	9.0625"	23
7	37-38	5	9.25"	23.5
7.5	38	5.5	9.375"	23.8
8	38-39	6	9.5"	24.1
8.5	39	6.5	9.6875"	24.6
9	39-40	7	9.875"	25.1
9.5	40	7.5	10"	25.4
10	40-41	8	10.1875"	25.9
10.5	41	8.5	10.3125"	26.2
11	41-42	9	10.5"	26.7
11.5	42	9.5	10.6875"	27.1
12	42-43	10	10.875"	27.6

Table 4.1

How to know your arch type?

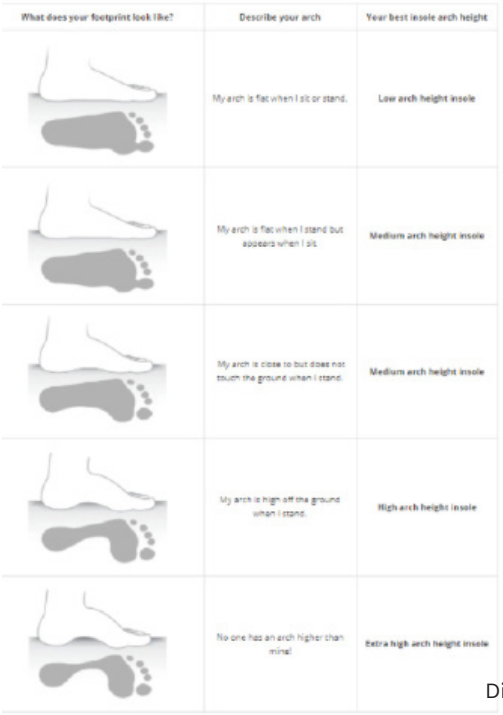


Diagram 4.14

An accurate method to measure arch dimensions:

Arch Height Index (AHI)
AHI is used to measure medial longitudinal arch and based on which foot can be categorized into high-arched, normal and low-arched.

AHI = Height of the dorsum of foot at 50% of foot length ÷ Truncated foot length

If the ratio is 0.356 or greater the foot is considered high arched, and a ratio of less than or equal to 0.275 is considered a low-arched foot. Description of arch mobility can be assessed by having AHI taken at 10% and 90% of body weight.

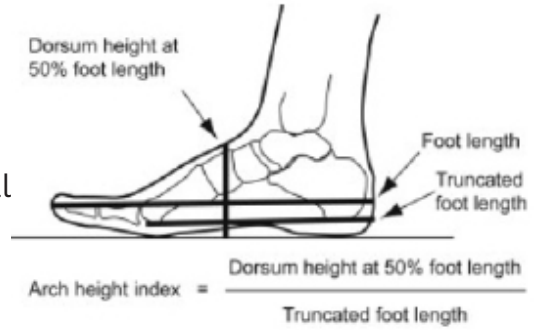


Diagram 4.15

[10]

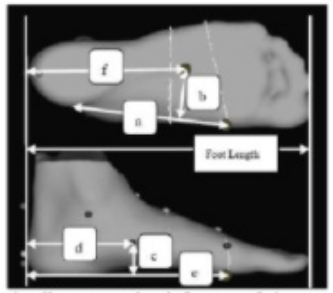


Figure 2. The illustration the definition of the six arch dimensions

Table 2. The definition of arch dimensions

dimensions	Definition
a. Arch length	The distance from the 1st metatarsal point protrusion to the landing point of medial heel (Luximon et al. 2003).
b. Arch depth	The vertical distance from the most medial point of medial border line to the line of arch length.
c. Arch height	The height of navicular (Xion et al. 2010).
d. Distance of navicular (%FL)	The straight distance of navicular to heel divided by foot length.
e. Distance of metatarsle tibiale (%FL)	The distance from the 1st metatarsal point protrusion to the heel divided by foot length (Witana et al. 2009).
f. Distance of the most medial point of medial border line (%FL)	The straight distance from the most medial point of medial border line (Hawes et al. 1992) to heel divided by foot length.

Table 4.2

[10] Imaizumi, Kazuya et al. “Effect Of Foot Load Changes On Foot Arch Evaluation Using Foot Pressure Distribution Data”. Journal Of Foot And Ankle Research, vol 7, no. S1, 2014. Springer Science And Business Media LLC, doi:10.1186/1757-1146-7-s1-a114.

[11]

Table 3 The mean, standard deviation and ANOVA test results

	Arch length (mm)	Arch depth (mm)	Arch height (mm)	Distance of navicular (%FL)	Distance of metatarsle tibiale (%FL)	Distance of the most medial point of medial border line (%FL)
Males	147.5 (7.4)	35.7 (8.4)	37.0 (5.1)	37.3 (2.1)	73.4 (1.6)	50.7 (4.4)
Females	134.9 (6.3)	35.4 (7.3)	33.1 (4.9)	36.6 (2.5)	73.3 (1.5)	52.8 (3.3)
p-value	***	NS	***	**	NS	***

NS: non-significant; ** p < 0.01; *** p<0.001

Table 4 The arch dimensions among different shoe sizes for females (N=150) and males (N=150)

	Shoe sizes (US)	Arch length (mm)	Arch depth (mm)	Arch height (mm)	Distance of navicular (%FL)	Distance of Metatarsle tibiale (%FL)	Distance of the most medial point of medial border line (%FL)
Females	4	122.6 (3.2)	35.2 (5.4)	32.5 (4.2)	35.8 (2.2)	52.2 (3.8)	72.8 (1.4)
	5	129.7 (3.8)	32.8 (8.4)	33.1 (4.8)	36.6 (2.5)	52.0 (3.8)	73.4 (1.5)
	6	135.0 (3.4)	35.9 (6.8)	32.8 (5.2)	36.9 (2.5)	53.2 (3.0)	73.6 (1.6)
	7	139.1 (3.0)	36.7 (6.1)	34.4 (4.1)	35.9 (2.3)	52.6 (3.3)	72.7 (1.5)
	8	144.6 (3.7)	35.7 (10.5)	32.4(5.9)	36.9 (2.8)	53.1 (3.3)	73.2 (1.4)
Males	7	138.1 (4.2)	37.7 (6.2)	38.1 (6.0)	37.4 (2.2)	73.0 (1.4)	51.7 (3.1)
	8	145.2 (4.0)	36.8 (7.9)	36.3 (4.8)	37.4 (2.2)	73.5 (1.7)	51.3 (4.3)
	9	150.7 (4.1)	35.5 (8.5)	37.6 (5.0)	37.0 (2.0)	73.4 (1.5)	51.0 (4.2)
	10	157.0 (3.4)	31.3 (10. 5)	36.9 (4.7)	37.4 (2.0)	73.5 (1.6)	47.9 (5.4)
	11	162.4 (4.1)	30.3 (9. 3)	35.1 (4.9)	36.4 (2.6)	73.4 (1.2)	49.3 (6.0)

Table 4.3

[11] Anthropometric Dimensions of Foot in Northwestern Iran and ... www.researchgate.net/publication/327021689_Anthropometric_Dimensions_of_Foot_in_Northwestern_Iran_and_Comparison_with_Other_Populations.

[12]

The base insole will be remoulded and reshaped according to different heights of arch & navicular height and the 50% length of foot when pressed down, the maximum arch height index during level walking and maximum MFL(midfoot length) is to be considered.

Variable	Mean	SD	Minimum	Maximum
Males (n = 24)				
Arch height index	0.354	0.019	0.322	0.394
Normalized navicular height	0.142	0.031	0.088	0.199
Arch index from inked footprint	0.241	0.056	0.111	0.352
Arch index from F-Scan	0.205	0.079	0.029	0.318
Inked footprint index	0.308	0.110	0.068	0.453
Modified arch index	0.101	0.063	0.006	0.245
Subjective ranking	2.000	0.659	1.000	3.000
Malleolar valgus index	13.072	4.175	5.587	21.694
Midfoot dorsal angle (α) (°)	25.125	2.595	20.750	31.000
Females (n = 24)				
Arch height index	0.352	0.029	0.311	0.416
Normalized navicular height	0.140	0.030	0.073	0.185
Arch index from inked footprint	0.235	0.035	0.156	0.329
Arch index from F-Scan	0.203	0.069	0.024	0.355
Inked footprint index	0.327	0.084	0.119	0.498
Modified arch index	0.105	0.059	0.005	0.207
Subjective ranking	1.875	0.680	1.000	3.000
Malleolar valgus index	11.026	4.934	2.399	19.557
Midfoot dorsal angle (α) (°)	24.615	2.368	20.000	29.750

Table 4.4

[12] Xiong, Shuping, et al. “Foot Arch CharacterizationA Review, a New Metric, and a Comparison.” Journal of the American Podiatric Medical Association, Allen Press, 1 Jan. 2010, meridian.allenpress.com/japma/article/100/1/14/104589/Foot-Arch-CharacterizationA-Review-a-New-Metric.

Shoes are made from dozens of overlapping materials being glued or stitched together. They require separation and proper treatment to be efficiently recycled, which is extremely complex and costly. As a result, 95% of shoes produced today will end up incinerated or in a landfill, even shoes made of clean or recycled material. Environmental organizations promote and encourage **mono-material** recycling because it is a high-quality recycling process which allows multiple outlets for the recovered materials and offers high-efficiency potential.



Image 4.6



Image 4.7

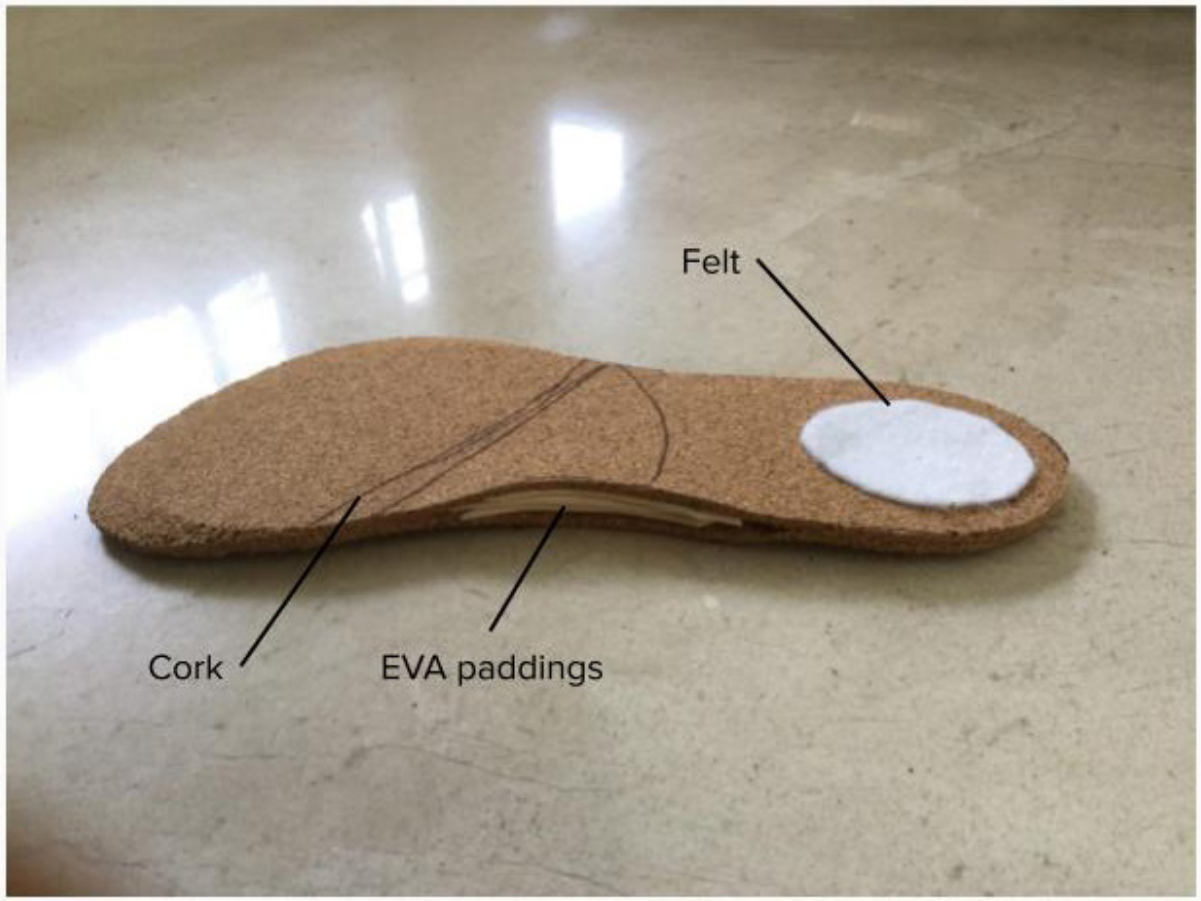


Image 4.8

EVA plastic is the standard material used in footwear around the world. If we need to reduce the product to mono-material manufacture, for future scope for easy recycling, the process we can use with EVA plastic is mould and press. EVA plastic because it’s a malleable, multi-use material that doesn’t mark. It’s also hypoallergenic and anti-bacterial.

Guide meeting

After generating ideas in different directions, It was time for me to get another input from my mentor.

I was lucky to be living in the same state as my guide mentor, and therefore when the situation allowed, I could visit him in person, taking all precautions.



Image 4.9

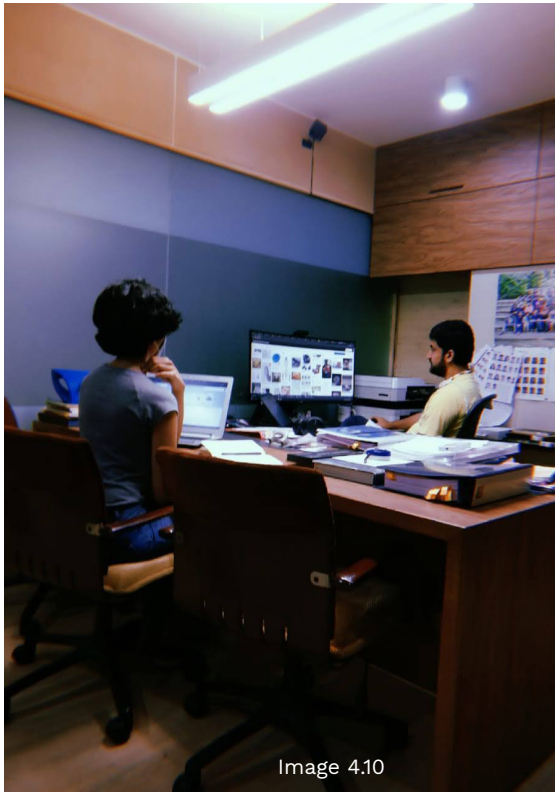


Image 4.10



During the meeting we discussed about the first level mock up that I had created with the material at home. Some combinations and few tweaks here and there, but the major takeaway was to move from paper to materials.

At this point of project, I had to start my experiments with PCL but due to covid implicated lock down, most of the international business was taking more time than normal. This was stretching my timeline by months.

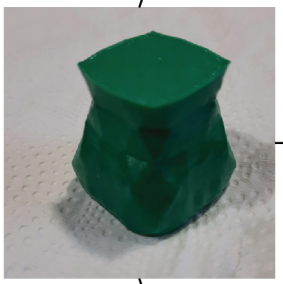
We decides to use pieces of a mask which was available at my home from my father’s radiation therapy. We also found 2-3 contact point who had the material available in filament form that could be easily 3d printed with a compatible printer.

Polycaprolactone exploration:

The first time I encountered the PCL material was in 2016. In radiation therapy after cancer treatment, it is required to capture the precise shape of whichever body area that needs the treatment. For this, A mask is created out of PCL- Polycaprolactone.

The process followed is - a perforated sheet of 3-4 mm thickness is first dipped into hot water(temp: 60-70^{o})as the material softens, the sheet is carefully put on whichever body part, firmly pressed from top, till it cools down and becomes stiff again.

With the already available PCL mask at home, a few experiments were run to check the reliability of the material. With a positive outcome, further experiments were conducted with fresh PCL filament/3d printed structure.



Before Heating

First structure with no rib structure



After heating the PCL becomes very soft in just a couple of seconds & becomes difficult to handle

2nd structure with 50% rib structure





After heating for roughly 2 minutes, the PCL becomes mouldable, yet sturdy on the joints.

3rd structure with complete rib structure



After heating for almost 5 minutes the PCL becomes soft in few spots, major area is still hard.

Table 4.5

First trial of 3D printed insole:



Image 4.11



Image 4.12

Observation chart:

Each time the insole was heated in a **microwave** inside a **cotton bag**

Time	Observation	Inferences
10 sec	- Major Area is soft - Heel area with more dense structure was still hard	Need to increase heating time
15 sec	- Back heel is soft - Thinnest area sticks to the cloth bag	Form needs to change, make thinnest area of 2 mm and so on
20 sec	- Majority of area becomes overly stretchable and rubbery - Sticks to the cloth bag	Heating time is too long

Table 4.6

Second trial of 3D printed insole:



Image 4.12



Image 4.13



Image 4.14



Image 4.15

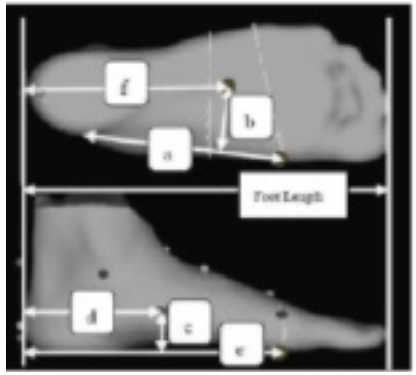


Diagram 4.16

C --- Arch height for proto: 34.5 mm
A --- Arch length for proto: 139 mm
B --- Arch depth for proto: 35.5 mm

E --- Half insole length for proto: 165 mm

Observation chart:

Each time the insole was heated in a **microwave** inside a **cotton bag** for 15 sec (Support structure in all is at 10%)

How was it shaped?	Observation	Inferences
User sits, insole is moulded using hands	- The surface of PCL sticks to one's hand - Finger prints and dents on the surface	Final result is not clean and smooth as expected
Insole on the floor, user stands on top till insole cools down	- The entire process takes roughly a minute - Bottom of the insole is flat due to floor pressure	Bottom side is flat - Doesn't fit in sports footwear easily
Insole in the mould, user stands on top to shape it	Insole placement in the mold is tricky and inconvenient - Bottom contour helps press near the arch area	Can be used with multiple footwear but less accurate shape
Insole in the footwear, user stands on top	- Insole placement is easier than before	Very specific to particular footwear - Accurate contour

Table 4.7

PCL - Polycaprolactone:

Once the time and method was narrowed down to 15 sec in a microwave, different support structures for 3d printing were explored to decide the final insole density and structure.

Each time the insole was heated in a **microwave** insidea **cotton bag**

Time	Support Structure	Observation
15 sec	10%	Entire insole softens at desired state, but the arch are collapses
15 sec	20%	Entire insole softens at desired state, Arch area is retaining it's shape, after molding
15 sec	40%	- Arch area is still sturdy compared to the thin are which has almost melted after 15 sec

Table 4.8

As the proof of concept was taking shape, it was now time to work around the form and CMF of the shoe. As always the process started with a mood board and form sketches inspired from there.



Massaging feature:

At first the massage feature was to be controlled through mobile application using a Bluetooth chip in the shoe. Below is the optimized circuit for mock up run.
User--->Mobile--->Application--->Bluetooth--->Power supply --->Vibrating motors

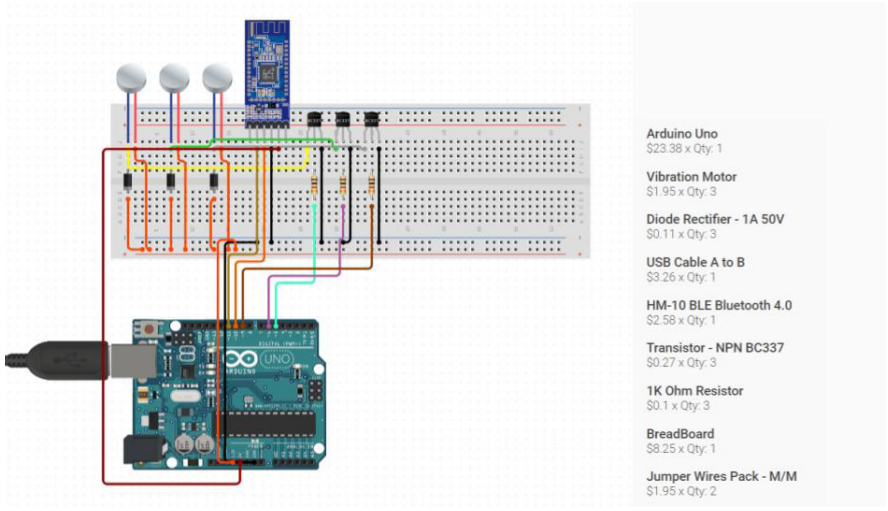


Diagram 4.16

Electronics/massaging feature:

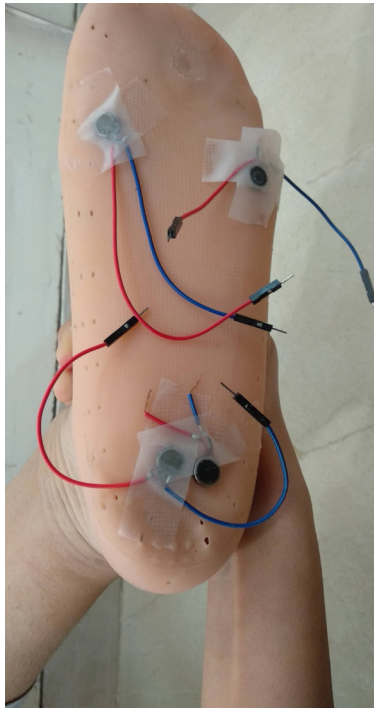


Image 4.16

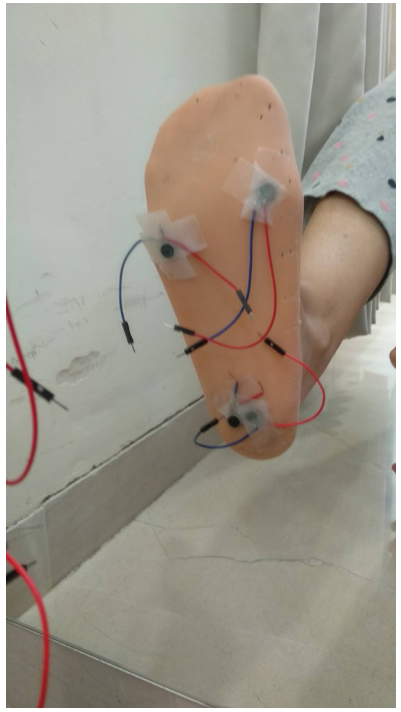


Image 4.17

Using a silicon based insole to decide different points to place the vibration motors for maximum area coverage.

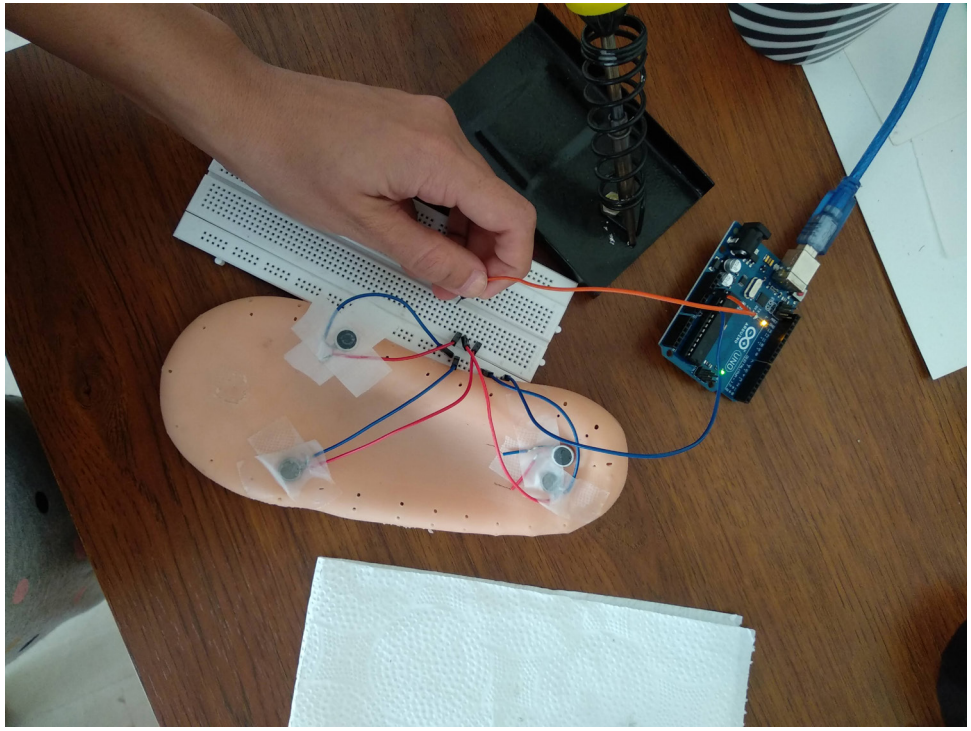


Image 4.18

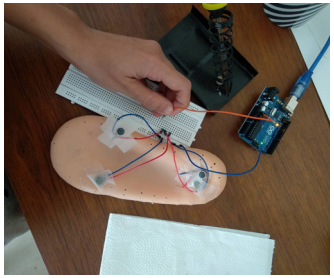


Image 4.19

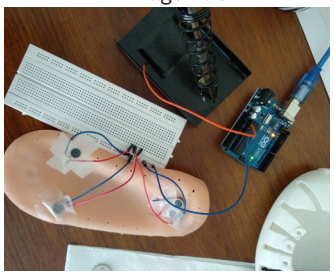


Image 4.20

Rhythmic vibrations
vs. on spot effect trial.

Once the placement of vibration motors was finalized for maximum effect, we tried to move to the next step.

With Mr Nathan Pereira's insight and further brainstorming, The next model with electronics was combined with an accelerometer, to capture the gesture and provide input to start different modes of vibrating motors.

User gesture ----> accelerometer ----> power supply ----> vibrating motors

(2 steps reduced)

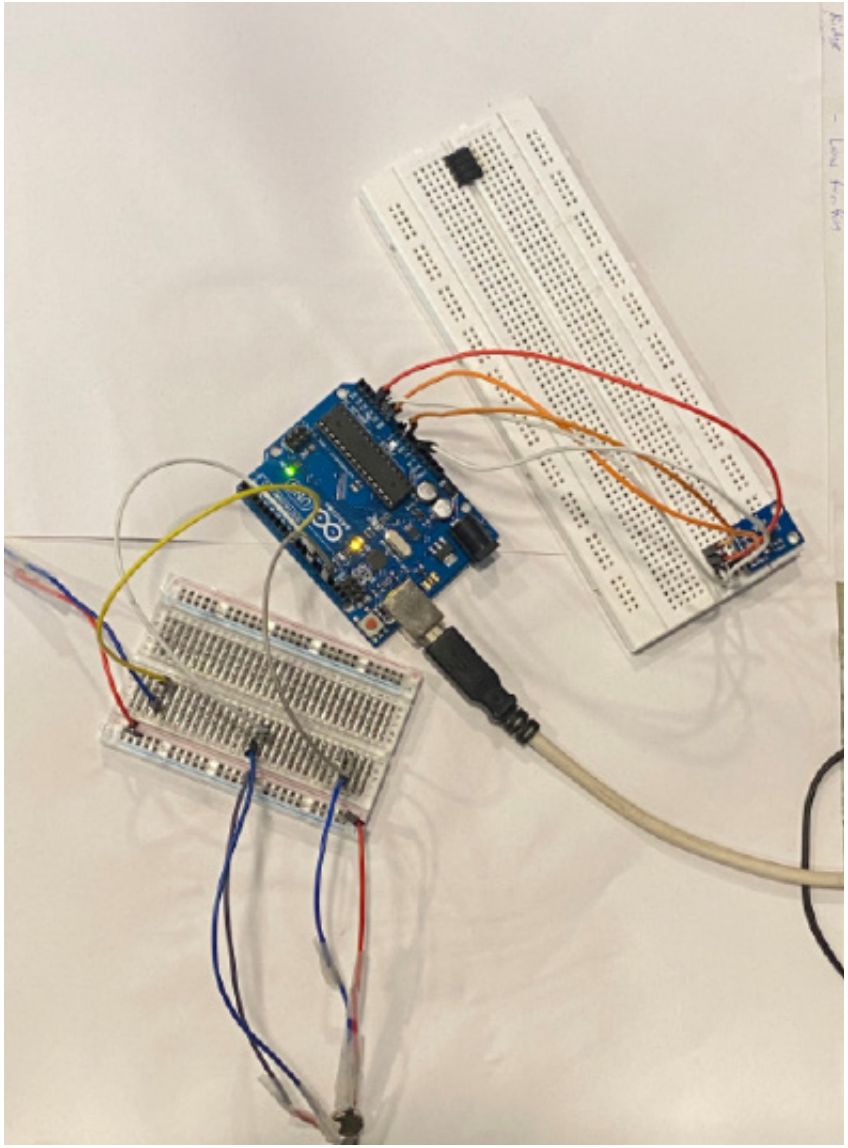


Image 4.21

Below are the graphs to show the motion sensed by the accelerometer and how the gesture is noted as the input to start the motors.

Stage 1.

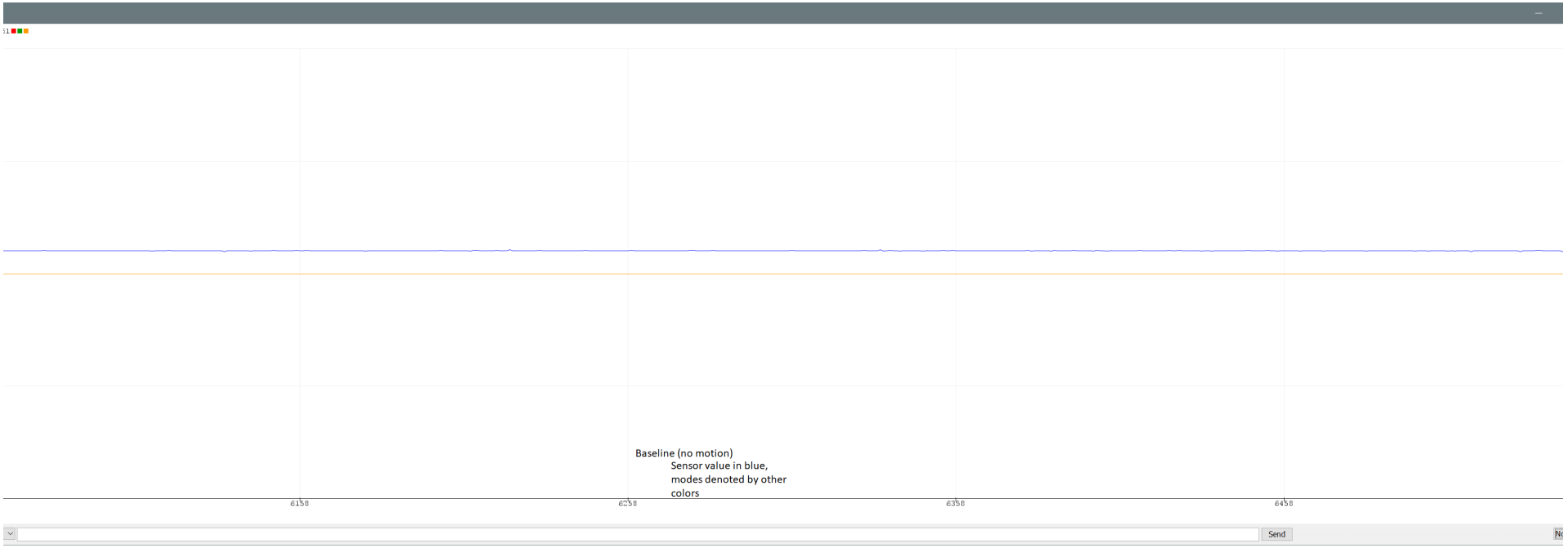


Diagram 4.16

Stage 2.

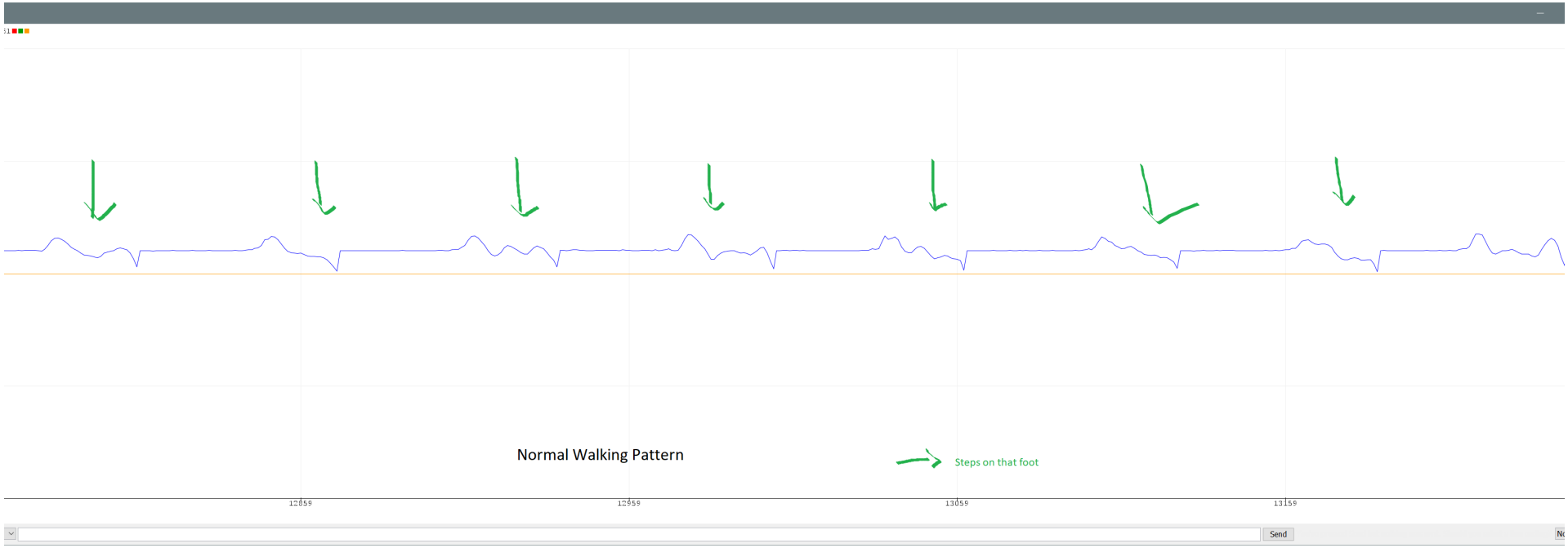


Diagram 4.17

Stage 3.

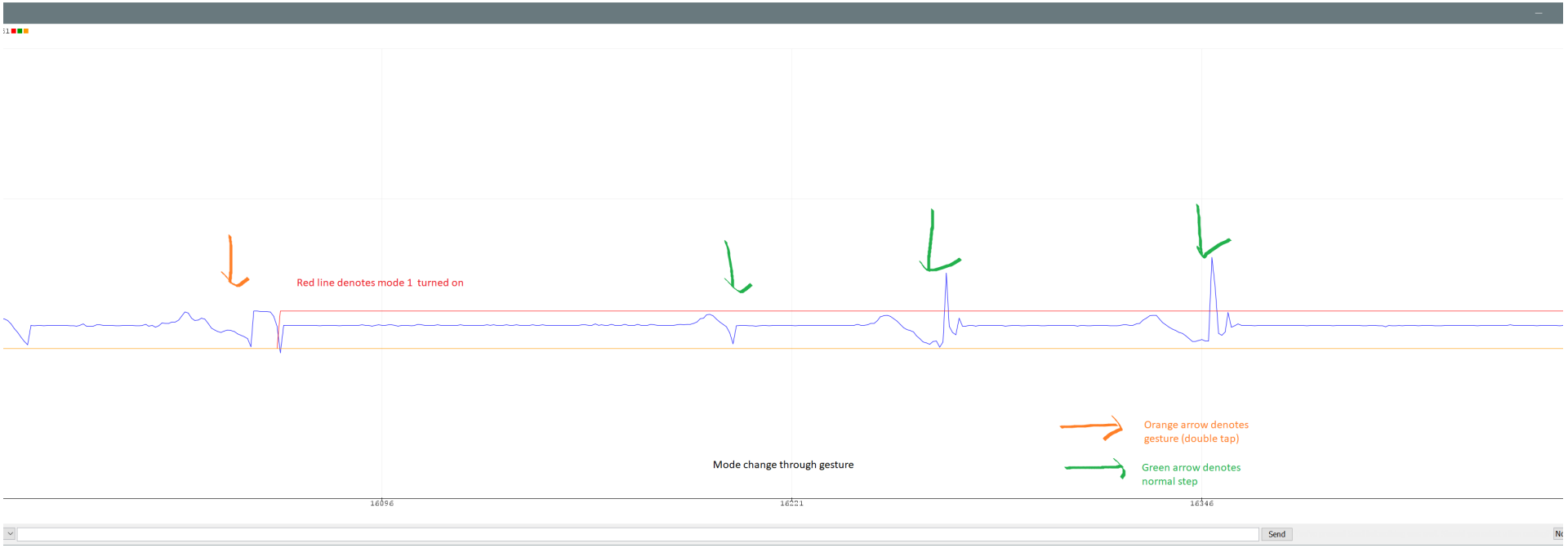


Diagram 4.18

Stage 4.

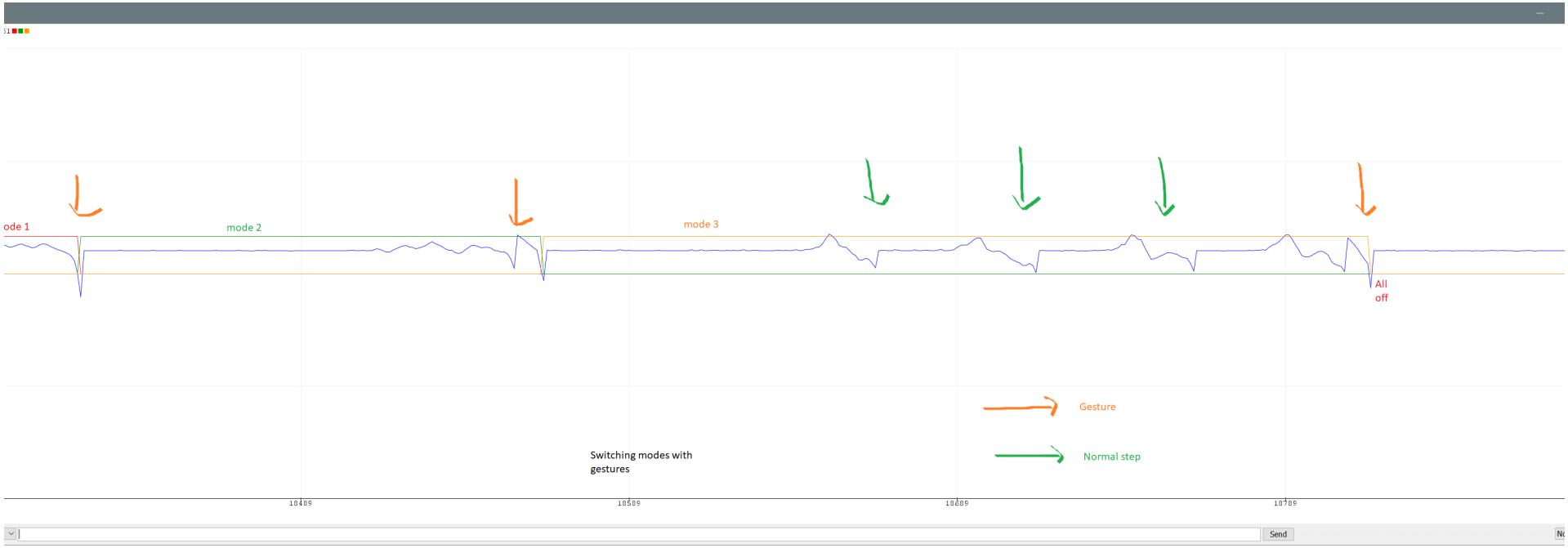
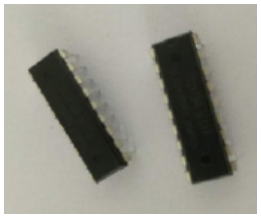


Diagram 4.19

Furthermore, the circuit was rebuilt by using smaller parts which can easily fit in the area of the shoe. At this point we were forced to use the whole parts of an accelerometer and an arduino mini due to a compromised production facility at home. The parts we used are mentioned here.



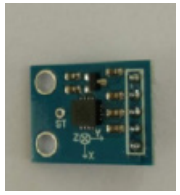
ULN 2803
23.1x8.0x7.15 mm



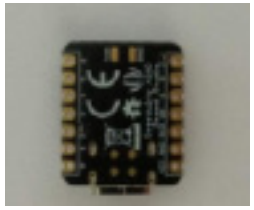
Battery cell holder
24.1x21.7x8.6 mm



Vibrating motor
3.0x10x10 mm



Accelerometer
21.2x16.9x11.2 mm



Arduino mini
18.0x22.5x 4.5 mm

The optimized circuit at this point looked like this.

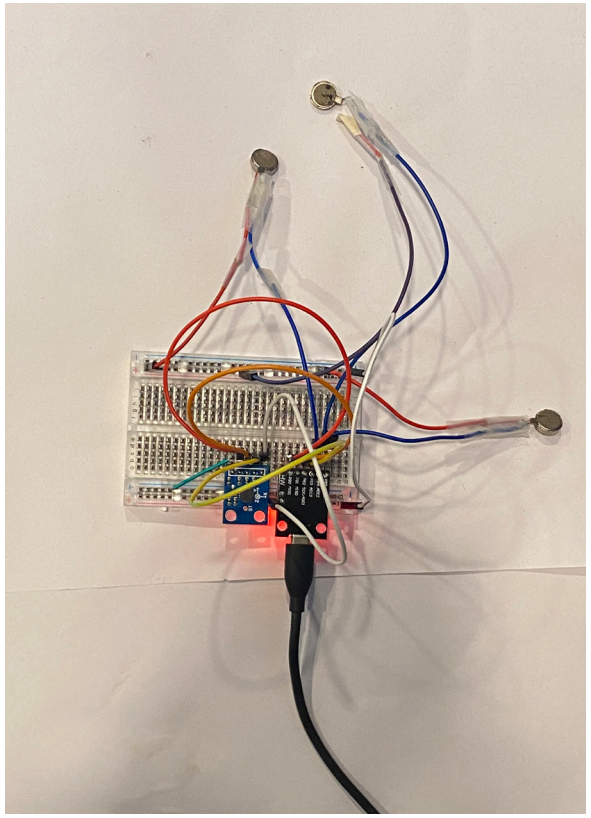


Image 4.22

Once the size of the technology was finalized, I went ahead to decide the placement on the foot contour - which allowed me to make the cavities in the sole to place electronics safely.

Doing so, led me to creating the 3d model for the prototype of the shoe, which would mimic the look and feel of the final product that was envisioned.

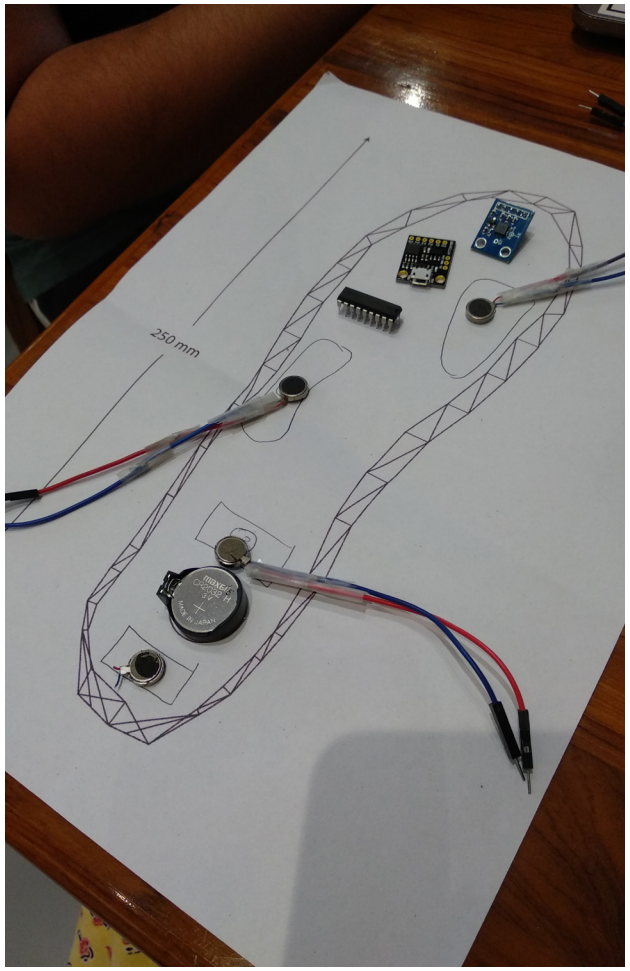


Image 4.23

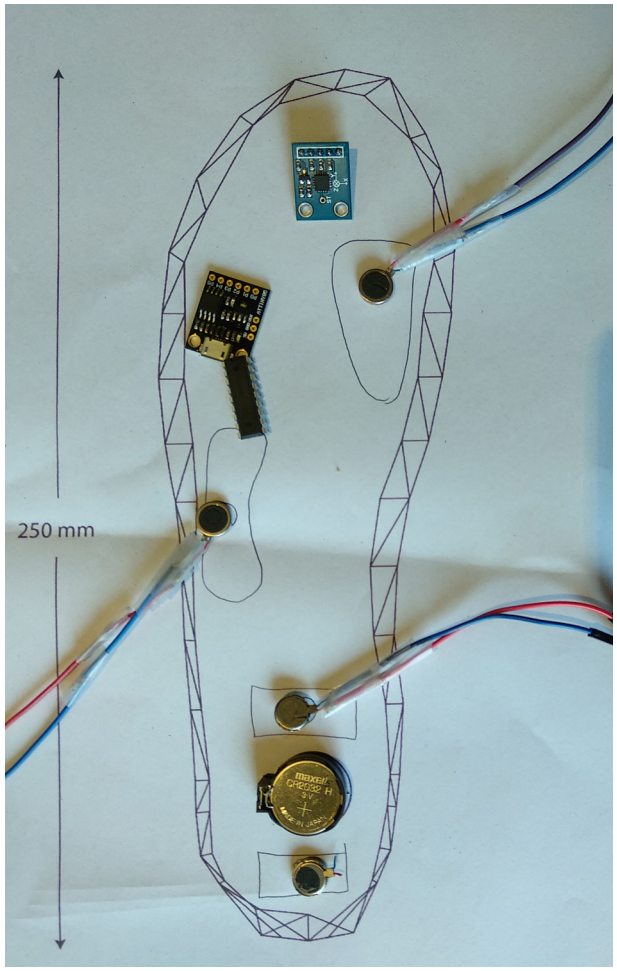


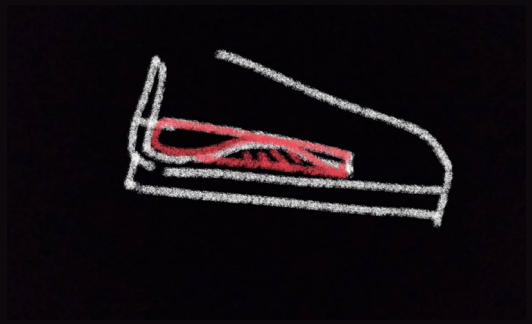
Image 4.24

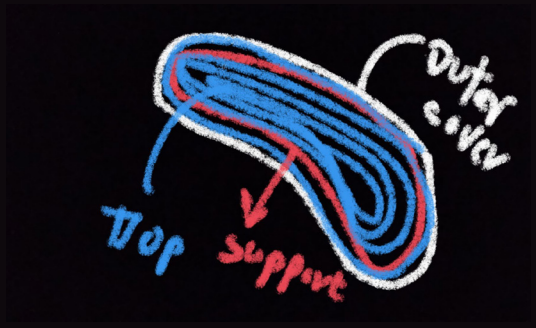
Visualization

- **Concept iteration**
- **Form study/mood board**
- **Proof of concept development**
- **Exploded view**
- **Technical specifications**
- **Product dimensions**
- **User Journey**
- **Cost estimate**



Concept iteration

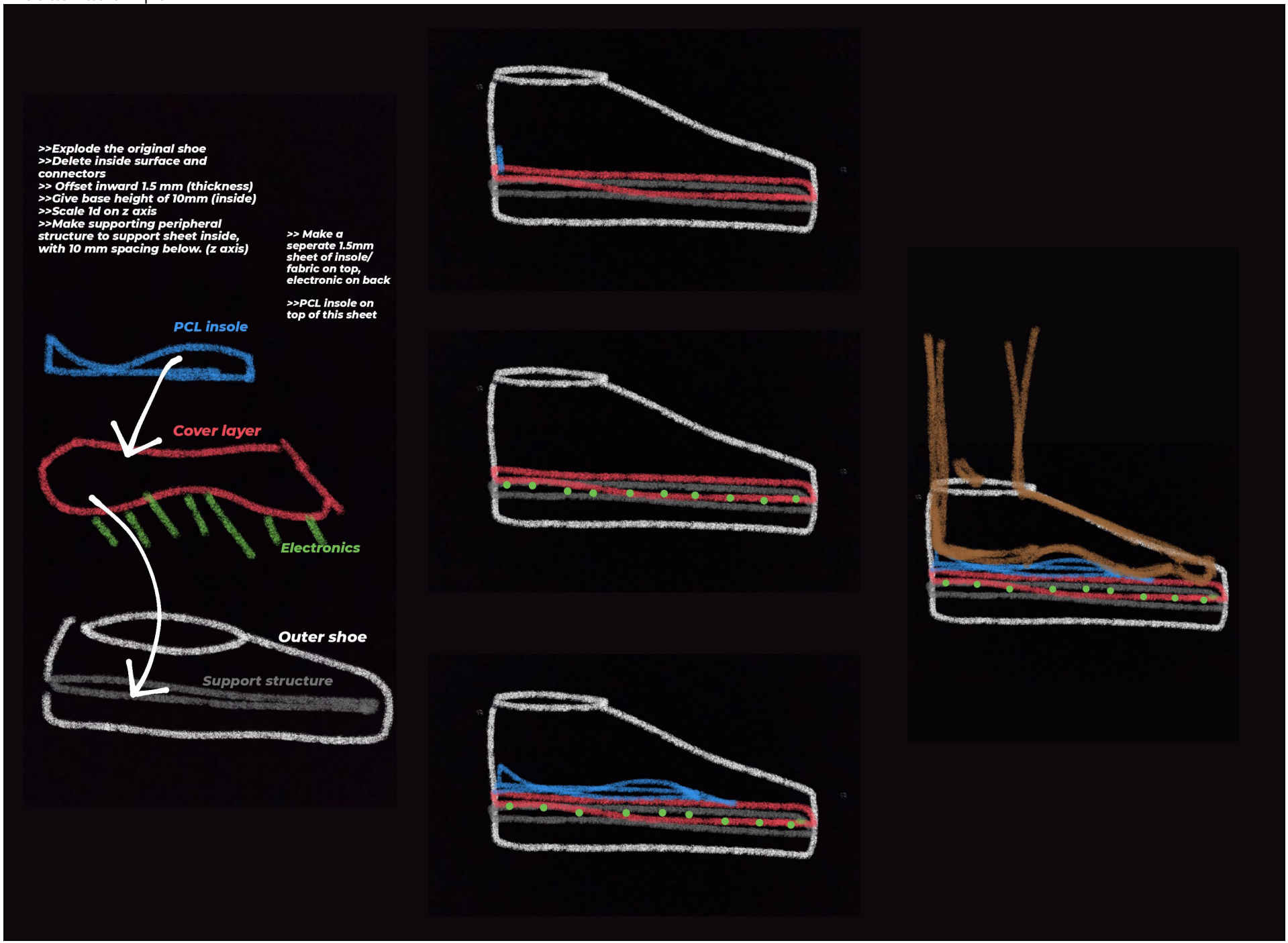




>>Explode the original shoe
>>Delete inside surface and connectors
>> Offset inward 1.5 mm (thickness)
>>Give base height of 10mm (inside)
>>Scale 1d on z axis
>>Make supporting peripheral structure to support sheet inside, with 10 mm spacing below. (z axis)

>> Make a seperate 1.5mm sheet of insole/fabric on top, electronic on back

>>PCL insole on top of this sheet


>>Explode the original shoe
>>Delete inside surface and connectors
>> Offset inward 1.5 mm (thickness)
>>Give base height of 10mm (inside)
>>Scale 1d on z axis
>>Make supporting peripheral structure to support sheet inside, with 10 mm spacing below. (z axis)
>> Make a seperate 1.5mm sheet of insole/ fabric on top, electronic on back
>>PCL insole on top of this sheet
PCL insole
Cover layer
Electronics
Outer shoe
Support structure

Form study/mood board



Image 5.1



Image 5.2



Image 5.3



Image 5.4



Image 5.5

Bold

Pleasent

Soft

Proof of concept

Which is further refined into a working prototype made with optimized electronic pieces embedded in a footwear made out of TPU (Thermoplastic Polyurethane). Here due to lack of resources a proof of concept is made using 1 chip of accelerometer, 1 chip of arduino, and a 9v battery. In the final production of the product, these 3 modules can be converted into one chip of the size of 10x10x2 mm and a wireless charging coil of the size of 42 mm diameter. The optimized circuit is shown in a render on the next page.

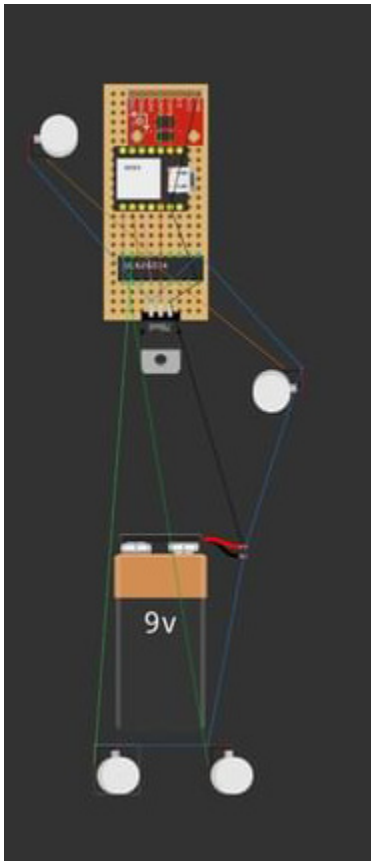


Diagram 5.6

Circuit diagram



Image 5.7

Top side of insole in left shoe

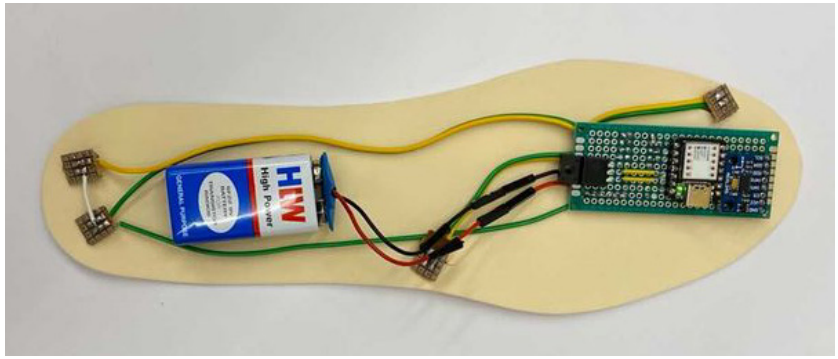


Image 5.8

Bottom side of insole in left shoe

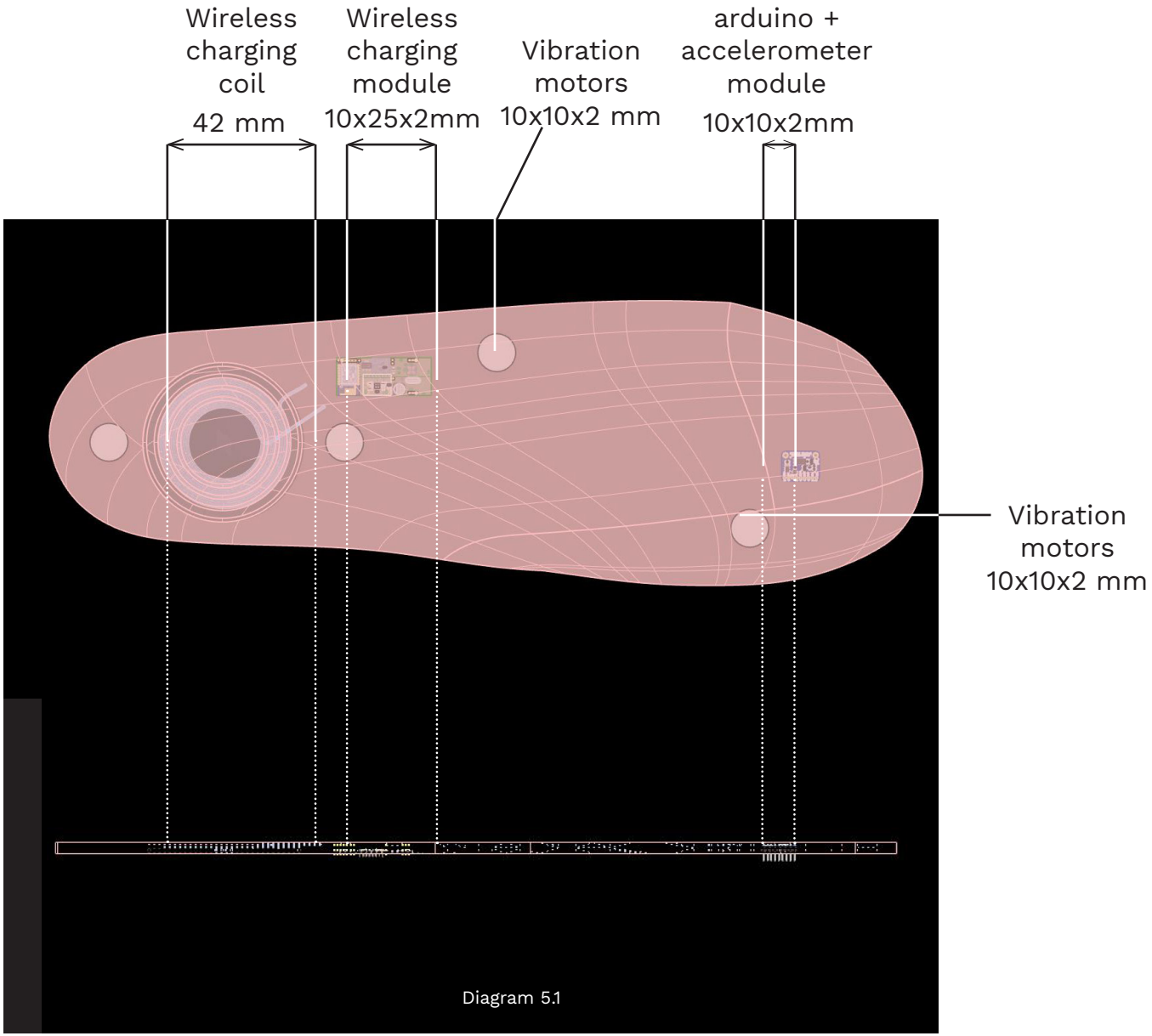

Wireless charging coil
42 mm
Wireless charging module
10x25x2mm
Vibration motors
10x10x2 mm
arduino + accelerometer module
10x10x2mm
Vibration motors
10x10x2 mm

Diagram 5.1

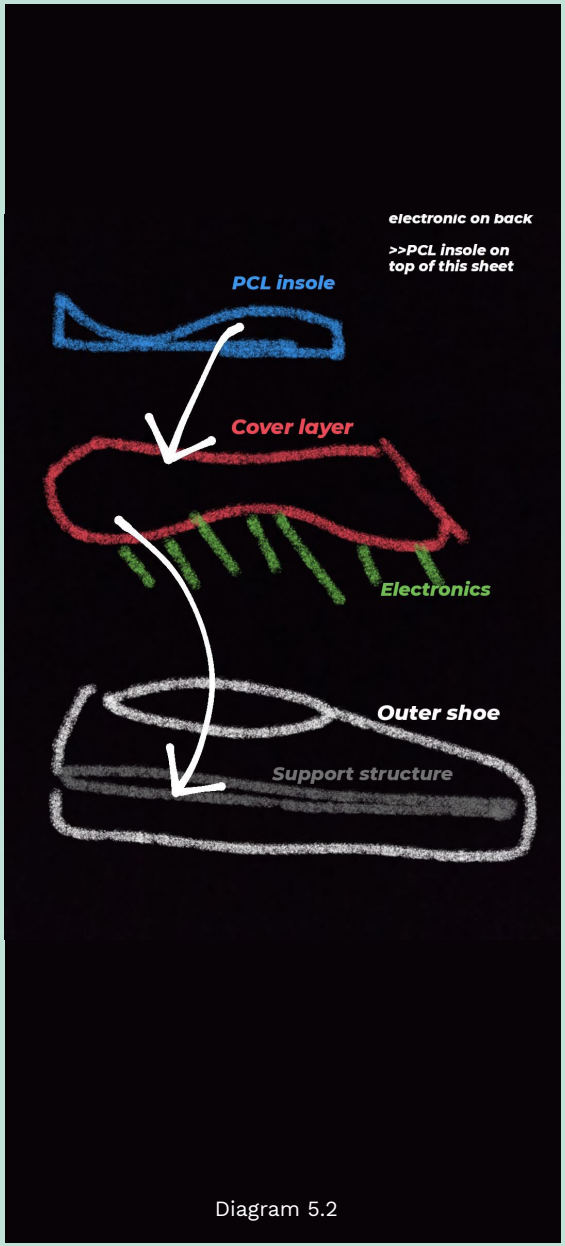


Diagram 5.2



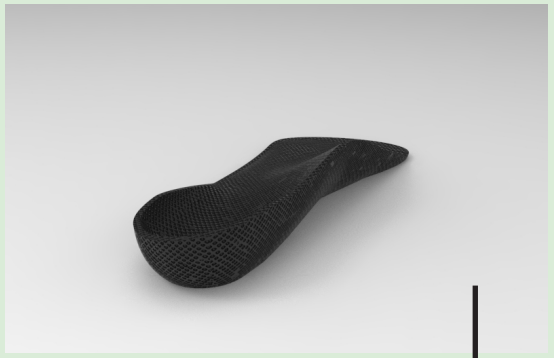
Image 5.9



Image 5.10



Image 5.11



Render 5.1



Render 5.2



Render 5.3

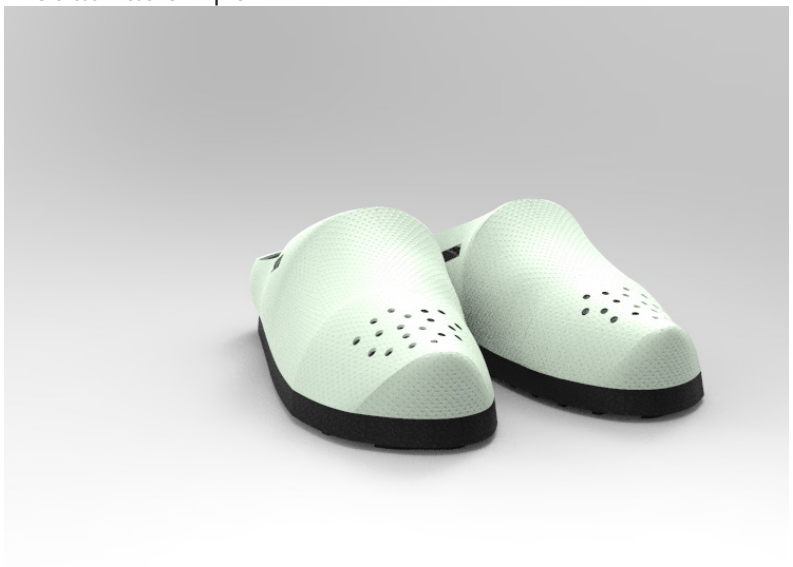
SKETCH

PHYSICAL WORKING PROTOTYPE

VISUALIZATION



Render 5.4



Render 5.5



Render 5.7

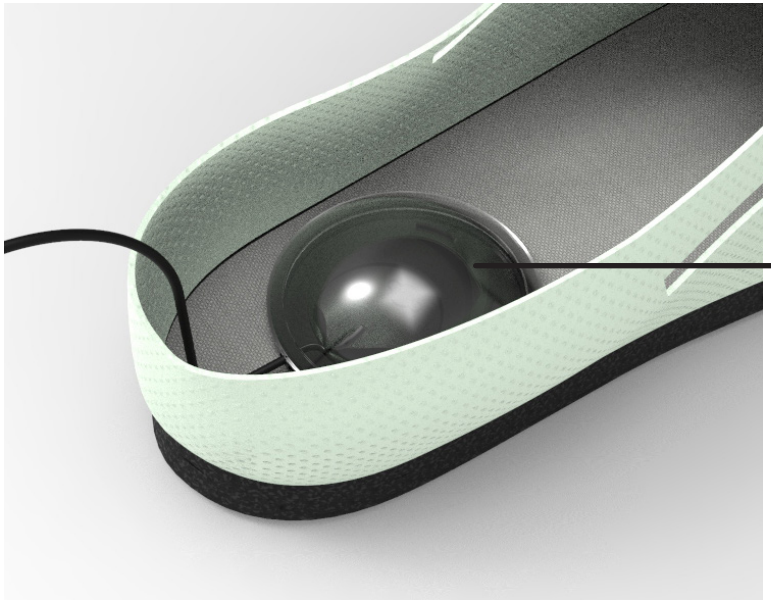


Render 5.6



Render 5.8

Indicator grooves for charging pod placement

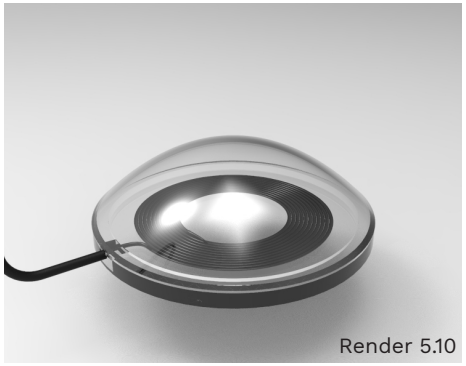


Render 5.9

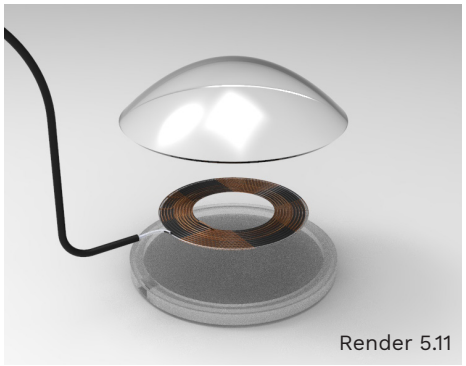
Charging pod

Detailed view

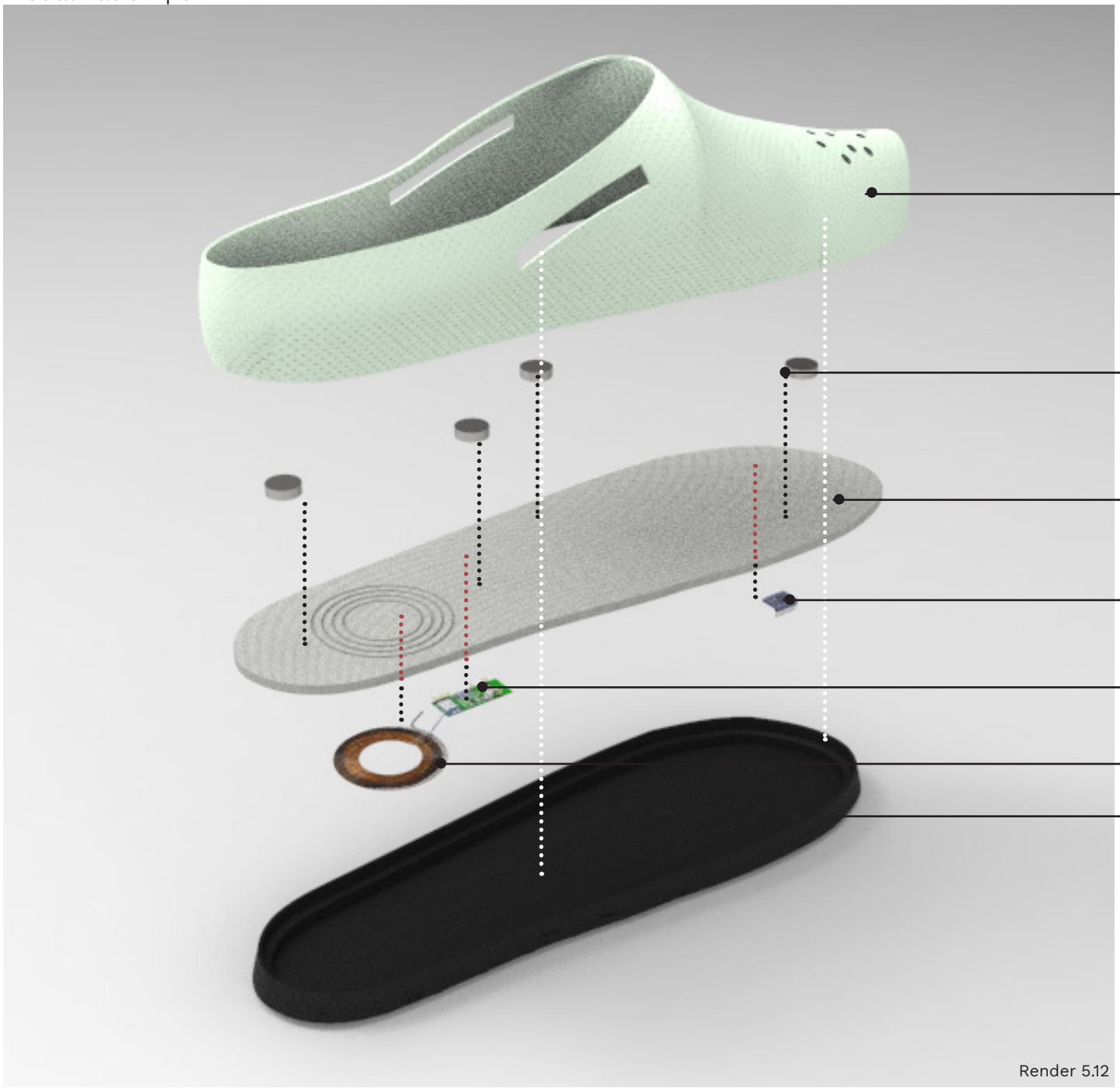
Exploded view



Render 5.10



Render 5.11


Top layer made
out of single TPU
(2.5 mm thickness)
(Press molded)
Vibrating motors
Embedded electronics
into the grooves of TPU
- top layer with
industrial felt
Chip module 1
Charging module 2
Charging module 1 - coil
Bottom case single TPU
(Wall thickness of 4 mm)
(Press molded)

Render 5.12



Render 5.13

Technical Specifications

Electric components:

- *Chip module 1 contains, Accelerometer, PCB, Bluetooth*
- *Charging coil made of copper and charging module*
- *Vibrating motors (coin sized)*

Upgrade PI film for resisting tear and humidity.

Materials:

- Polycaprolactone (PCL) used in molding insole
- Flexible Thermoplastic Polyurethane (TPU) - Elastollan[13] is used to make the outer casing of shoe, bottom case of shoe entirely of one material for easy breakdown of product at the end of its life-cycle.
- Industrial felt to cover top layer inside the shoe for comfortable skin contact

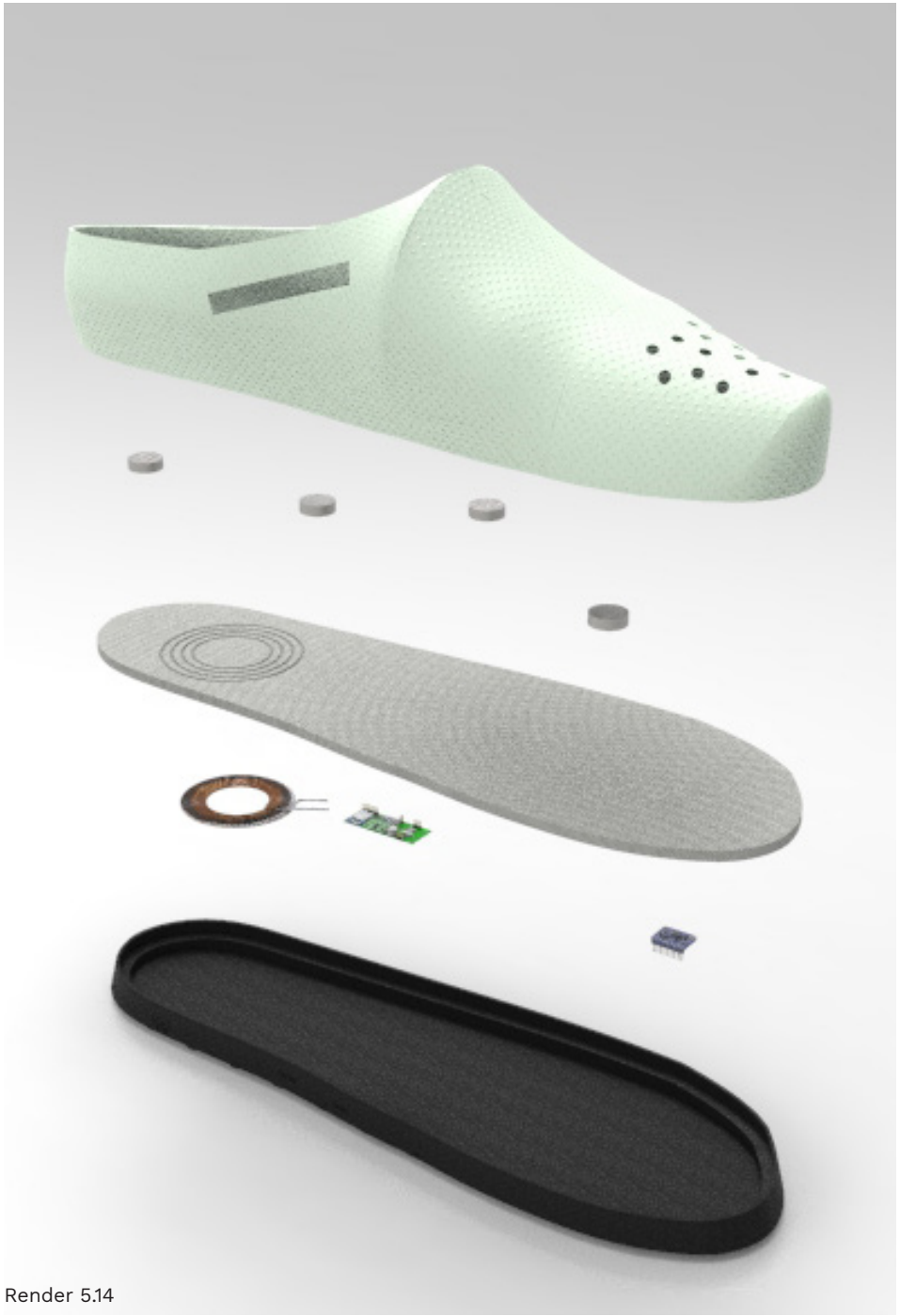
Battery:

- 5V 2A Large Current Wireless Charger Module Transmitter Receiver Charging Coil Module

- Due to the adoption of a Contactless charging power supply, to complete sealing of the products, waterproof and dust-proof; increase product service life, use more convenient.

Connectivity:

- Bluetooth chip inside both shoe chip module for mode changing

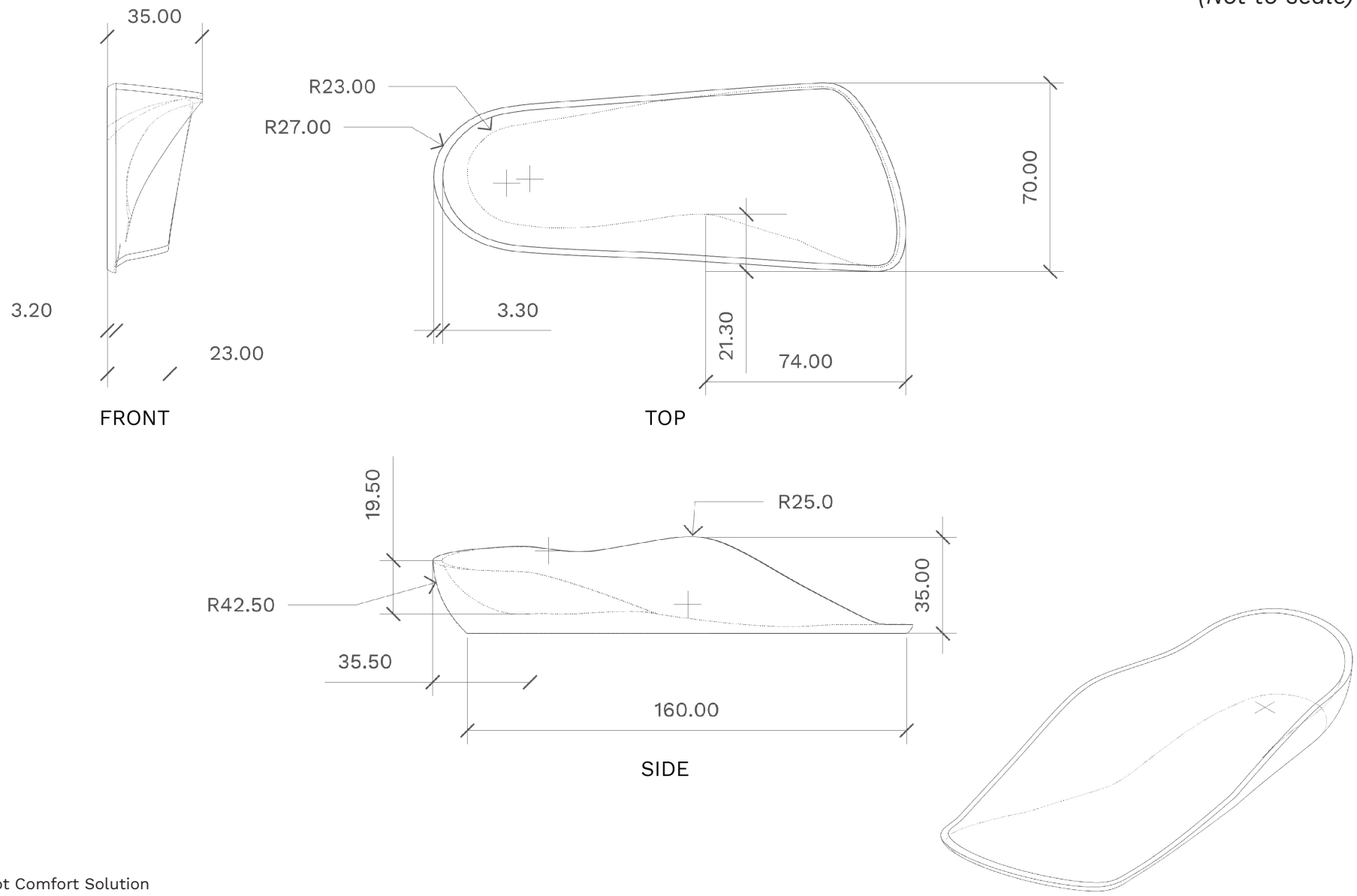


Render 5.14

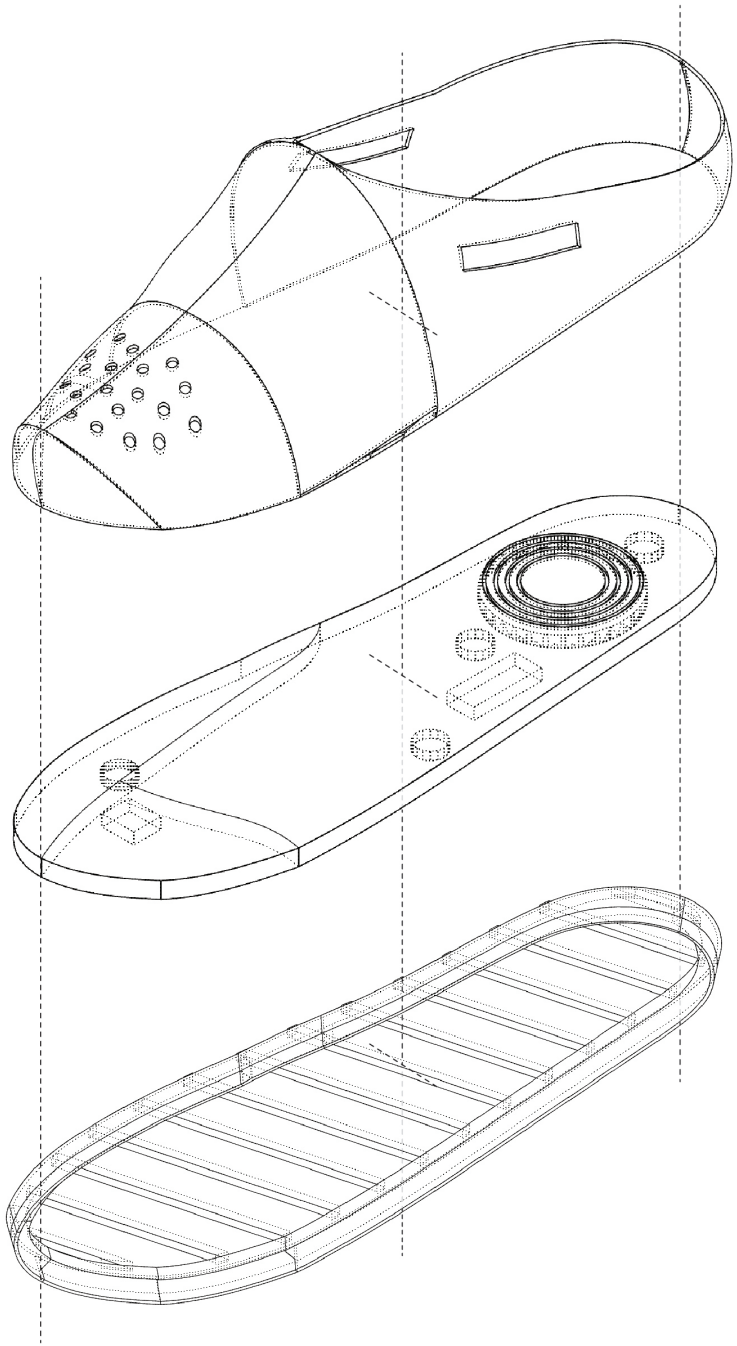
Product Dimensions

1. Dimension drawing of the Mouldable Insole
2. Isometric Exploded view
3. Dimension drawing of Charging pod

All Dimensions in mm
(Not to scale)

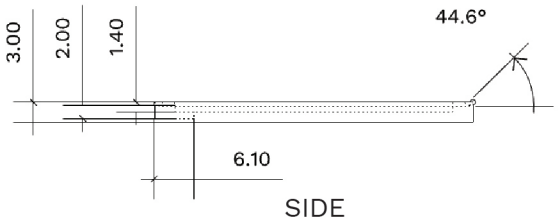


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Drawing title: Mouldable Insole
Drawing number: 1 (Diagram 5.2)
Scale: Not to scale

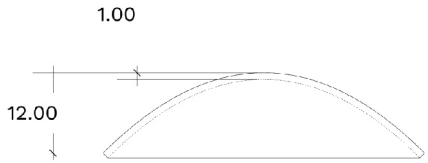


Name: Foot Comfort Solution
Drawing title: Isometric Exploded View
Drawing number: 2 (Diagram 5.3)
Scale: Not to scale

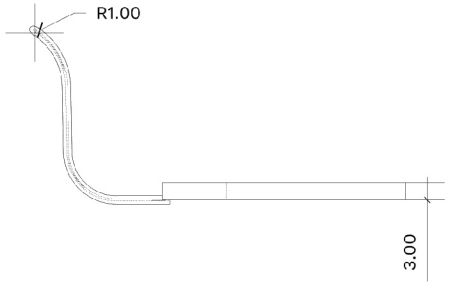
All Dimensions in mm
(Not to scale)



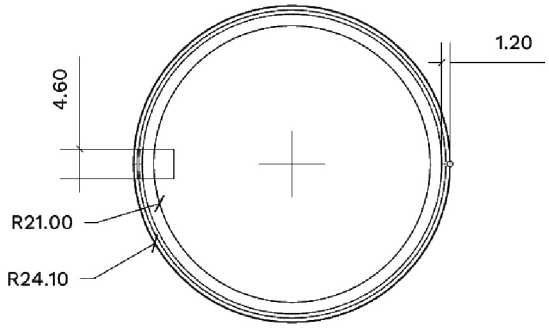
SIDE



SIDE

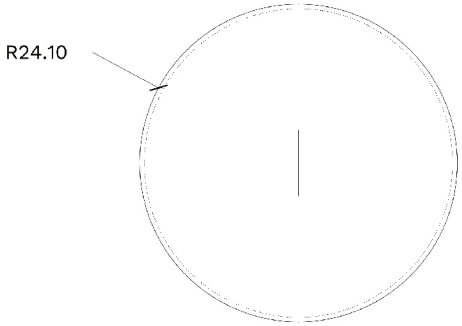


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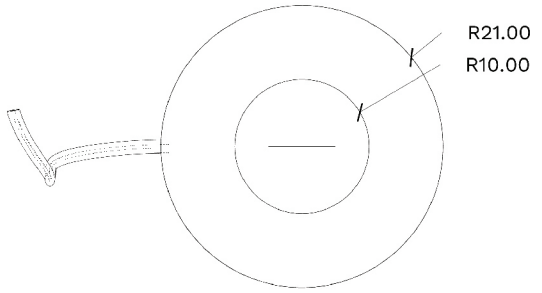
TOP

BOTTOM PART OF CASING



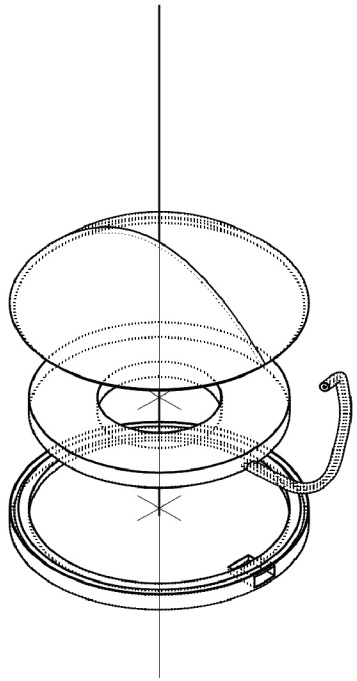
TOP

TOP PART OF CASING



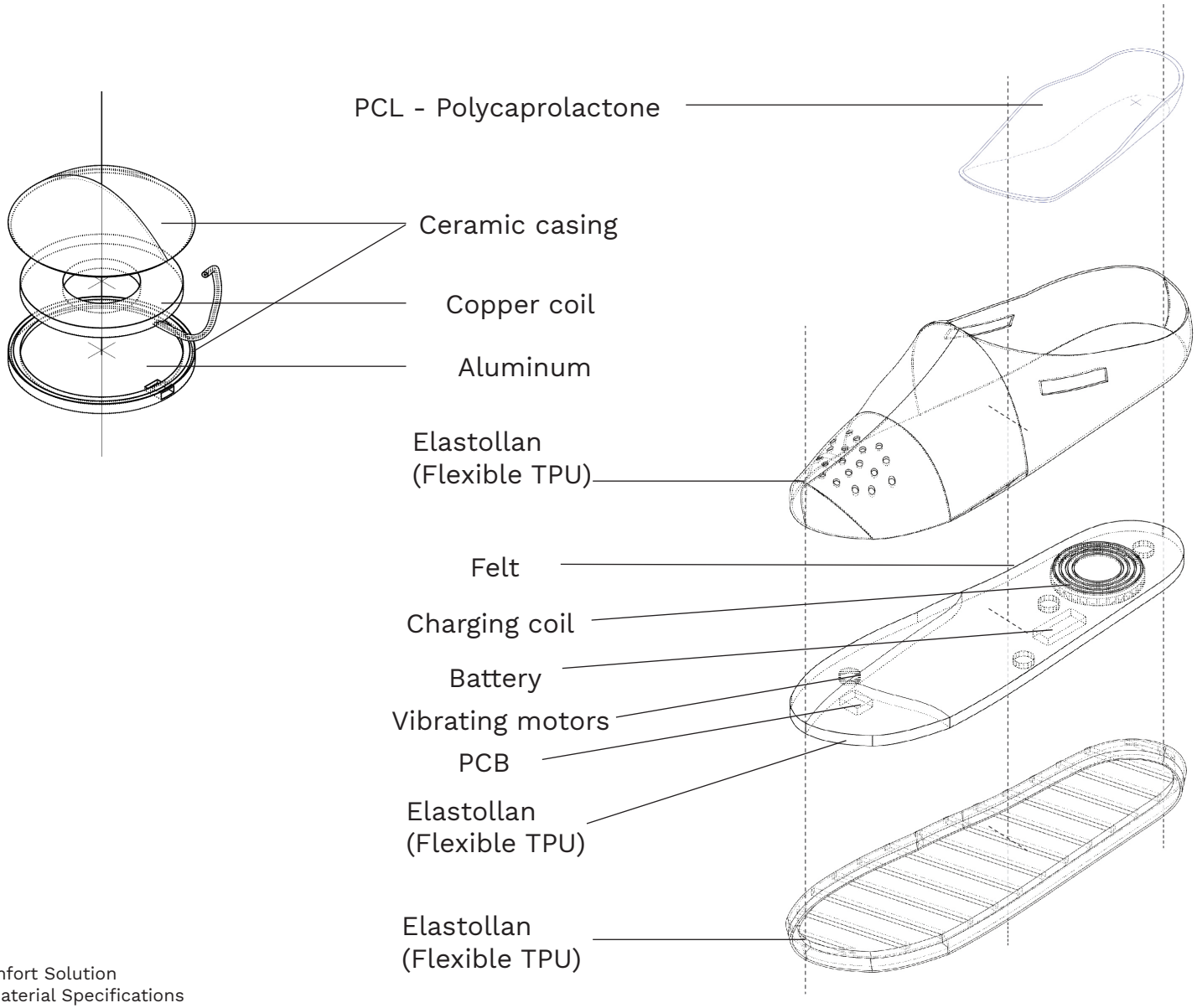
TOP

CHARGING COIL



Name: Foot Comfort Solution
Drawing title: Charging pod
Drawing number: 3 (Diagram 5.4)
Scale: Not to scale

All Dimensions in mm
(Not to scale)



Name: Foot Comfort Solution
Drawing title: Material Specifications
Drawing number: 4 (Diagram 5.5)
Scale: Not to scale

User Journey

First time use

1

The user receives the product in a standard cardboard box. The box contains 1 pair of massaging shoes, a wireless charging pod, 1 pair of molding insoles inside an individual cotton bag, a user manual.

2

The molding insoles can be used with any desired footwear (recommended to be used with your daily wear). Place the insole inside the cotton bag and put it in a microwave for 15 seconds.

3

When the microwave alarm goes off, take out the insole from the cotton bag and place it carefully inside the shoe. Make sure the heel area or the shoe and insole match with each other.

4 *Step inside the shoes and stand still for a minute till the insole feels room temperature.*

5 *Your customized daily wear insoles are ready to use with the selected shoe.*

- *The insole can be washed with soapy water.*
- *The insole can be reheated for molding 6-7 times.*
- *It is recommended to remold it inside a new pair of your daily footwear.*

User Journey

Regular Use

1

Tap either your left or right shoe (front area) 3 times in a row to start a massage.
The Bluetooth in both the shoes will make sure that the pair turns on at once.

2

Tap ONE TIME, for changing one mode up.
Different modes are,
1. Frontal area
2. Heel area
3. Entire foot

3

Tap 3 times with either of the shoe to stop the massage. Shoe automatically goes on battery saver mode when disabled for more than 15 minutes.

4

The battery life of the shoes is 18 hours. When the intensity of massage starts to taper, simply put the charging pod inside on heel area on the marking, and recharge it within 3-4 hours.

Costing Estimate

The Foot comfort solution, being a Lifestyle enhancing product, It would be sold to users who belong to higher class, or upper middle class. This was the reason why the product cost was never considered to be a primary constraint throughout the duration of the project. An estimated breakdown of the pricing and components, along with service charges can be found here. These values are approximates and must be considered as ballpark values.

The service model that will be used for the product would involve compensation on the next purchase when returned, making it easier for the company to sterilize and recycle the product, thus making it a reusable service model.

Part Detail	Cost in INR
Polycaprolactone (PCL)	65
Ellastolan	120
Ceramic casing	90
Vibrating motors	110
Custom PCB (accelerometer and circuit)	275
Battery	100
Wireless charging coil	550
Total (Product Cost)	**1310**
Taxes (@30%)	393
10% Logistics Cost	131
10% Retailer’s Margin	131
5% Company’s Margin	65.5
5% Service Cost	65.5
Sub Total (Additional)	**786**
Minimum Retail price	**2096**

6. Epilogue



- Broader possibilities
- Limitations
- Future scopes
- Reflections
- References
- Visual sources
- Endnote
- Glossary
- Colophon
- Contact

Broader possibilities

- With a Bluetooth module embedded in the PCB inside the shoe, It is likely to develop mobile based application support for health check monitoring.
- Since the Massaging feature is operated with an easy gesture control, the shoe can be beneficial at the times of foot cramps to bring faster relief.
- The Footwear and insole combination can be further developed for broader audience.

Limitations

- With other competitive brands like Fitbit, Apple watch, Amazon in the market creating fitness trackers for roughly the past 5 years, it is difficult for a Footwear product to replace their product.

- Most waterproofing technologies are effective only when there is no sudden impact or outer force on the outer casing.
  Brands like Nike and Adidas have been successfully able to create gaming shoes which have electronic parts inside. But making a footwear successfully waterproof to protect the electronics inside even during rains is something that needs to be looked into.

1. A heating coil does not heat up the PCL evenly throughout the surface area - which is why, currently the product is heated inside a cloth bag in a microwave.
2. A heating coil will certainly damage the electronic components inside the footwear.

- If a coil can be designed taking into account the electronic components for the massaging features and heat the insole within the shoe, the user experience can be upgraded. In this case, the coil can be utilized for keeping the feet warm during winters too - which can be an added feature.

Future Scope

- ***From here, The brand has two possible ways ahead,***

  1. Using the database gathered for PCL, and the nature of the material, Brand can come up with more applications of the material, and creating an ecosystem in the field of lifestyle and accessory.

  2. Work in the market of smart footwear solutions. Brands like Adidas and Nike have recently launched footwear in the sector. It is a fresh-budding segment in footwear where a lot has to be done. There can be more luxury products with customization and tech-incorporation.

Reflections

Most of the students have envisioned themselves taking up their final year project with a company to learn and understand the professional world while still being in the safe spot of being a student. At the beginning of my 8th semester, I had the same action plan. The global pandemic situation of COVID-19 brought changes to all of us. A self sponsored project in the discipline of Product Design is always Challenging. And yet, 8 out of 17 of us have finished their Self-sponsored projects this year.

Personally, my journey with Product design started with a thought of 'Making people's life easier than what it is right now'. At the start of my 1st year I would have never imagined myself shifting from Simple-Effective products and the Craft sector to the field of footwear design. But that is what NID prepares you for and let's you carve your own journey.

These 5 months of project have surely made me look at a foot differently. A footwear is not just an accessory. We dive a little deep and connect this work to comfort, Lifestyle, necessity. But what I have realized from my understanding is that proper footwear is what defines your experience, your Gait, your personality.

As the Project moved forward, my perceptions about a lot of things began to shatter. I was engaging in things that I had not considered within my comfort zone. I have improved on my skill-sets, eye for detail, Collaboration methods, Organizational and documentation skills.

In the end, the principles of product design that I had picked up over the years contributed vastly towards this project.

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Visual Sources

Acknowledgments

Image 1.2
Product Design, 2017

Image 3.5
Rupal shah, 2020

Image 3.8
Parag Parikh, 2020

Image 4.7, 4.8
Clicked by Anushree Joshi, 2020

Diagram 4.18, 4.19, 4.20, 4.21, 5.1
Developed by Karan Shah_

Image 4.21, 5.1, 5.2
Clicked by Karan Shah

Sourced on Internet

Diagram 1.1
Nathan W. Pyle (pyle, 2019)

Image 1.1
National Institute of Design (n.d.). History and Background. [Image] Available at: http://www.nid.edu/institute/history-background.html

Image 3.1, 3.2, 3.3, 3.4
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Diagram 3.1, 3.2
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Image 3.9, 3.10, 3.11, 3.14
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Image 3.12, 3.13
Ortholite

Image 3.15, 3.16
YouTube

Diagram 3.5, 3.6, 3.7, 3.8
IndustryARCAnalysis, Expert Insights

Table 4.1, 4.2 ;
Diagram 4.15, 4.16
Imaizumi, Kazuya et al. “Effect Of Foot Load Changes On Foot Arch Evaluation Using Foot Pressure Distribution Data”. Journal Of Foot And Ankle Research, vol 7, no. S1, 2014. Springer Science And Business Media LLC, doi:10.1186/1757-1146-7-s1-a114.

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Diagram 4.17
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