A Project Report On **Project 3**

“Design interventions for PARKINSON’S Accessory to resolve freezing of gait.”

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Indian Institute of Technology - Bombay

Approval Form

This is to certify that the Industrial Design Project entitled "Design interventions for Parkinson's. Leg Accessory to resolve freezing of gait" by Naiga Catherine is approved for fulfillment for Master of design degree in Industrial Design.

Prof . Purba Joshi [Project Guide] :

Signature of the Chair Person:

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Declaration form

I declare that this written report represents my ideas in my own words, and where others' ideas or words have been included, I have adequately cited and referenced theoriginal sources.
I also declare that I have adhered to all principles of academic honesty and integrity and have not falsified, misinterpreted, or fabricated any idea, data, facts or source inmysubmission.
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Signature:
Name of the student: Naiga Catherine
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Date: 027/06/2023

Acknowledgement

I would like to sincerely thank my guide, Prof. Purba Joshi for his invaluable guidance at this stage of the project. Special thanks to my friends for helping me to make the right decisions, prototyping, and photography. I am also grateful to all the faculty, staff and students of Industrial Design Centre (IDC) for their kind help and useful opinions and suggestions. I would like to thank my family and friends for their unconditional support.

Abstract

Parkinson's disease is a neurodegenerative disorder that affects millions of individuals worldwide, significantly impacting their mobility and quality of life. One of the most distressing symptoms experienced by Parkinson's patients is freezing of gait (FOG), characterized by sudden and temporary immobilization of the lower extremities. This report explores design interventions aimed at alleviating the challenges associated with FOG, with a focus on developing an innovative accessory to mitigate this symptom.

The report begins by providing a comprehensive overview of Parkinson's disease and its impact on gait and mobility. It delves into the intricate mechanisms underlying FOG, highlighting the complex interplay of motor, cognitive, and environmental factors contributing to its occurrence. By understanding these underlying factors, it becomes possible to identify potential design opportunities for interventions.

A thorough review of existing research and technological solutions for FOG intervention is conducted, outlining the strengths and limitations of current approaches. This literature review serves as the foundation for proposing a novel accessory designed specifically to address FOG episodes in Parkinson's patients. The accessory considers factors such as portability, usability, and effectiveness in triggering movement initiation during FOG events.

The design process is outlined, incorporating user-centred methodologies such as interviews, observations, and iterative prototyping to ensure the accessory meets the unique needs and preferences of Parkinson's patients. Various design iterations and user feedback are incorporated to refine the final accessory, considering aspects such as form, ergonomics, sensory stimulation, and biofeedback mechanisms.

Evaluation methods and metrics for assessing the effectiveness of the accessory in mitigating FOG symptoms are discussed. Objective measurements, such as motion tracking and gait analysis, are proposed to quantify improvements in gait parameters, while subjective assessments, including patient surveys and user feedback, provide valuable insights into user satisfaction and acceptance.

The report concludes by discussing the potential impact of the proposed accessory in improving the quality of life for Parkinson's patients. It highlights the importance of a multidisciplinary approach involving clinicians, designers, engineers, and patients to ensure the successful implementation of these design interventions. Furthermore, it identifies avenues for future research and collaboration to refine and expand upon the proposed design interventions for FOG and other symptoms associated with Parkinson's disease.

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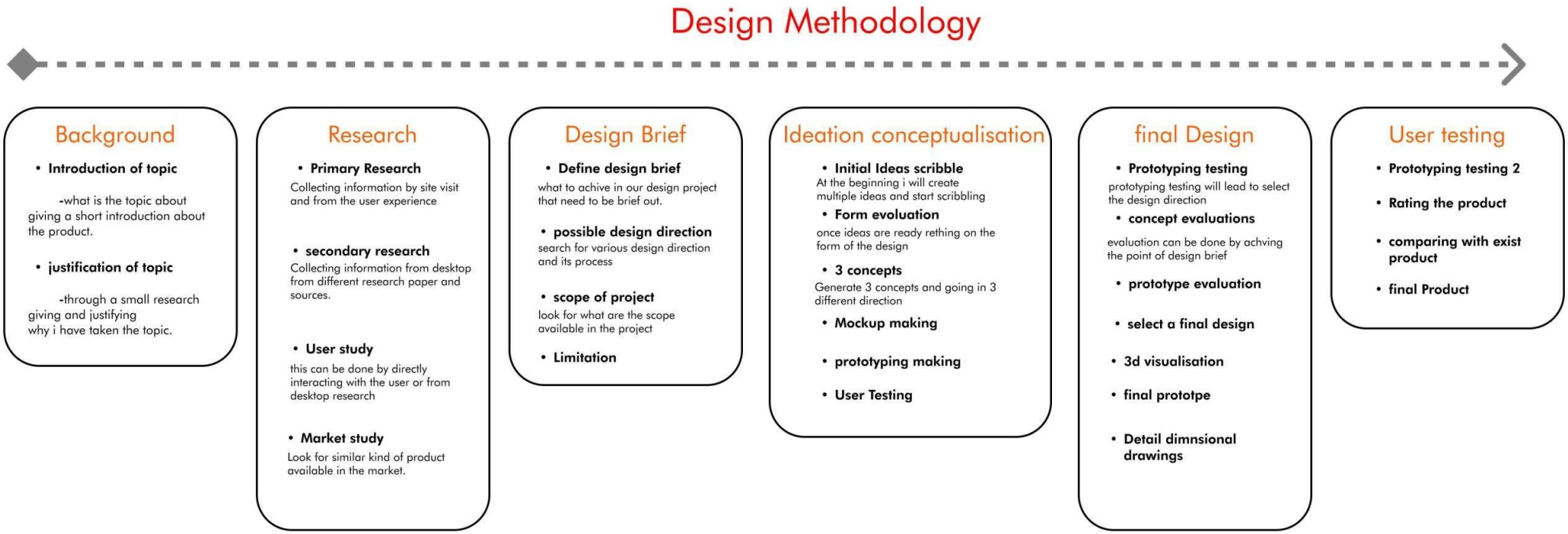


1. Introduction

Parkinson's disease (PD) is a chronic neurodegenerative disorder that affects millions of individuals worldwide, causing a range of motor and non-motor symptoms. Among the many debilitating symptoms experienced by Parkinson's patients, freezing of gait (FOG) stands out as one of the most distressing and challenging to manage. FOG is characterized by a sudden and temporary inability to initiate or continue walking, leading to episodes of immobility and instability. These freezing episodes significantly impair the mobility, independence, and overall quality of life for individuals living with Parkinson's.

The phenomenon of freezing of gait is multifactorial, influenced by various complex interactions between motor, cognitive, and environmental factors. While medications and physical therapies can partially alleviate FOG symptoms, there is a growing recognition of the potential for design interventions to play a crucial role in addressing this specific symptom.

This report aims to explore and propose design interventions specifically targeted at addressing freezing of gait in Parkinson's patients. By investigating existing research, technological solutions, and understanding the underlying mechanisms of FOG, we can identify opportunities to develop an accessory that effectively assists individuals during freezing episodes. This research intends to contribute to the growing field of user-cantered design interventions for Parkinson's disease and offer potential solutions to improve the daily lives of those affected by FOG.

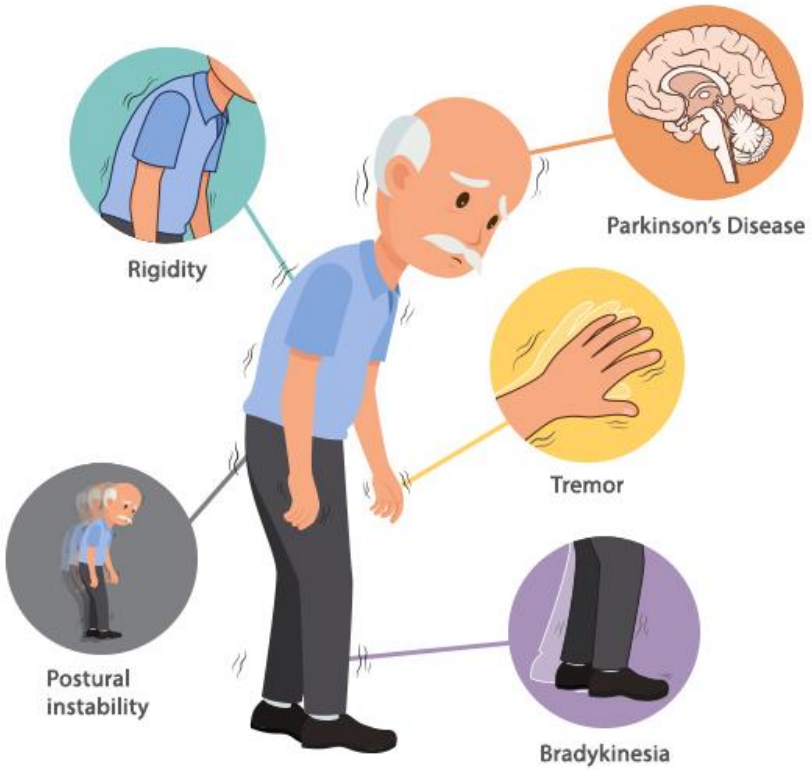


Figure 1 – symptoms of Parkinson's

To accomplish this objective, a multidisciplinary approach incorporating principles of design, engineering, medicine, and patient perspectives will be employed. The report will outline a comprehensive understanding of Parkinson's disease, emphasizing its impact on gait and mobility. It will explore the factors contributing to freezing of gait, including motor impairments, cognitive processing, and environmental triggers.
A review of existing interventions, including technological advancements, will provide insights into current solutions for FOG management. By examining their strengths and limitations, we can identify gaps and opportunities for novel design interventions.
The proposed accessory will be developed through an iterative design process, utilizing user-centered methodologies to ensure the final product meets the unique needs and preferences of Parkinson's patients.
Evaluation methods will be established to assess the effectiveness of the accessory in mitigating freezing of gait symptoms. Objective measurements, such as motion tracking and gait analysis, will be considered alongside subjective assessments, incorporating patient surveys and user feedback. These evaluations will provide valuable insights into the usability, effectiveness, and acceptance of the proposed design intervention.
Ultimately, this report aims to contribute to the body of knowledge surrounding design interventions for Parkinson's disease, with a specific focus on addressing freezing of gait. Through a collaborative effort involving researchers, clinicians, designers, engineers, and patients, we strive to improve the lives of those affected by Parkinson's disease and enhance their ability to move with confidence and independence.

Figure 2 – falls of a PD patient.

This comprehensive study aims to provide an in-depth understanding of Parkinson's disease, including its underlying mechanisms, clinical manifestations, diagnostic criteria, and available management strategies. By exploring the multifaceted aspects of the disease, we can gain insights into its pathophysiology, progression, and the challenges faced by patients and caregivers.

1. **Pathophysiology of Parkinson's Disease:**

The pathophysiology of Parkinson's disease involves the progressive degeneration of dopaminergic neurons in the substantia nigra region of the brain, leading to a significant reduction in dopamine levels. This dopamine deficiency disrupts the delicate balance of neurotransmitters, resulting in the characteristic motor and non-motor symptoms observed in PD.

2. **Motor Symptoms:**

The motor symptoms of Parkinson's disease are characterized by a wide range of impairments, including bradykinesia (slowness of movement), rigidity (muscle stiffness), resting tremors, and postural instability. These symptoms significantly impact motor control, coordination, and balance, leading to difficulties in performing daily activities.

3. **Non-Motor Symptoms:**

Parkinson's disease is not solely confined to motor symptoms; it also manifests as a complex array of non-motor symptoms. These may include cognitive impairments, such as memory loss and executive dysfunction, mood disturbances like depression and anxiety, sleep disorders, autonomic dysfunction, and sensory abnormalities. Understanding and managing these non-motor symptoms are critical for comprehensive care of Parkinson's patients.

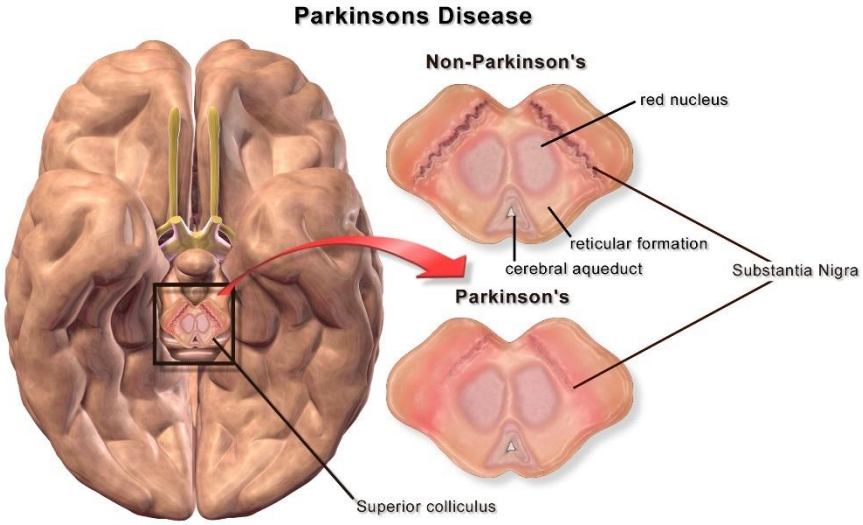


Figure 3 – subtantia nigra

4. Diagnosis and Clinical Assessment:

Accurate diagnosis of Parkinson's disease relies on a combination of clinical evaluation and the exclusion of other potential causes of parkinsonism. The most widely used diagnostic criteria are those established by the Movement Disorder Society (MDS), which consider motor symptoms, response to dopaminergic therapy, and the presence of supportive features.

5. Management Strategies:

While there is currently no cure for Parkinson's disease, several management strategies aim to alleviate symptoms, improve functional abilities, and enhance the overall quality of life for patients. These strategies include pharmacological interventions, such as dopamine replacement therapy, as well as non-pharmacological approaches, including physical therapy, speech therapy, occupational therapy, and deep brain stimulation (DBS) surgery.

6. Emerging Research and Therapies:

Advancements in research are continuously expanding our understanding of Parkinson's disease, with ongoing investigations into potential disease-modifying therapies, neuroprotective agents, and novel treatment approaches. Genetic studies, stem cell research, and the exploration of targeted therapies offer promising avenues for future breakthroughs in managing and potentially preventing PD.

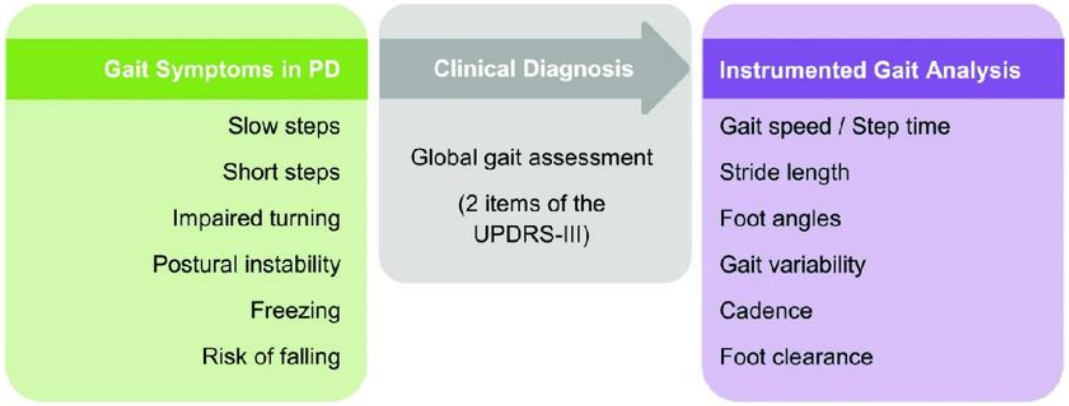


Figure 4 – clinical diagnosis based on the unified Parkinson

2. Stages of Parkinson's

Parkinson's disease (PD) is a progressive disorder, and its progression is typically categorized into stages to help understand its clinical course and guide treatment decisions. It's important to note that the staging system is not strictly linear, and individuals may experience variations in symptom severity and progression. Here is a detailed overview of each stage:

Stage 1: Unilateral involvement In this initial stage, Parkinson's symptoms are mild and typically affect only one side of the body. Tremors, slowness of movement (bradykinesia), and other motor symptoms may be present, but they are generally subtle and may not significantly impact daily activities. The symptoms may include a slight tremor or changes in posture and gait.
Stage 2: Bilateral involvement At this stage, Parkinson's symptoms begin to affect both sides of the body. Tremors, rigidity, and bradykinesia become more noticeable, making it difficult to perform certain tasks. The person may experience difficulties with walking, balance, and coordination.
Stage 3: Balance impairment Stage 3 marks a significant milestone in the progression of Parkinson's disease. Balance and coordination difficulties become more pronounced, leading to a higher risk of falls. While individuals can still maintain independence, their movements become slower, and there is a notable impact on daily activities. Assistance with tasks such as dressing and hygiene may be required.

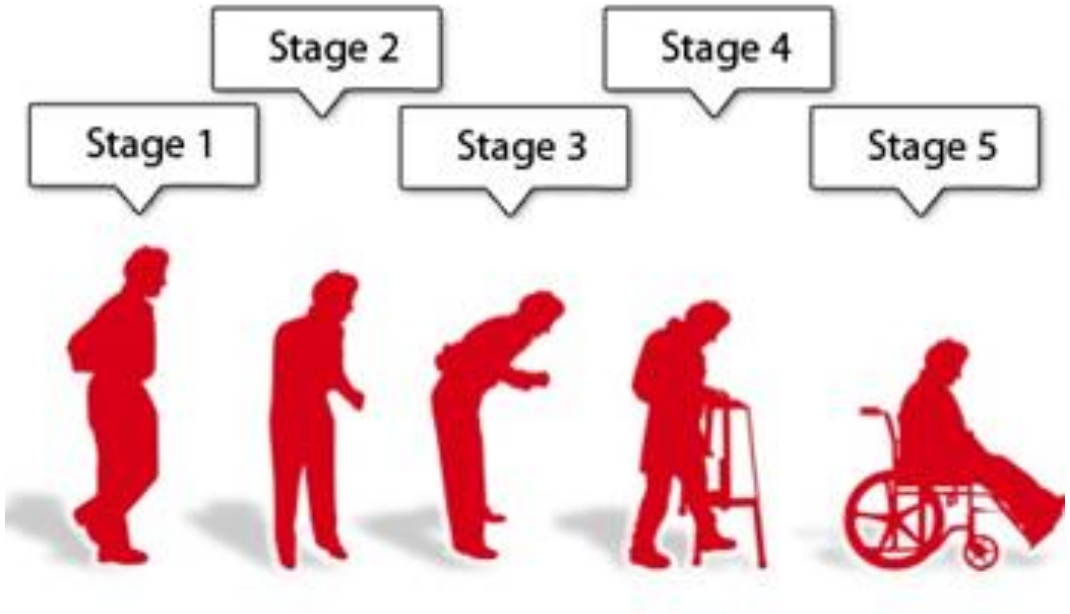


Figure 5 – stages of Parkinson's

Stage 4: Severe disability, but still able to walk or stand unassisted During this stage, the symptoms of Parkinson's disease significantly limit a person's ability to carry out daily activities independently. Mobility is impaired, and individuals may experience severe bradykinesia, rigidity, and postural instability. Walking and standing may still be possible without assistance, but it becomes challenging and requires significant effort. Assistance with daily tasks and the use of mobility aids may be necessary.

Stage 5: Wheelchair-bound or bedridden In the final stage of Parkinson's disease, individuals are typically wheelchair-bound or completely bedridden. The motor symptoms are severe, and the person may require around-the-clock assistance for all activities of daily living. Cognitive impairments and psychiatric symptoms may also be present.
It's crucial to remember that the progression of Parkinson's disease can vary widely among individuals. Factors such as age at onset, overall health, and response to treatment can influence the rate of progression and symptom severity. Treatment approaches, including medication adjustments, physical therapy, and supportive care, aim to manage symptoms at each stage and improve quality of life for individuals with Parkinson's disease.

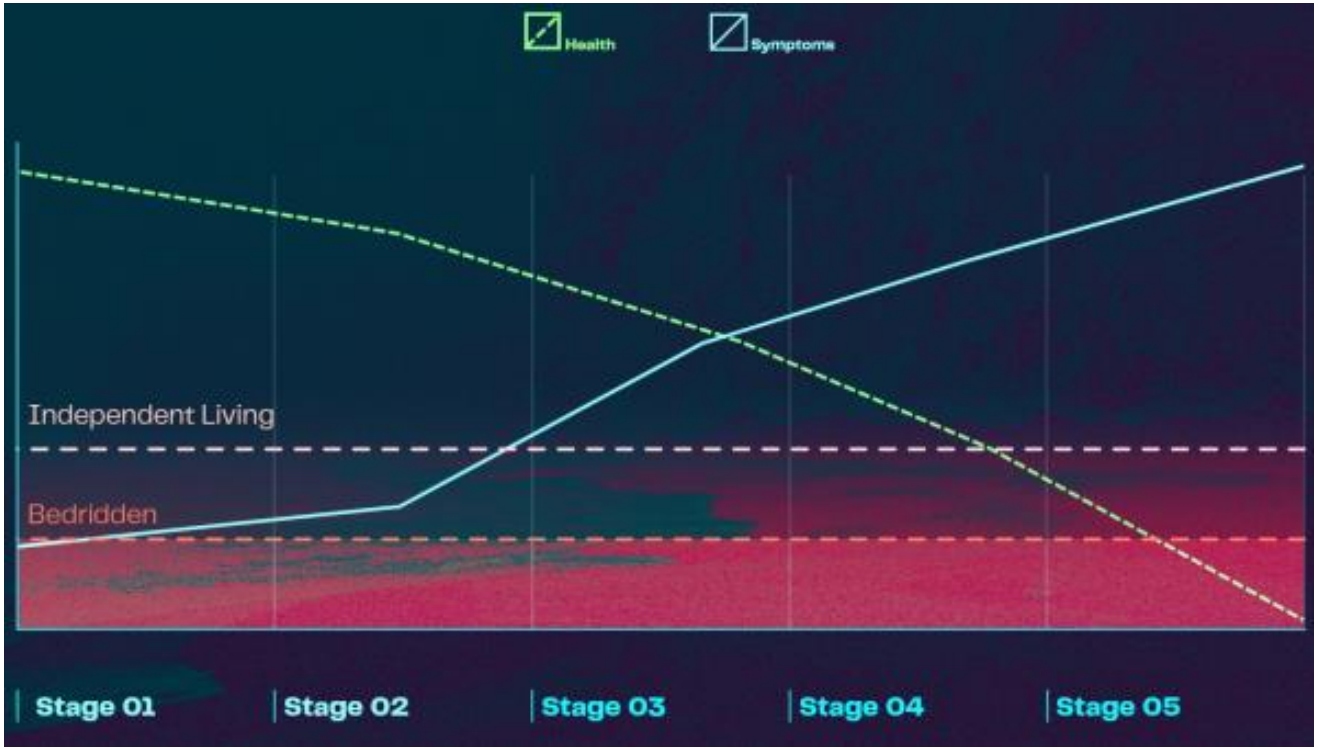
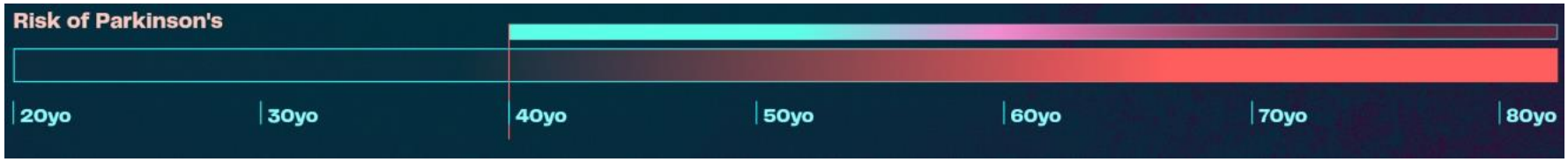


Figure 6 – stages of Parkinson's and independent living

3. Parkinson's in India



Parkinson's disease (PD) is a significant health concern in India, as it affects a substantial number of individuals across the country. While specific data on the prevalence of Parkinson's in India is limited, studies suggest that the prevalence rate is comparable to global estimates.

Here are some key points regarding Parkinson's disease in India:

- Prevalence: The prevalence of Parkinson's disease in India varies across different regions. Studies have reported a prevalence rate ranging from 41 to 328 cases per 100,000 population. However, these figures may not represent the true burden of the disease due to underdiagnosis and limited access to healthcare in certain areas.

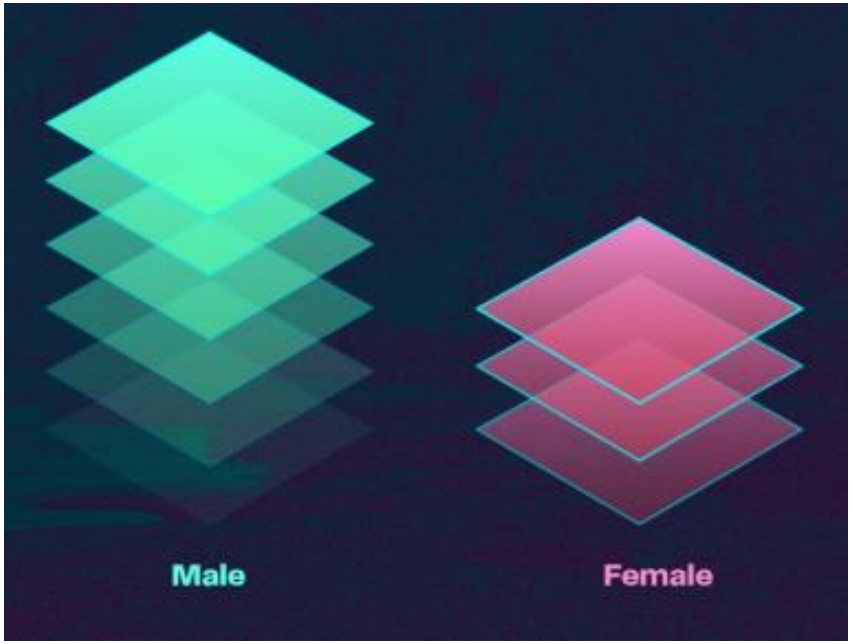


Figure 7 – Parkinson's in Males and Females

Demographic Factors: Parkinson's disease can affect individuals of all ages, but the risk increases with age. India's large population and increasing life expectancy contribute to a growing number of individuals living with Parkinson's.

Challenges in Diagnosis: Limited awareness about the disease among the general population and even healthcare professionals can lead to delayed or missed diagnosis. Additionally, lack of specialized movement disorder clinics and neurologists with expertise in Parkinson's management in certain regions can impact timely diagnosis and treatment.

Access to Treatment: Availability and affordability of medications, physiotherapy services, and specialized care facilities may vary across different regions. This discrepancy in access to care can affect the quality of life and disease management for individuals with Parkinson's.

Research and Support: There is an increasing focus on Parkinson's disease research in India. Collaborative efforts between academic institutions, hospitals, and non-profit organizations aim to improve understanding, diagnosis, and management of the disease. Additionally, support groups and patient advocacy organizations play a vital role in providing resources, information, and a supportive network for individuals and families affected by Parkinson's.

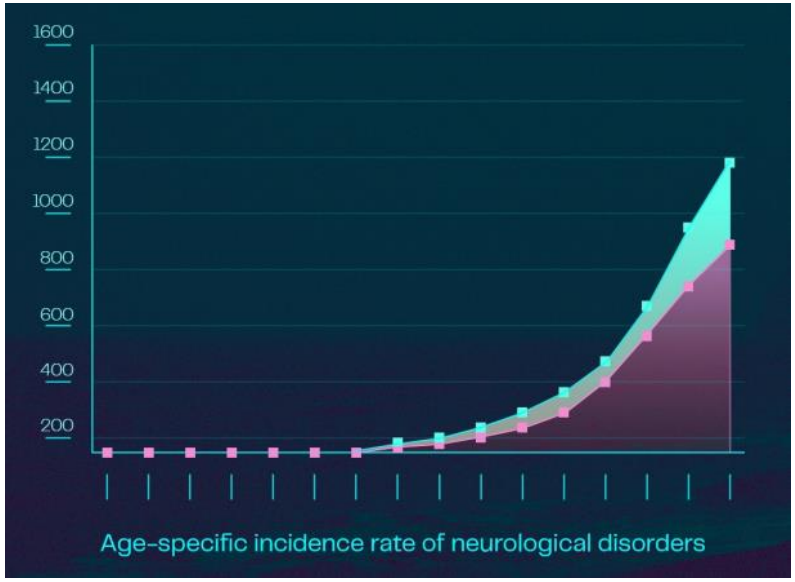


Figure 8 – Rate of neurological disorders

4. Prominent Symptoms – Male vs Female

Parkinson's disease (PD) affects both males and females, but there may be differences in the presentation and prevalence of certain symptoms between the two genders.
While the core motor symptoms of Parkinson's are similar in both males and females, some variations have been observed. It's important to note that these differences are generalizations and individual experiences may vary.

Here are some prominent symptoms of Parkinson's in males compared to females:

1. Motor Symptoms:

Tremors: studies suggest that males may experience more prominent tremors
Bradykinesia: Slowness of movement is observed in both genders.
Rigidity: affects both males and females to a similar degree.
Postural Instability: Challenges with balance and postural control are prevalent in both genders.

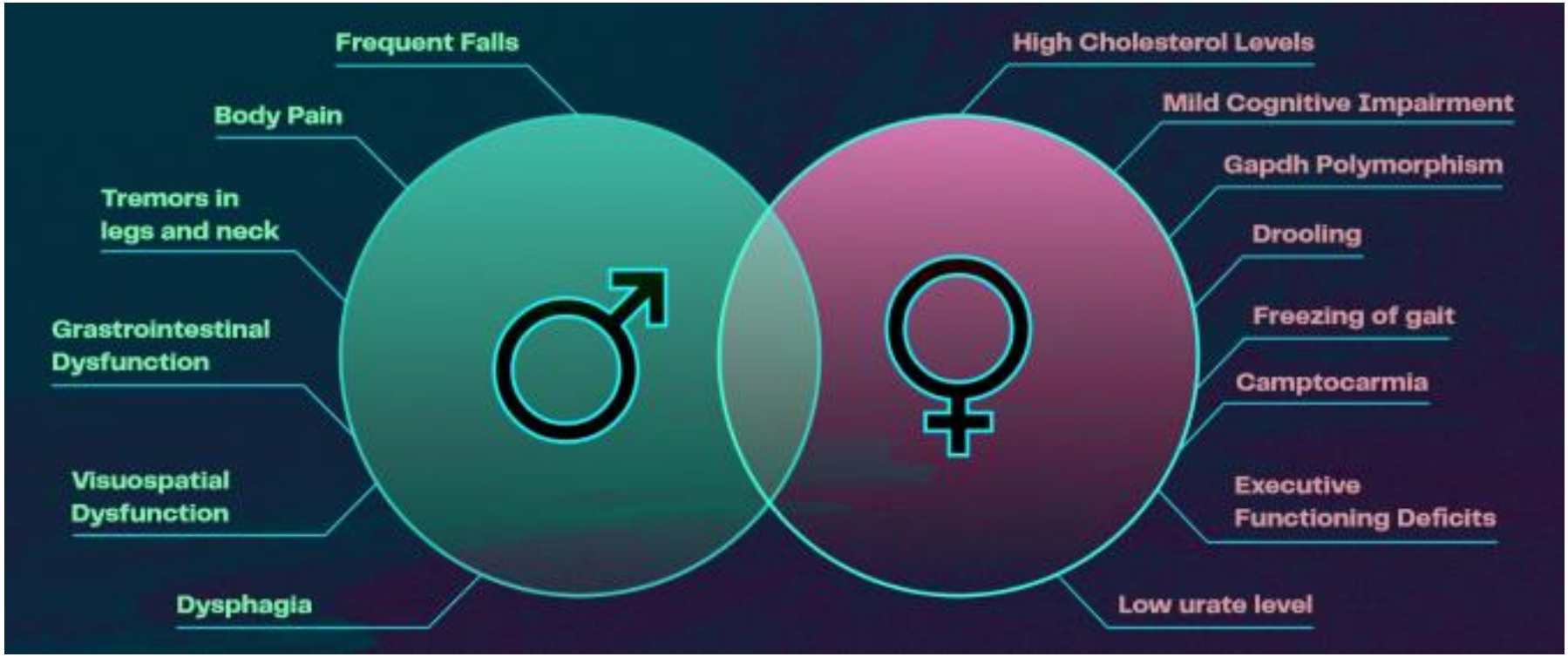


Figure 9 – symptoms in male vs female

2. Non-Motor Symptoms:

- Depression: Studies have shown that depression is more common in females with Parkinson's compared to males.
- Cognitive Impairment: Some studies suggest that males may be more susceptible to cognitive decline and dementia associated with Parkinson's disease.
- Sleep Disorders: Both males and females with Parkinson's may experience sleep disturbances, such as insomnia or excessive daytime sleepiness.
- Urinary Symptoms: Males with Parkinson's may be more likely to experience urinary symptoms, such as urgency or frequency, compared to females.
- Sexual Dysfunction: Both genders may experience sexual dysfunction, but it can manifest differently. Males may encounter erectile dysfunction, while females may experience decreased libido and vaginal dryness.

3. Response to Medications:

- Some studies have suggested that females may have a slightly better response to dopamine replacement therapy compared to males. However, individual variations in treatment response are significant, and this finding may not be consistent across all patients.
- It's important to note that these gender differences in symptom presentation are not absolute, and there is considerable overlap between males and females. Parkinson's disease affects each person uniquely, and the progression and severity of symptoms can vary widely among individuals, regardless of gender.

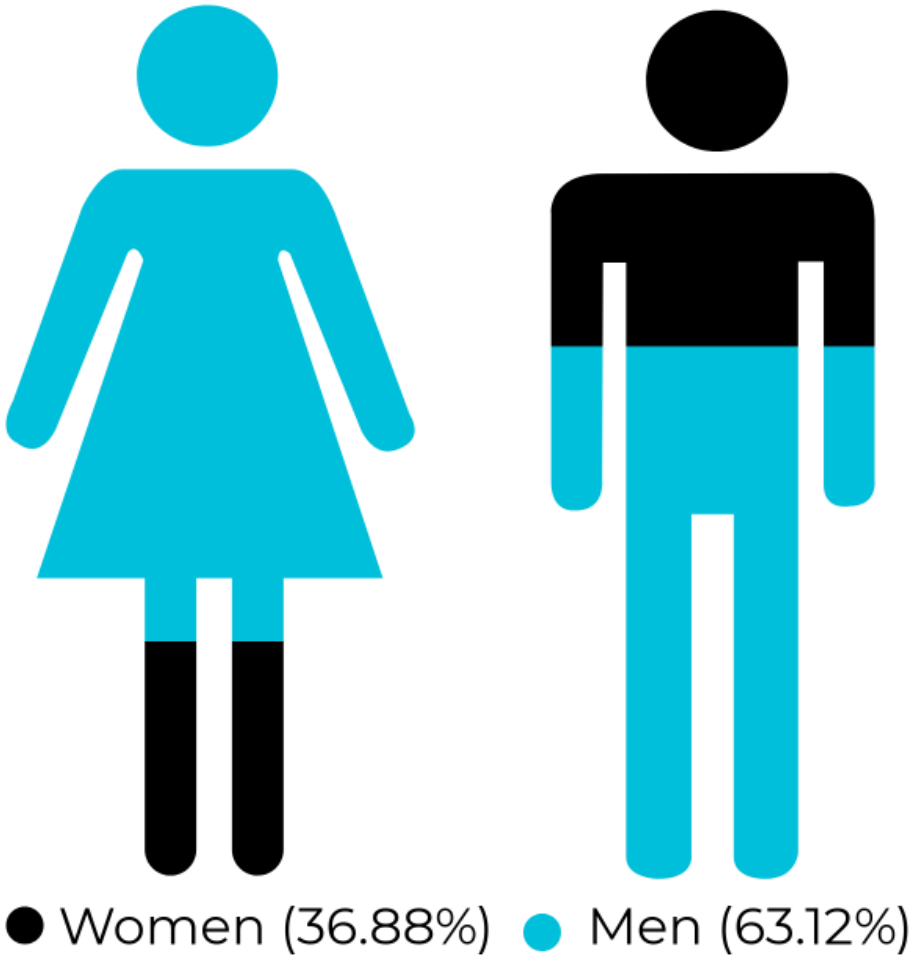


Figure 10 – percentage of patients in male and female

5. Parkinson's stakeholders

Parkinson's effects not only the patient, but their friends, family, profession, hobbies. Their entire close circle becomes effected. As a person sooner or later, will require assistance from their loved ones or professional caregiver.

The following are key stakeholders in the context of Parkinson's disease:

Patients:

Individuals living with Parkinson's disease are the primary stakeholders. They experience the symptoms, challenges, and impact of the disease first-hand. Their well-being, quality of life, and access to appropriate care and support are of utmost importance.

Caregivers and Families:

Caregivers, including family members and friends, play a crucial role in supporting and assisting individuals with Parkinson's. They provide physical, emotional, and practical care, often making significant lifestyle adjustments to accommodate the needs of the person with Parkinson's.

Healthcare Professionals:

Neurologists, movement disorder specialists, nurses, physical therapists, occupational therapists, speech therapists, and other healthcare professionals involved in Parkinson's disease care are essential stakeholders. They provide diagnosis, treatment, and ongoing management of the disease, offering specialized expertise and guidance.

Researchers and Scientists:

Scientists and researchers contribute to advancing knowledge about Parkinson's disease through studies, clinical trials, and scientific investigations. Their work aims to uncover the underlying causes, develop better treatments, and improve overall understanding of the disease.

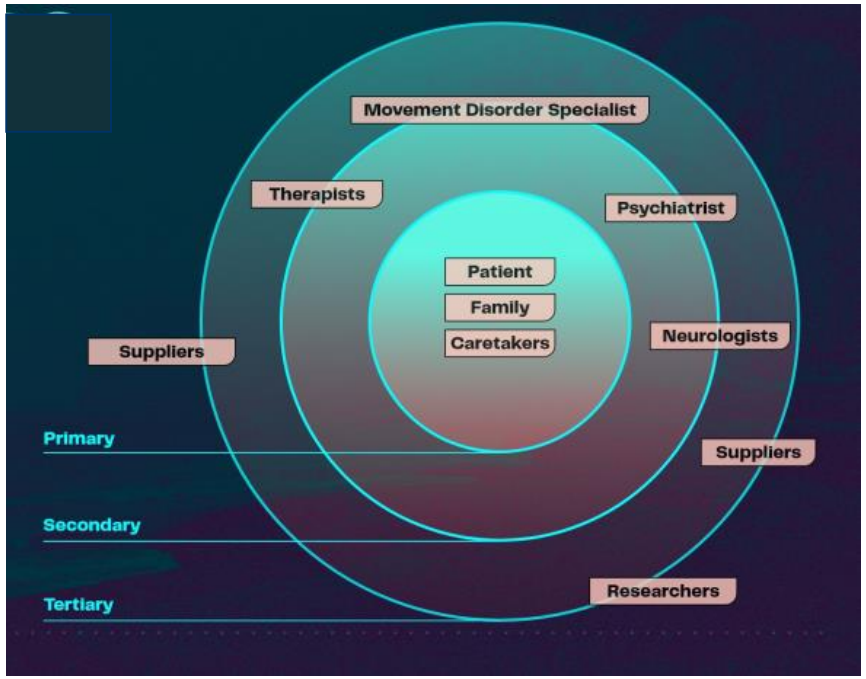


Figure 11 – stakeholders

Pharmaceutical Companies:

Pharmaceutical companies play a crucial role in developing and manufacturing medications used to manage Parkinson's disease symptoms. They conduct research, clinical trials, and provide access to medications that help alleviate symptoms and improve patients' quality of life.

Government Agencies and Policy Makers:

Government agencies, such as health departments and regulatory bodies, establish policies, guidelines, and regulations related to Parkinson's disease care, research funding, and drug approvals. Policy makers shape healthcare systems and influence access to care, reimbursement policies, and public health initiatives.

Support Services and Rehabilitation Centers:

Support services, rehabilitation centres, and long-term care facilities play a significant role in providing specialized care, therapy, and support for individuals with Parkinson's disease. These institutions offer a range of services, including physical therapy, speech therapy, occupational therapy, counselling, and social support.

Medical Device and Assistive Technology Companies:

Companies involved in the development and manufacturing of medical devices and assistive technologies specifically designed for Parkinson's disease contribute to improving patients' mobility, communication, and overall quality of life.

Academic Institutions and Educators:

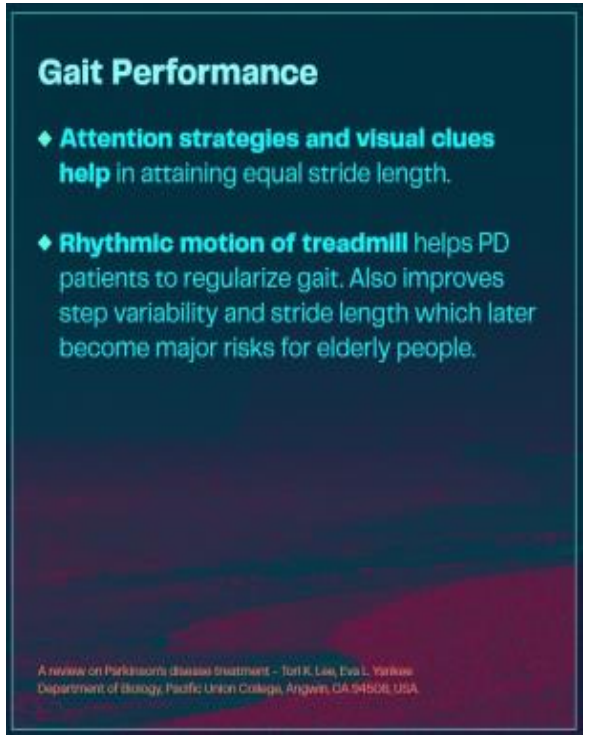
Academic institutions, universities, and educators contribute to the education and training of healthcare professionals specializing in Parkinson's disease. They provide curriculum, research opportunities, and knowledge dissemination to enhance understanding and expertise in the field.

Non-Profit Organizations and Patient Advocacy Groups:

Non-profit organizations and patient advocacy groups dedicated to Parkinson's disease play a significant role in supporting patients and families. They provide resources, education, support networks, and raise awareness about the disease. These organizations also advocate for research funding, policy changes, and improved access to care.

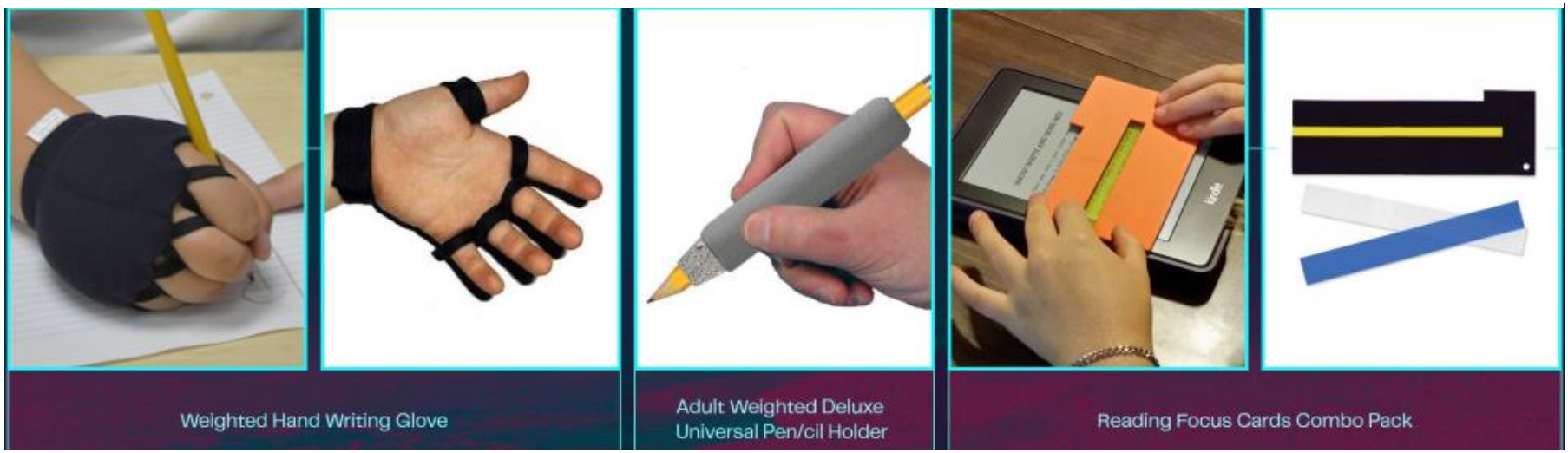
Collaboration and engagement among these stakeholders are vital for advancing research, improving care, and addressing the multifaceted challenges faced by individuals with Parkinson's disease. By working together, stakeholders can make a significant impact in improving the lives of those affected by the disease and ultimately strive towards finding better treatments and a cure.

6. Insights from Literature Study

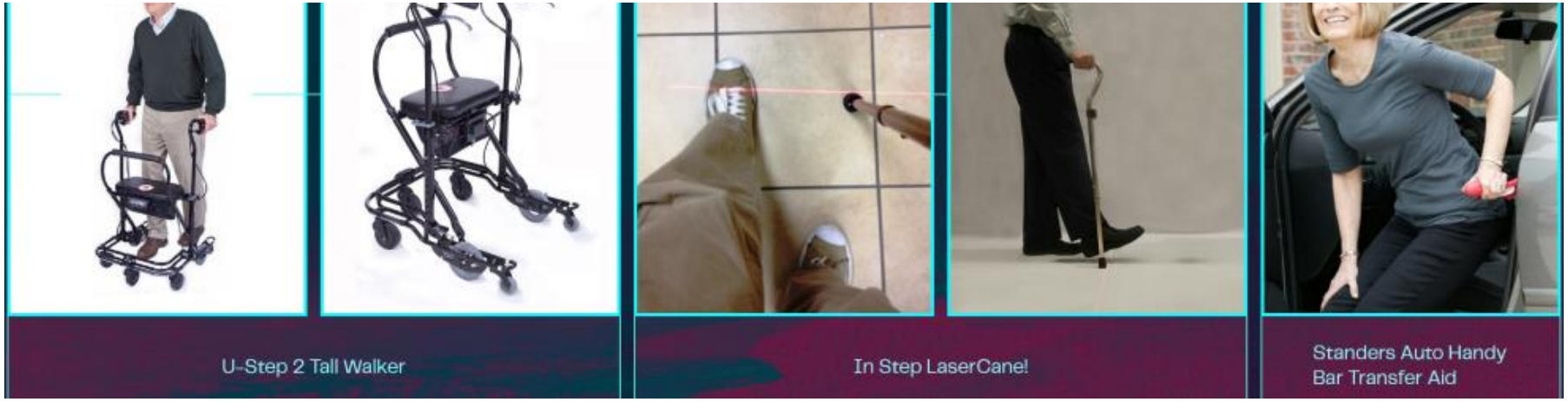


7. Products in the Market

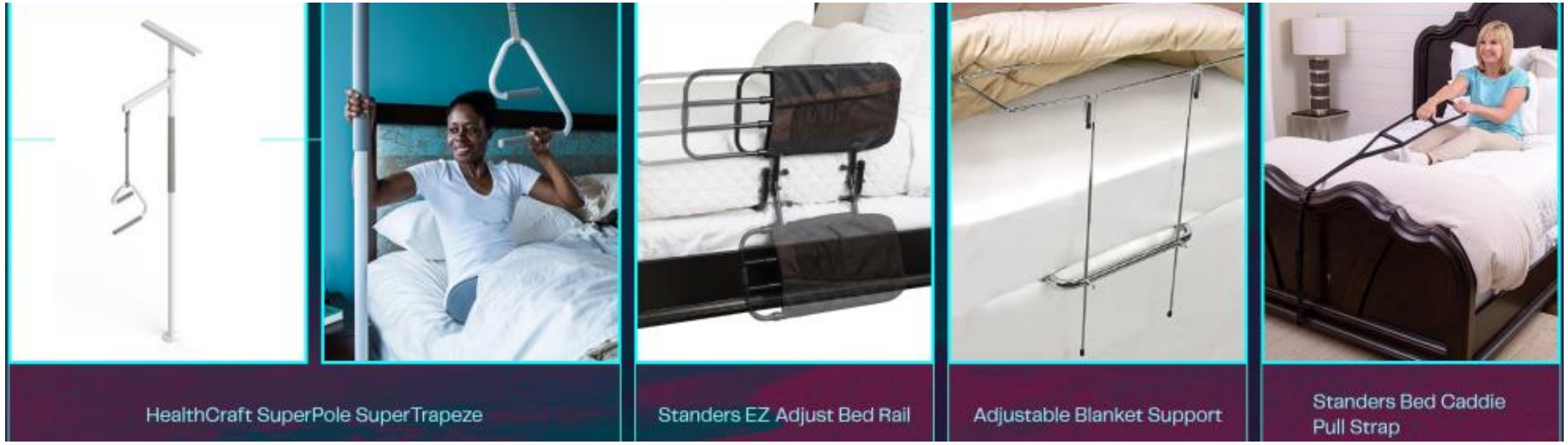
7.1 Writing Aids



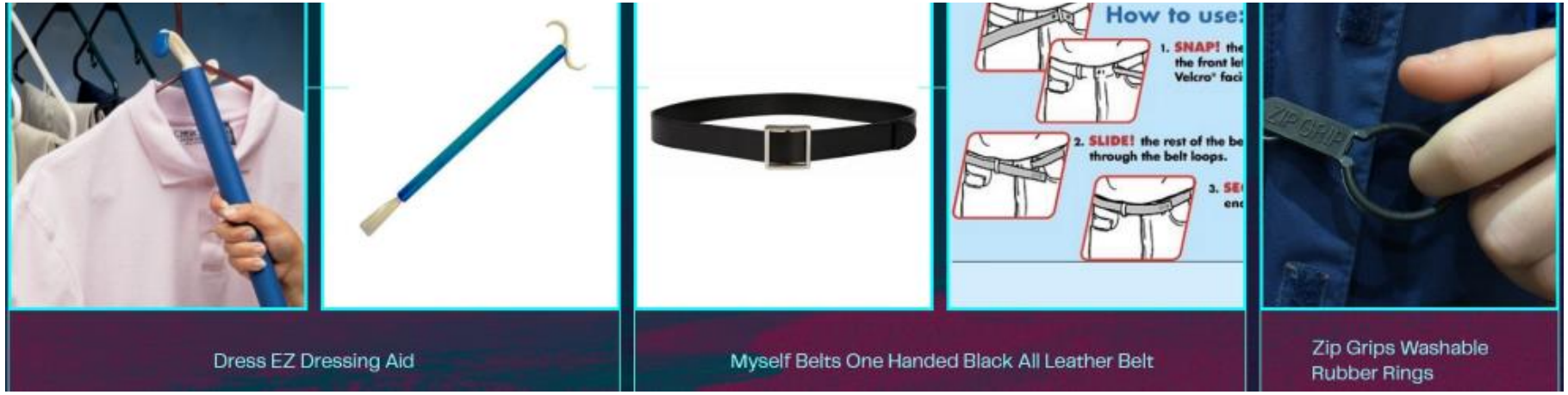
7.2 Walking Aids



7.3 Dressing Aids

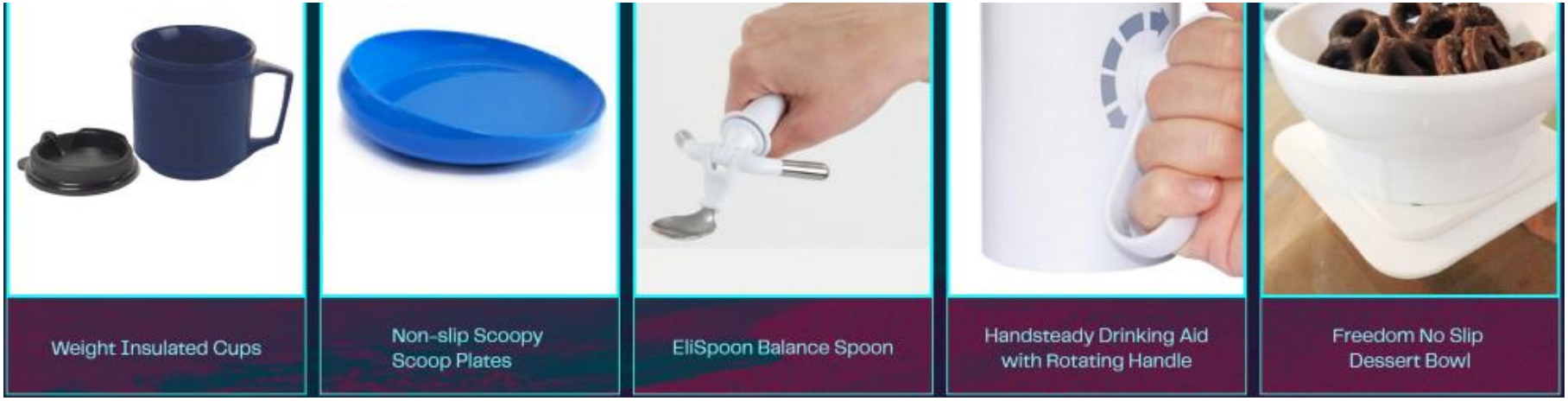


7.4 Bedroom Aids

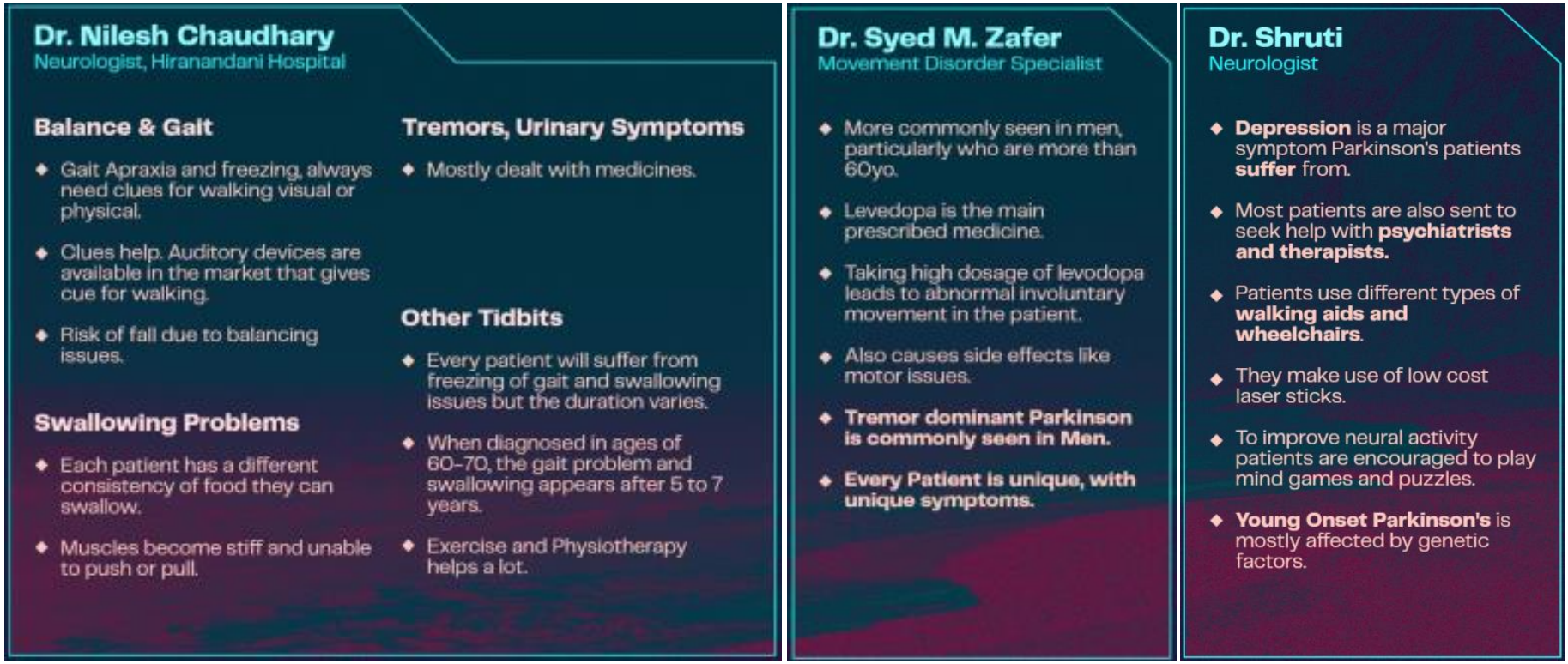


7.5 Grooming Aids

7.6 Dining Aids



8. Initial conversation with doctors



9. Design Opportunities

- Cognitive
  i. Executive Dysfunction
  ii. Slowed cognitive processing.
  iii. Impaired Recall
  iv. Impaired Time Perception
  v. Visuospatial Difficulties

- Motor
  i. Tremors of 4-6 hz
  ii. Pill-rolling tremors
  iii. Rigidity
  iv. Postural Instability
  v. Gait and posture disturbances
  vi. Slurred speech
  vii. Mask like facial expression
  viii. Handwriting issues

- Neuropsychiatric
  i. Depression
  ii. Anxiety
  iii. Apathy and Anhedonia
  iv. Pathological Gambling
  v. Compulsive sexual behaviour
  vi. Ponding

- Gastrointestinal
  i. Constipation
  ii. Impaired stomach emptying
  iii. Excessive production of saliva
  iv. Swallowing impairment

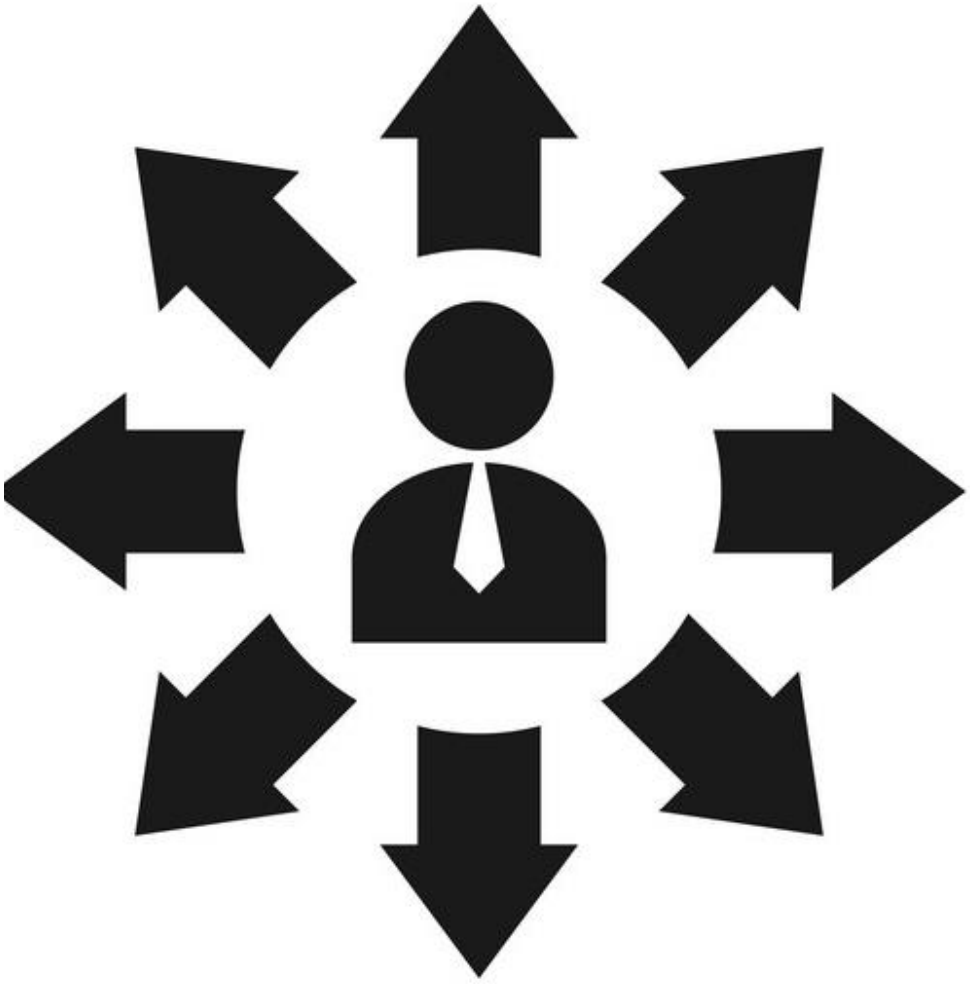


Figure 12 – design opportunities

10. Area of Focus – FREEZING OF GAIT

- Freezing of gait (FoG) is one of the **most disabling** yet poorly understood symptoms of Parkinson's disease (PD).
- FoG is an **episodic gait pattern** characterized by the **inability to step** that occurs on **initiation or turning while walking or change in surface** particularly with perception of tight surroundings.
- This phenomenon **impairs balance, increases falls, and reduces the quality of life**.
- Up to **63% of patients with idiopathic Parkinson's disease** experience FoG, with increasing **incidence in later stages.**
- Risk factors for FoG include **male sex**, **left-sided disease onset**, early gait abnormalities, **more axial symptoms**, **higher daily dose of levodopa**, and other nonmotor symptoms such as **hallucinations, depression, and anxiety.**
- Episodes can be brief as **1 to 2 secs 30 secs.**
- Specifically, three patterns of FoG have been distinguished including: trembling in place, shuffling forward, complete akinesia

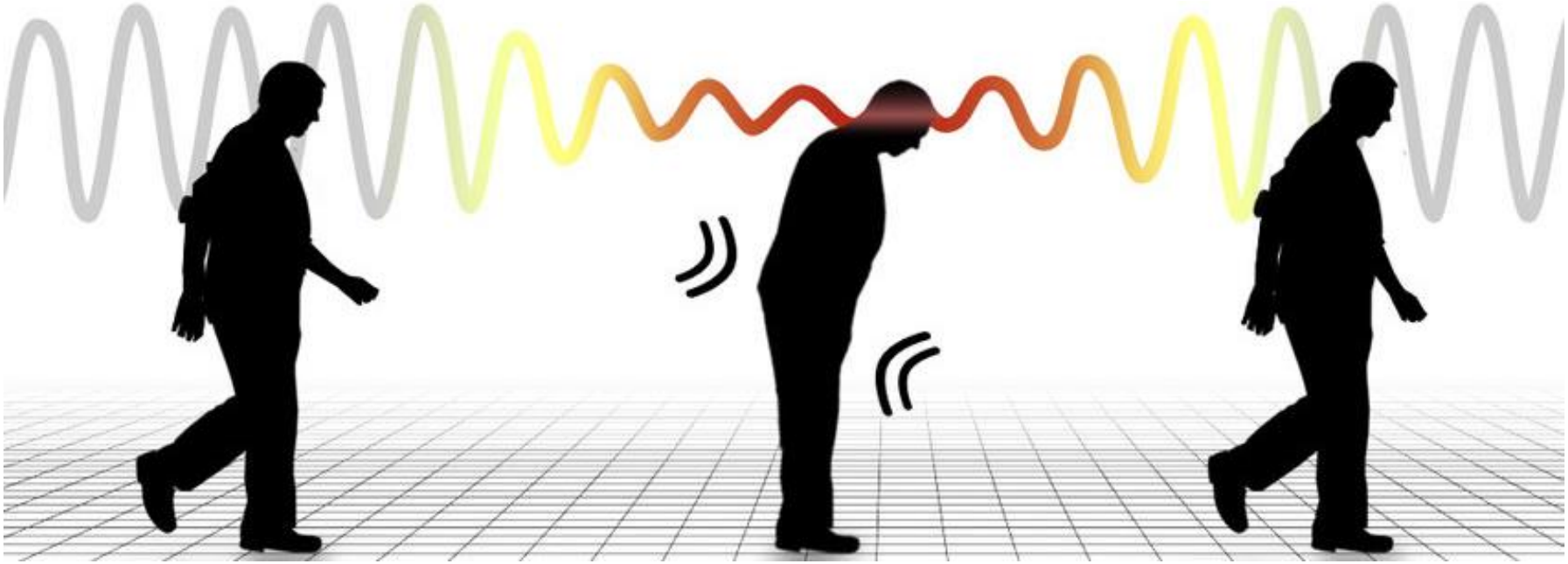


Figure 13 – freezing episode

10.1 Gait in different stages

10.1.1 Gait in early to mid-stages of PD

- Face **slowness of gait and change in amplitude and rhythm** are seen.

- **Amplitude**
- they show lower **stride length** at any given velocity.
- They can **modulate velocity** of walking but **fail to adapt stride length to gait speed.**
- **Cues** are needed at this point.
- External visual cues and focused attention can be used to increase step amplitude.

- **Rhythm**
- **subtle alterations of timing of stride** have been observed, but significant disturbance of gait rhythm is not present in early stages of pd.

- **Dual tasking**
- impaired dual tasking capacity are frequently seen which often **leads to falling.**
- Eg. Using mobile phones while walking

10.1.2 Gait advanced stages of PD

- As disease progress, **complex disturbances** of gait become major determinants of disability and **quality of life.**
- In most patients**, neither gait disturbance nor balance** problems can be **controlled by drugs.**
- Furthermore, **cognitive decline and lack of attention and alertness** can negatively influence gait and balance.
- **Complex gait disturbances like freezing and festination** (The involuntary **shortening of stride** and quickening of gait that occurs in some disease)
- **Episodic absence or marked reduction of forward progression** of feet despite the intention to walk.
- They **cannot initiate movement.**
- Followed by episodes of **shuffling forward** with steps that range from **millimeters to a couple of centimeters in length.**
- Increase with increase in **severity and longer levodopa treatment.**
- Festination while walking is clinically defined as the tendency to move forward with **increasingly rapid but smaller steps,** associated with the center of gravity falling forward over the stepping feet.

10.2 How to overcome an initial gait cycle.

Experiencing freezing of gait (FOG) can be challenging, but there are several strategies that may help individuals overcome or manage this symptom. Here are some approaches to consider for overcoming initial freezing of gait

Person experiences gait when they must switch attention from one thing to another or while moving to a busy environment and becomes difficult to focus on one activity.
Leads to sudden freeze and rocking of feet (busy feet without picking up)

10.3 Treating freezing of gait.

10.3.1 Medicines

- Freezing of gait episodes often occur when a person is **under-medicated** and can **improve with increased amounts of their PD meds**, usually carbidopa/**levodopa.**
- The levodopa therapy helps in restoring the **dopamine level** so that the patient can have **improved motor abilities.**
- However, brain abnormalities that lead to freezing of gait are **very complex**, so giving more dopaminergic medication is only **part of the solution.**
- In fact, some people have what is referred to as **ON freezing**.
- This means that freezing of gait episodes occur **even when other PD symptoms are well treated** with their medication regimen.
- Risks of using Levodopa medicines include impulsive behavior, Dyskinesia – this occurs when the patient is suddenly seen to have involuntary movements which are beyond the control, wearing off symptoms - the patient becomes extremely stiff when the effect of the drug wears off before the next dose so prescribed, Anxiety and Depression - Mostly, these effects are seen to occur when the patient stops the use of this drug.

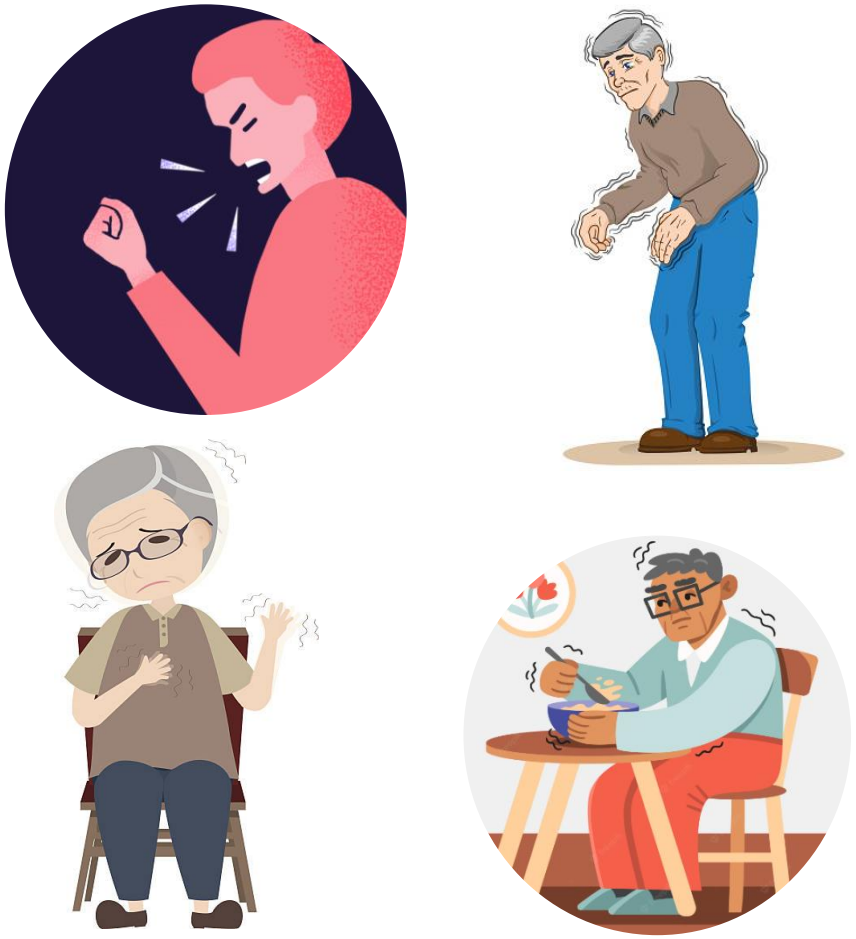


Figure 14 – risks of Levodopa

Figure 14 – risks of Levodopo

10.3.2 Cues

- **Cueing,** or the introduction of an **external sensory stimulus** which provide temporal (related to time) or spatial (related to space) information to "break" a freezing episode.
- There are three cueing modalities: **visual, auditory cueing, and somatosensory cueing.**
- cueing may compensate for the defective internal rhythm generator of the basal ganglia, consequently affecting the coordination and execution of movement.
- **Try another movement** – raise an arm, touch your head, point to the ceiling, then re-start.
- **Change direction**: if can't move forward, try stepping sideways first, and then go forward.
- **laser pointer**: when you freeze – shine the laser in front of your foot and step on the light – this visual cue can help you re-start.
- **Rhythmic auditory cueing** is one such technique which utilizes rhythm and music to improve gait in PD and other neurologic diseases.
- Wear a **metronome** on your belt or carry a small one in your pocket – turn it on and the **external beat** can help you re-start.
- humming a song and time your re-start with the beat of the music, Count "1-2-3-go" and then step forward.
- **March** in place a few times and then step forward.

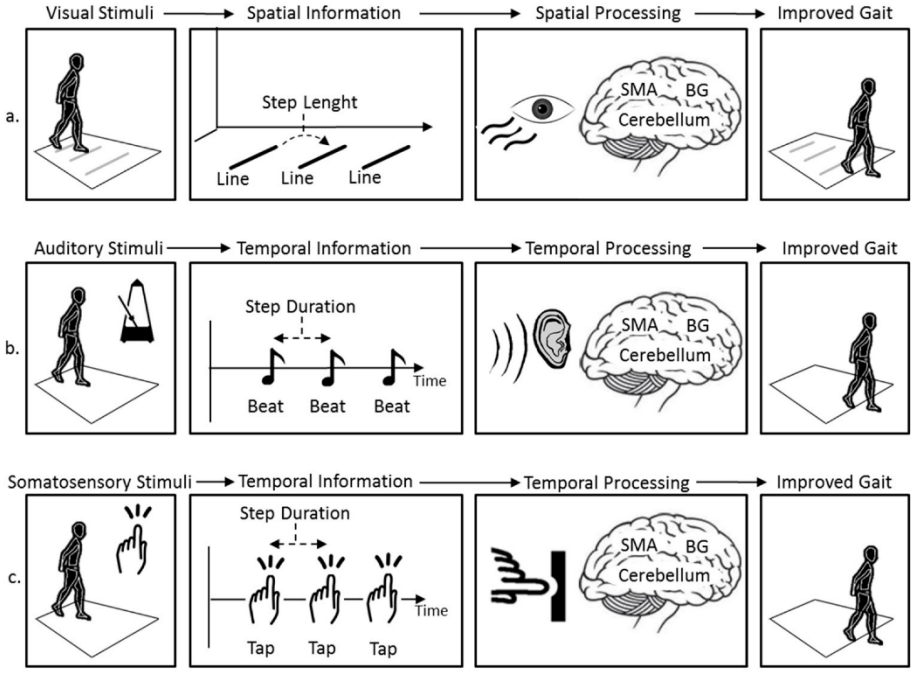
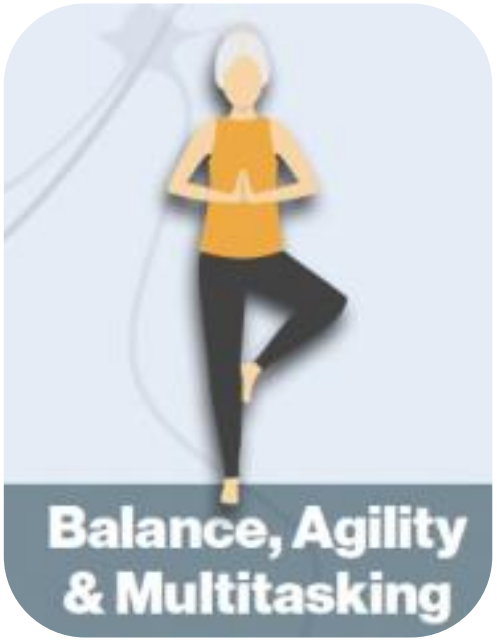


Figure 15 – Cues

10.3.3 Exercises

- Gait training on a treadmill
- General exercises: such as stretching and resistance training.
- Conventional physiotherapy: muscle strengthening and balancing exercises.
- Dual task training: doing two tasks at once; usually one mental and one physical.
- Robotic-assisted walking: walking exercises wearing an exoskeleton device.
- Action observation training: intently watching an action, then practicing that action
- Mind-body exercises: working through coordination-oriented movements, such as Tai Chi, dance, yoga.



11. Market Study

11.1 walking aids to help with freezing of gait.

Often freezing of gait cannot be overcome with medication adjustment and physical therapy, and a walking aid needs to be introduced for safety and walking support.
There are many types of walkers that are available for people with walking difficulties.

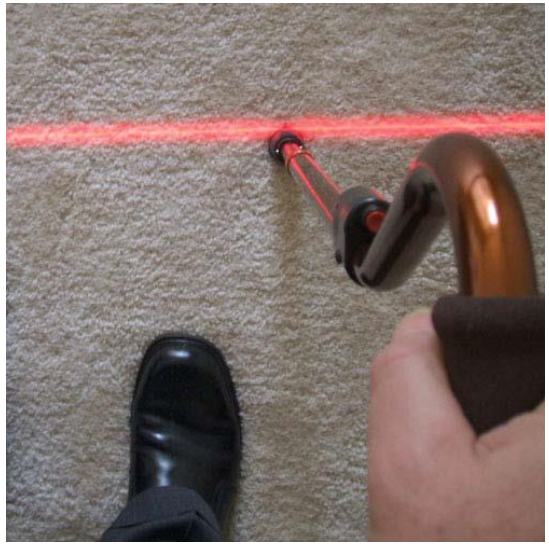
- **Basic walker** – usually just a metal frame without wheels.
- **Wheeled walker** – a metal frame with wheels. The wheels may be on two or four legs and the wheels may swivel or be fixed.
- **Rollator** – a walker with swivel wheels on all four legs and hand brakes. The brakes typically need to be engaged for the walker to stop. Often the rollator has a seat and a basket for convenience.
- A common concern with all these walkers is that there either is no braking system, or the **braking system must be engaged in order for the walker to be stopped.**
- Therefore, if a f**reeze** occurs with the feet stuck to the floor, and the person is not **fast enough to engage the brake,** the walker will continue to move, leading to **fall.**
- The **U-step walker** was designed specifically for this scenario. Although it may not help every patient with PD, it has some features that are worth knowing about.

The U-step walker has a **reverse braking system** which means that without engaging anything, the walker is in the **braked position** and the wheels will not turn. A **lever must be gripped or pressed** (depending on the model) for the wheels to turn. Therefore, if a freeze occurs, the walker should stay stable. In

Figure 16 – Walking Aids

11.2 Current devices and registered patents on cueing technology to treat Freezing of Gait, describing the main trends on this topic.

Device	Method and Description	Performance
Gait Assist 	**Personalized wearable system for FoG** support and gait training in unsupervised environments. The two functionalities of the Gait Assist are **gait support during daily-life activities to avoid or reduce FoG episodes: training support—as a personal assistant for the gait exercises**. It provides audio feedback at critical moments throughout walking when FoG appears.	• Tested with five patients; • FoG real-time hit rate was equal to 97% (99 out of 102), with a detection delay of 0.25s; • FoG events shorter than that period could not be detected; • A decision in the algorithm regarding the FoG event is performed in at most 1 ms. • The system can be continuously used in the assistive mode for up to around 4 hours.
Wearable Assistant for Online FoG Detection 	A **tiny computer for recording data and online signal processing.** Customized platform based on an Intel Scale family processor and uses a Linux operating system.	• The device successfully identified 237 FoG events in eight patients (0–66 per patient). • The length of the FoG events ranged from 0.5 to 40.5 s, and over 50% of the FoG episodes lasted longer than 5 s. • Specificity ranged from 39.7 to 88.9%, and sensitivity from 34.1 to 99%

System and method for alleviating freezing gait and gait hypokinesia in users with extrapyramidal disorders.	Visual cue for a user of a walker or walking aid device. Provide a constant or recurring stimulus to reduce or substantially eliminate the occurrence of FoG, gait hypokinesia, or stride reduction in a user, such as one suffering from parkinsonism.	Patent (n/a)
Laser cane 	External cues improve walking ability in PD patients, stating that it significantly enhances FoG, specifically by increasing patients' stride length and velocity immediate improvements during gait initiation when using the Laser Cane over other interventions.	• Buated et al. applied an external cue with a laser cane in 30 patients, significantly reducing time, the number of freezes (steps) from 0.33 ± 0.84 to 0, and increasing stride length (cm) from 6.82 ± 18.54 to 90.05 ± 19.44. • McCandless et al, in their study with 20 participants, the visual cue with the laser cane reduced the percentage of freezing episodes from 81.58 to 27.50%, increasing velocity (m/s) from 0.335 to 0.455.

Walking assistance method and apparatus	Walking assistance method and apparatus, in detail, a control device that may estimate a gait motion of a user based on pressure data indicating information on a pressure applied to a sole of the user, and provide a feedback corresponding to the gait motion to the user by controlling a vibrator to apply vibration to the sole of the user, is provided.	Patent (n/a)
Intelligent wearable monitor systems and methods	An intelligent wearable monitoring system includes a wireless personal area network to monitor a patient's motor functions. The private wireless network consists of a smart accelerometer unit, a personal server, and a remote access unit. The intelligent accelerometer unit measures the acceleration data of the patient in real-time. Motor function information is transmitted to a remote access unit for statistical analysis and formatting into visual representations.	Patent (n/a)
Wearable vibratory stimulation device and operational protocol thereof	The wearable stimulation device includes a measuring instrument for obtaining data relating to a body motion of a user who wears the vibratory stimulation device, a walking pattern database for storing normal walking pattern data collected by measuring general persons having standard walking patterns.	Patent (n/a)

Walking Aid System	The walking aid system comprised of a sensor section for sensing the motion rhythm of a walker, a recording section for recording values of measurements of the motion rhythm felt with the sensor section, a target setting section for setting a target value for the motion rhythm of the walker, a timing generating section for generating a timing signal according to the difference between the measurement and the target value, and a stimulus generating section for generating rhythm stimulus that is recognizable by the walker, according to the timing signal generated with the timing generating section	Patent (n/a)
Movement initiation device used in Parkinson's disease and other disorders which affect muscle control.	A portable wearable device produces rhythmic stimuli in auditory, visual, tactile, and/or vibratory activity that initiates or assists in the continuing movement of the body's muscles that tend to become rigid and immobile. Includes a housing, a clinician-accessible controller, a user-accessible controller, a transducer for producing sound or vibratory signals, and a computer interface.	Patent (n/a)

12. Insights from interaction with doctors

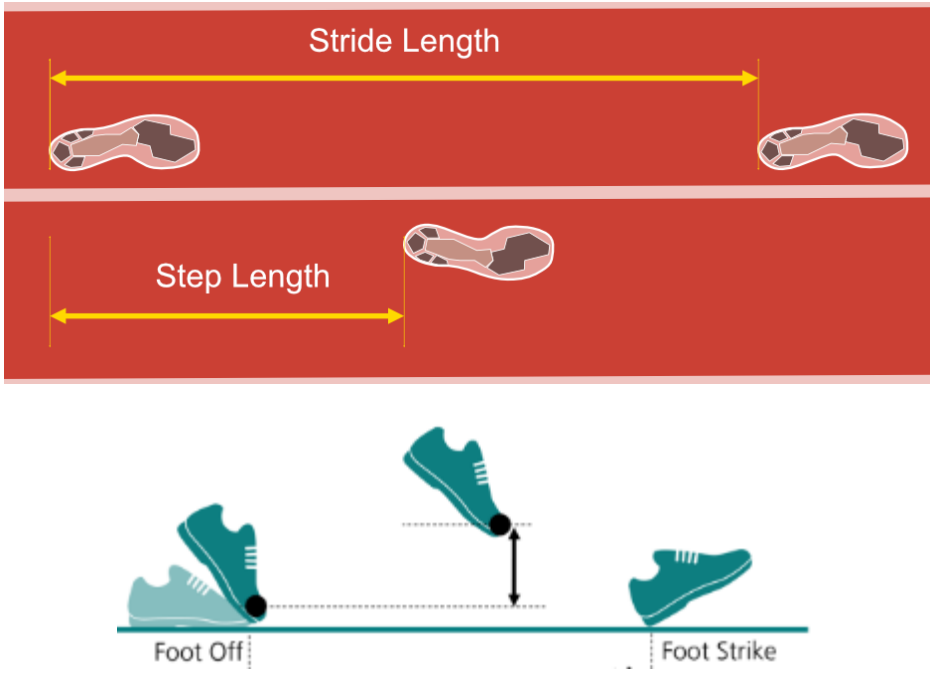
Dr. Vidhya Lakshmi
Hiranandani Hospital, Powai, Mumbai

- A gait episode starts with shuffling of footsteps.
- To maintain balance, Parkinson's patient lean forward.
- This in turn leads to neck hyper extension and change in posture.
- Further leading to a state of anxiety and sudden freezing
- Some patients face falling during this phase.
- From this state providing cues help them to initiate a movement where some patients tend to fall during the attempt of moving forward
- When and how the gait episodes are seen in patients differ from one person to another.
- It is observed that in most of the patients' episodes are found after 1.5 hours of taking levodopa medicine of after 3 to 4 hours when the effect of the medicine is decreased.
- Identifying an episode from calculating the time of intake of levodopa medicines help to an extend to reduce the gait episode.

Figure 17 – Interaction with doctors

13. Ways to detect an Imminent Freeze

- There are wearable insoles with the capacity to recognize patterns, namely.
- stride time (the time elapsed between the first contact of two consecutive footsteps of the same foot),
- step length,
- foot clearance,
- postural sway,
- gait kinematics (the study of joint angles and segment orientation during walking.), and
- plantar pressures (the pressure field that acts between the foot and the support surface during).



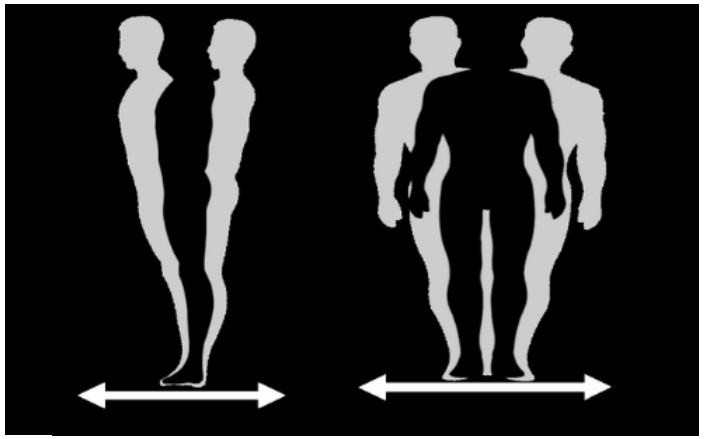


Figure 18 – Postural Sway

Figure 19 – Plantar Pressure

- Most of the wearable devices are developed based on inertial sensors that are comprised of an accelerometer and gyroscope.
- Accelerometers are used to measure accelerations but are unable to measure the rotations or angles. Therefore, these cannot help with detecting the turns during walking activities.
- On the other side, gyroscopes serve in detection of angular velocity of body and also there are less chances of mechanical noise than in an accelerometer's case, hence turning is better assessed during motion.
- Being critical with gyroscopes, it can be mentioned that their drawback relates to the high-power consumption during long-term recording.
- Battery life, type, and number of inertial sensors, sampling rate, recording and processing time, and, most importantly, the learning algorithm is the key factor that makes the difference between the accuracy and precision of wearable device.
- Some common limitations of these solutions are that their intervention ends in prevention or identification.
- The ability to associate a personalized intervention by receiving, processing, and sending data with advanced algorithms for health professionals or caregivers is usually not present or requires other devices.
- With the help of EEG
- An electroencephalogram (EEG) is a test that measures electrical activity in the brain using small, metal discs (electrodes) attached to the scalp.
- These electrodes around the head detect change in signal that leads to freezing by listening to brain.
- This can give early warning before the person freezes.
- Give feedback to the person in the form of sound to do action thereby preventing freezing.

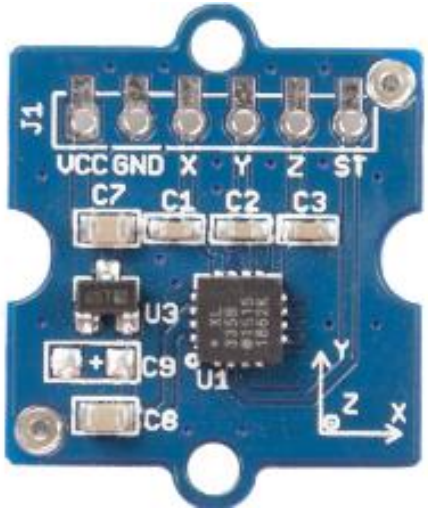


Figure 20 – Accelerometer

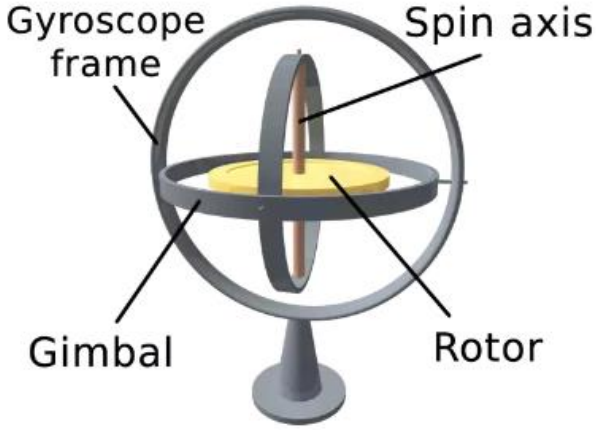


Figure 21 – Gyroscope

14. Objective

To design an assistive kit that helps the patient to **initiate movement from sudden freezing of gait** with the help of cues.
It should also detect and **automatically deploy cues** to a freezing episode.

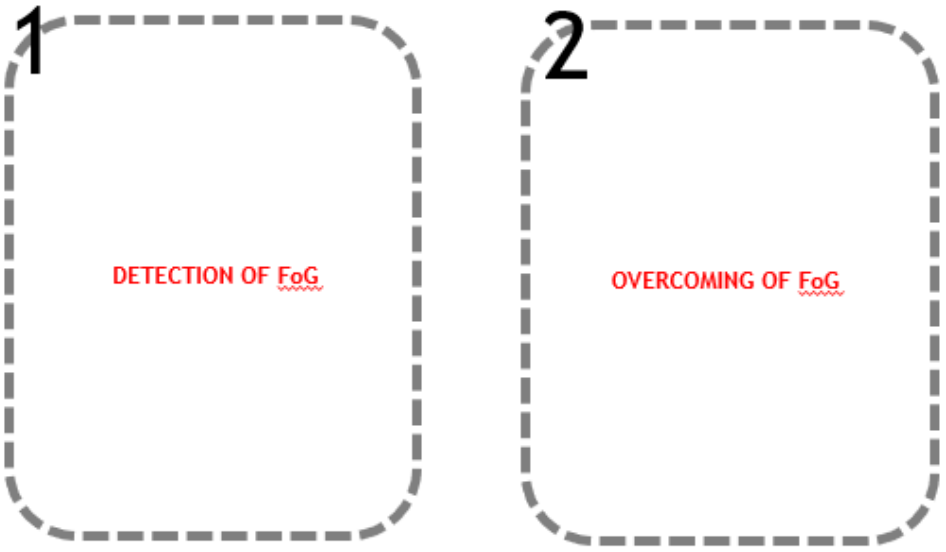
15. Design Brief

To design an assistive kit for Parkinson's patients to help them from freezing of gait which,

- Detect an imminent freeze by observing the change in pattern of stride length and then automatically deploy a cue.
- Doesn't make the patients freeze at a point.
- Makes them feel independent.
- Lightweight and doesn't look like a device and give dignity to the user.

16. Freezing Episode of PD

17. Components of Assistive Aid Kit



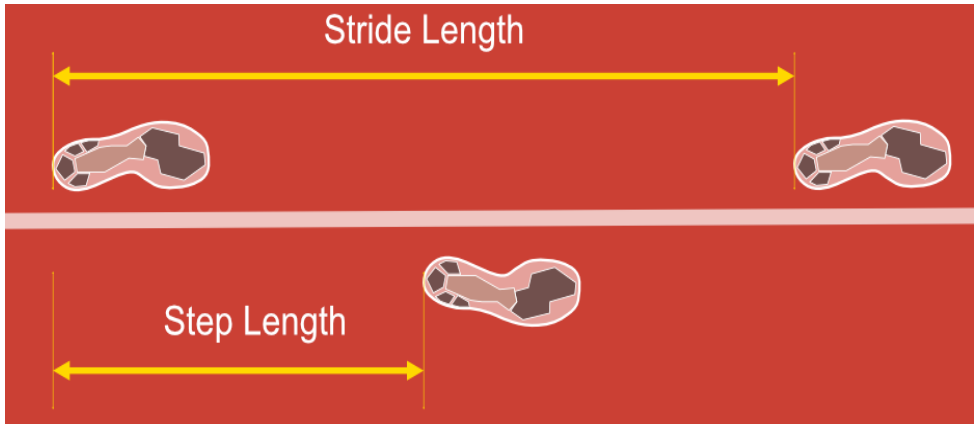


Figure 22 – stride length and step length

17.1 Detection of FoG

17.1.1 Stride Length and Step Length

Stride length and step length are two important measurements in gait analysis

What is stride length?

Stride length is the **distance covered when you take two steps**, one with each foot. Start with your two feet together and start walking. You can start with either foot, but let's say you start with your left:

1. Lift your left foot up and step forward.
2. Now both feet are on the ground with the left foot ahead of the right one.
3. Lift your right foot and swing it forward past your left foot and place it on the ground.
4. Now both feet are on the ground with the right foot ahead of the left one.

The distance traveled during that motion is your stride length. In other words, your stride length is the distance from the toe of your right foot (starting position) to the toe of your right foot (ending position), or the heel of your right foot (starting position) to the heel of your right foot (ending position).

What is step length?

A step length is the distance covered when you take one step. Start with your two feet together and start walking. You can start with either foot, but let's say you start with your left:

3. Lift your left foot up and step forward.
4. Now both feet are on the ground with your left foot ahead of your right one.

The distance your left foot traveled (from the toe of your right foot to the toe of your left foot, or from the heel of your right foot to the heel of your left foot) is your step length. There might be a difference between your left step length and your right step length.

What is the average step length and stride length?

- the average person's walking step length is 2.5 feet (76.2 cm), so the average stride length would be approximately **5 feet (152.4cm).**

There are a number of factors that can impact stride length including:

- height
- age
- injury
- illness
- Terrain
- This information is also interesting for you to have in evaluating your personal fitness. If you get a new pedometer or fitness tracker — such as a Fitbit, Garmin, Xiaomi, Misfit, or Polar — you may need to enter your step length during the initial set up.

17.1.2 Ways to detect Stride Length

1. **Measuring Gait Velocity and Stride Length with an Ultrawide Bandwidth Local Positioning System and an Inertial Measurement Unit**

- One possible modality to profile gait speed and stride length includes using wearable technologies.
- Wearable technology using global positioning system (GPS) receivers may not be a feasible means to measure gait speed.
- An alternative may include a local positioning system (LPS).
- Considering that LPS wearables are not good at determining gait events such as heel strikes
- applying sensor fusion with an inertial measurement unit (IMU) may be beneficial.
- Speed and stride length can be thus determined from an ultrawide bandwidth LPS equipped with an IMU
- Ultrawide bandwidth technology is a radio frequency signal that operates in a bandwidth equal to or greater than 500 MHz.
- Most off-the-shelf GPS systems only have a sampling rate of 5 Hz or 10 Hz, If the sampling rate is lower than 10 Hz, precision and accuracy may be reduced.
- In a GPS, the satellite used to collect data can be quite distant.
- However in an LPS, the source of the radio wave emitter is in close proximity to the user.
- thus LPS can be a valid method to determine speed and stride length.

2.TapeLine

- It is an adaptive stride-length estimation algorithm that automatically estimates a pedestrian's stride-length and walking-distance using the low-cost inertial-sensor embedded in a smartphone.
- Tapeline consists of a Long Short-Term Memory module and Denoising Autoencoders that aim to sanitize the noise in raw inertial-sensor data.
- In addition to accelerometer and gyroscope readings during stride interval, extracted higher-level features based on excellent early studies were also fed to proposed network model for stride-length estimation.

3. Pedestrian Stride Length Estimation from IMU Measurements and ANN Based Algorithm

- This is a stride length estimation algorithm based on a back propagation artificial neural network (BP-ANN), using a consumer-grade inertial measurement unit (IMU);
- PDR can achieve continuous position estimation when satellite signals cannot be used.
- When the sensor is attached onto the body or a handheld device, PDR can achieve better positioning performance than traditional inertial navigation, even when a tactical level sensor is used.
- PDR comprises four phases: step detection, step (or stride) length estimation, heading estimation, and navigation results update.
- Because accelerometers placed on the body are motion-sensitive, the data can be processed to detect steps.
- PDR has become an effective positioning technology, and acceleration signal statistical parameters can be used to estimate stride length.

17.1.3 How is Stride Length calculated in Apple watches.

- Running Stride Length:
- Tap to add an estimate of how much distance you cover from one step to the next while running in meters.
- Along with cadence, stride length determines your overall running speed.
- Apple Watch can log running stride length automatically during outdoor running workouts.
- To calibrate the step tracker, it's important to ensure that your Location Services settings are ON allowing your Apple Watch to measure your distance walked or run via GPS
- In particular, Apple Watch Series 6 and later models can now measure and display additional elements of your running form
- Vertical oscillation is the amount your torso moves vertically with each step while running.

Figure 23 – apple watch

17.2 Overcoming FoG

This objective is validated using 3 different design directions.

EYEWEAR + EARPLUG

- The attachment has got 2 parts, **earplugs and Lazer producing part** which can be attached to the specs of the user with a supporting head band to give stability.
- One that doesn't look like a device and give dignity to the user.
- Lazer projection from the attachment with specs
- This produces **3-dimensional projection** on ground when there are no obstacles in front of the patient.
- **Earplugs gives rhythmic beats** that help the person to unfreeze.
- E.g., Sound of walking on gravel
- Apart from this part it should have a band to detect the change in stride length.

NECKWEAR + EARPLUG

- The attachment has got 2 parts, **earplugs and Lazer producing part** which can be **worn on neck.**
- One that doesn't look like a device and give dignity to the user.
- This produces 3-dimensional projection on ground when there are no obstacles in front of the patient.
- Earplugs gives rhythmic beats that help the person to unfreeze.
- E.g., Sound of walking on gravel
- Apart from this part it should have a band to detect the change in stride length.

LEGWEAR + SENSORY STIMULI

- The product has got **3 parts, a leg band to detect the change in stride length, Lazer producing** part which can be attached to the footwear and a support on **calf muscles that gives stimuli.**
- One that doesn't look like a device and give dignity to the user.
- Lazer produces 3-dimensional projection on ground when there are no obstacles in front of the patient.
- Tactile cues in the form of vibrations on the calf muscles

17.3 Visual projection examples

Figure 24 – visual cues

17.4 Sensory stimuli on calf muscle

Calf muscle

- calf muscle sits in the back of your lower leg. It starts below your knee and extends to your ankle. It allows you to walk, run, jump and flex your foot. It also helps you stand up straight.

What is the calf muscle?

- The calf muscle is in the back of your lower leg, behind your shin bone.
- It actually includes three muscles.
- Together, the muscles help you walk, run, jump, stand on your toes and flex your foot (lift your toes up toward your knee).

What is the purpose of the calf muscle?

- calf muscle supports when you stand and enables you to move your foot and your lower leg.
- It propels (pushes) you forward when you walk or run.
- It also allows you to jump, rotate your ankle, flex your foot and "lock" your knee.

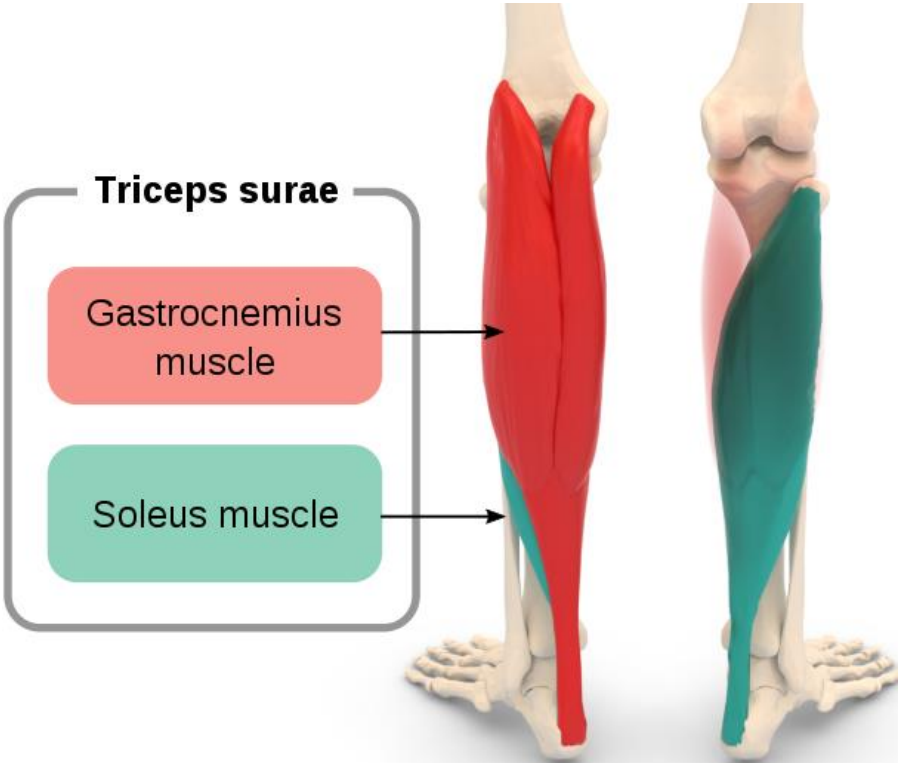


Figure 25 – calf muscles

18. Design Directions

18.1 Design Direction 1

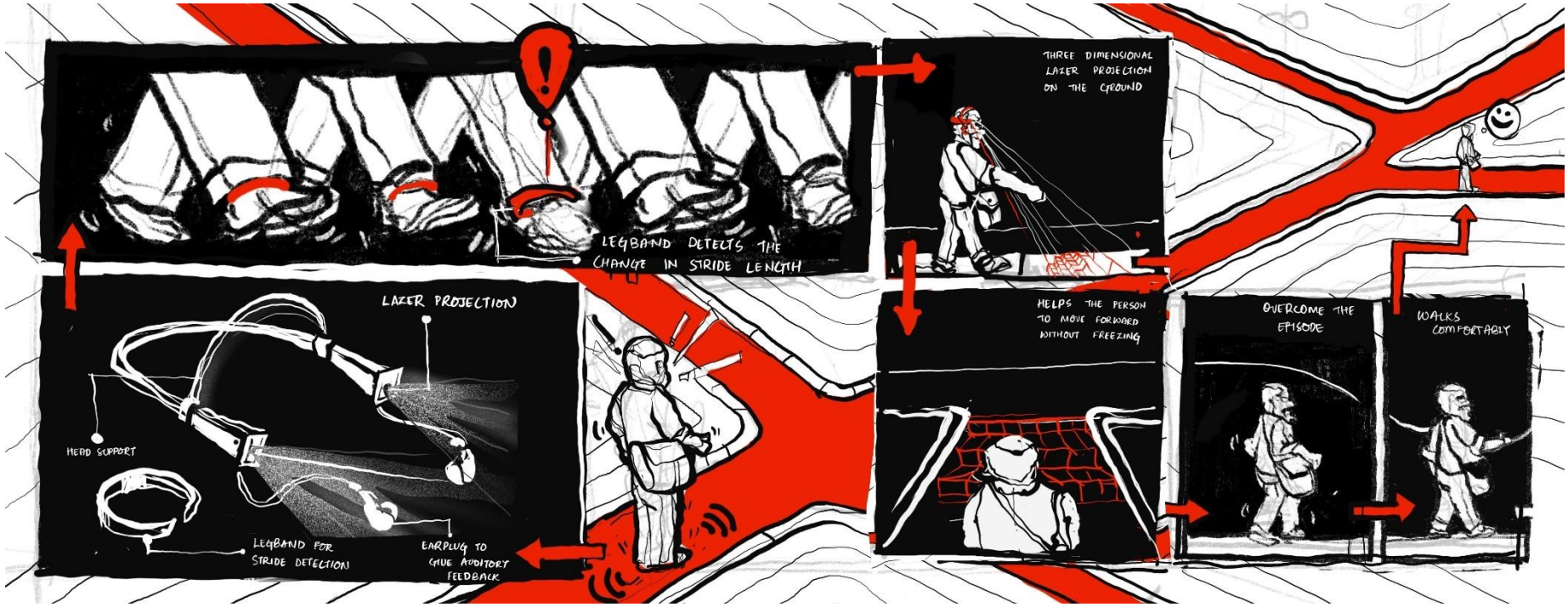
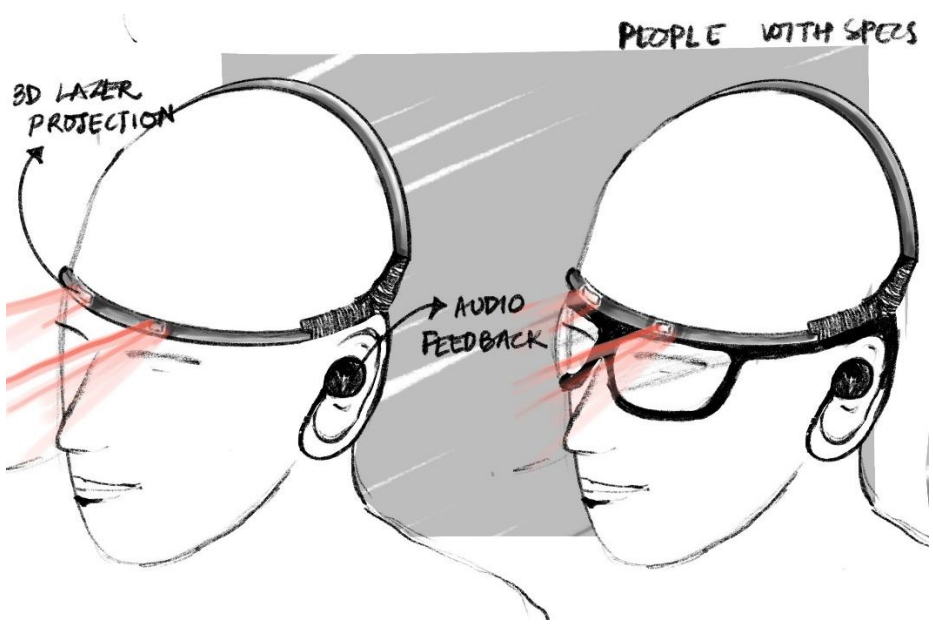
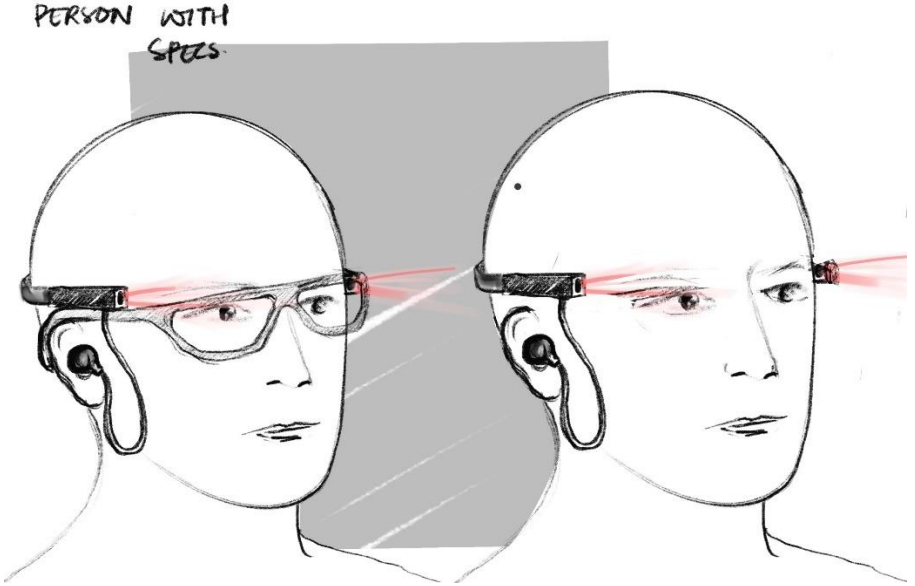
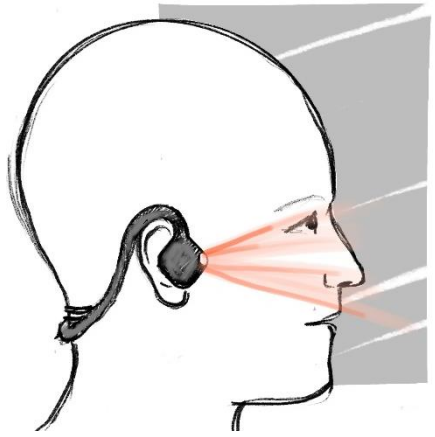


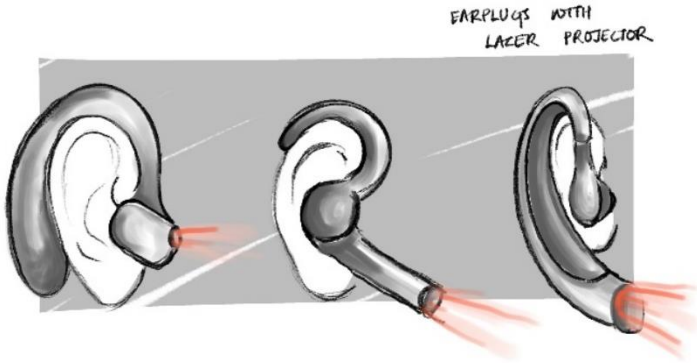
Figure 26 – concept 1 storyboard

Major consideration was whether an eye wear or a head wear can be used by a person with spectacles.





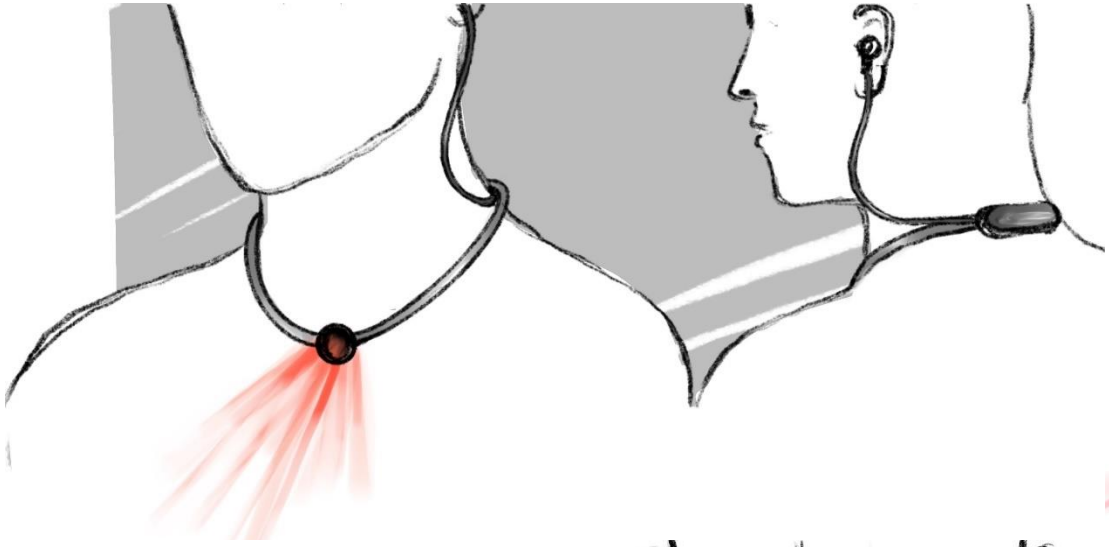


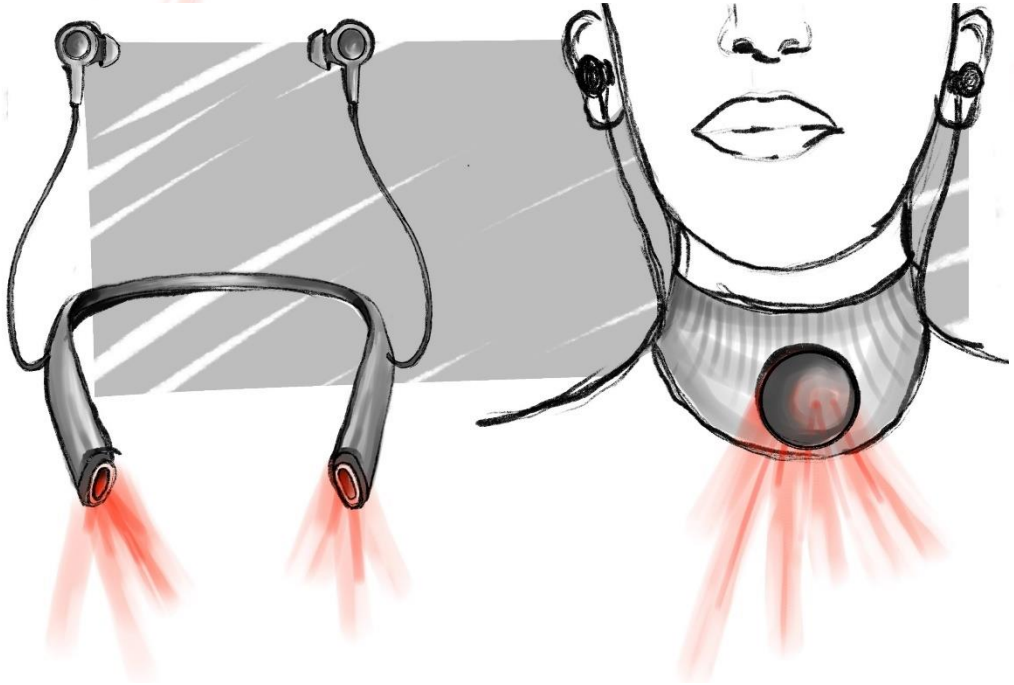


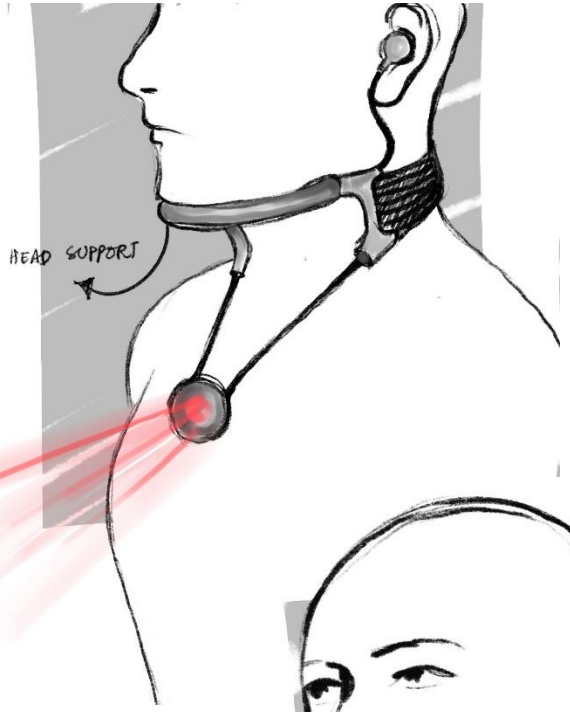
18.2 Design Direction 2

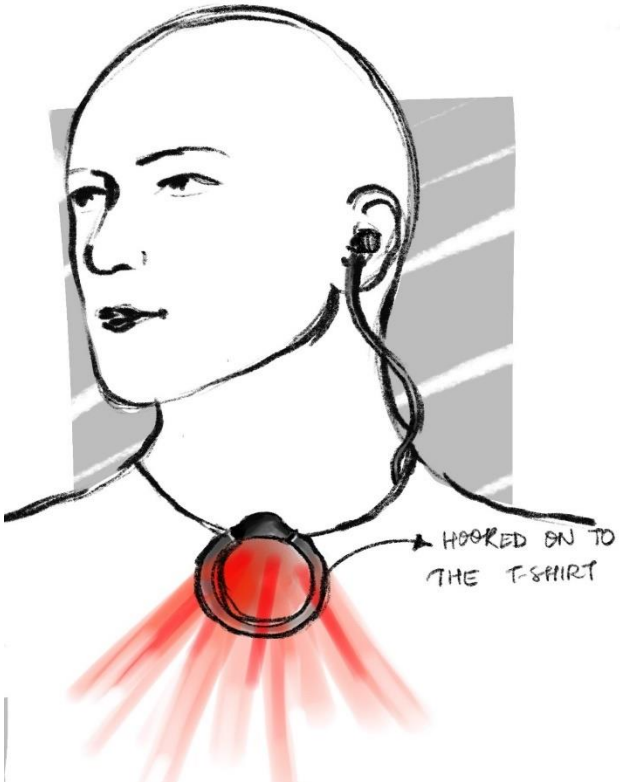
NECKWEAR + EARPLUG – Visual and Auditory cues

Figure 27 – concept 2 storyboard






HEAD SUPPORT


HOOKED ON TO
THE T-SHIRT

18.3 Design Direction 3

LEGWEAR + SENSORY STIMULI – Visual and Sensory cues

Figure 28 – concept 3 storyboard

Vibrator working

- Small vibrating motors are used in a wide range of applications like scanners, tools, GPS trackers, control sticks, and medical instruments.
- but some use electromagnet coils.
- Some vibrators run on batteries while others have a power cord that plugs into a wall socket.

What is the Vibrator Motor?

- Vibration motor is a coreless DC motor, and the size of this motor is compact.
- The main feature of this motor is, it has magnetic properties, lightweight, and motor size is small.
- The configuration of these motors can be done in two varieties one is coin model and another one is a cylinder model.

1) Coin Type Vibrator Motor

- The coin type motor can be built with a case, bearing, rotor, shaft, magnet, bracket, FPC, counterweight, brush, coil assembly, lead wire, & adhesive UV.
- The commutation points get in touch with brushes end. It will strengthen the coils within the rotor.
- Stimulating the coils generates a magnetic field & it is well-built to cooperate with the ring magnet incorporated into the stator to cause rotation.
- Because of the magnetic field, a force can be generated which causes the weight to move. The frequent dislocation of the weight generates an unstable force called as vibration.

2) Bar/Cylinder Type Vibrator Motor

- Basically, this motor is balanced improperly.
- This force moves the motor, and its high-speed dislocation makes the motor to vibrate.
- The centrifugal strength which is produced by the unbalanced weight rotation will cause the motor throb in two axes like X-axis and Z-axis.

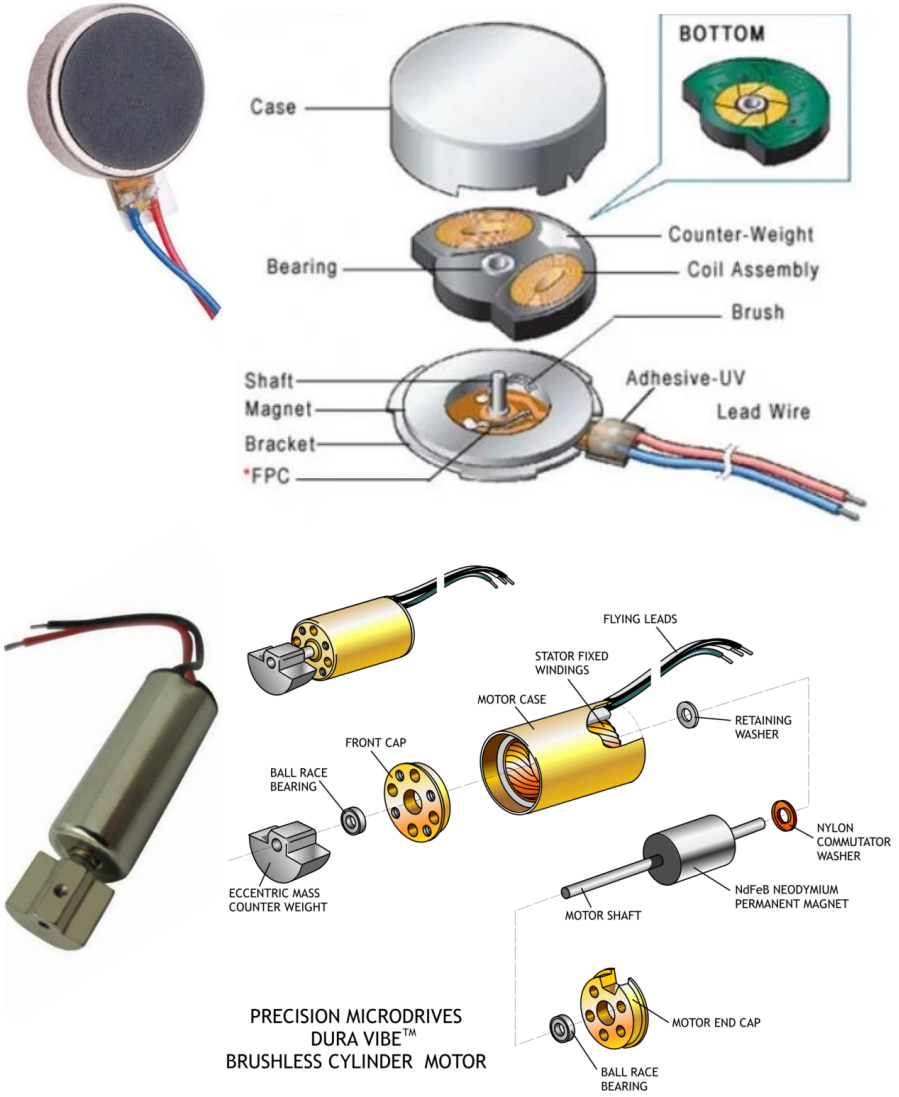


Figure 29 – vibrator motor

18.3.4 Effects of vibrator

Increases blood flow.

- Normal therapeutic applications of vibration have been shown to significantly increase blood flow.

Relaxes muscles.

- Various studies have shown that the application of vibration massage in the range of 20-60 Hz causes muscles to relax.
- This is the therapeutic range of massagers.
- Vibrations from 100-200 Hz have been shown to cause muscles to contract.

Reduces pain.

- The main way vibration massage helps reduce pain is to help address the causes of pain, such as tight sore muscles and trigger points.
- However, the application of stimulation at 100 Hz has been shown to neurologically block pain,

Inhibits cramps and spasms.

- Cramps and spasms are caused by neurological reflexes.
- This is an excellent protective mechanism that prevents muscles from being overstretched and damaged.

Increases performance.

- The application of vibration has been shown to enable the nervous system to stimulate more receptors in muscles, both in number and type.

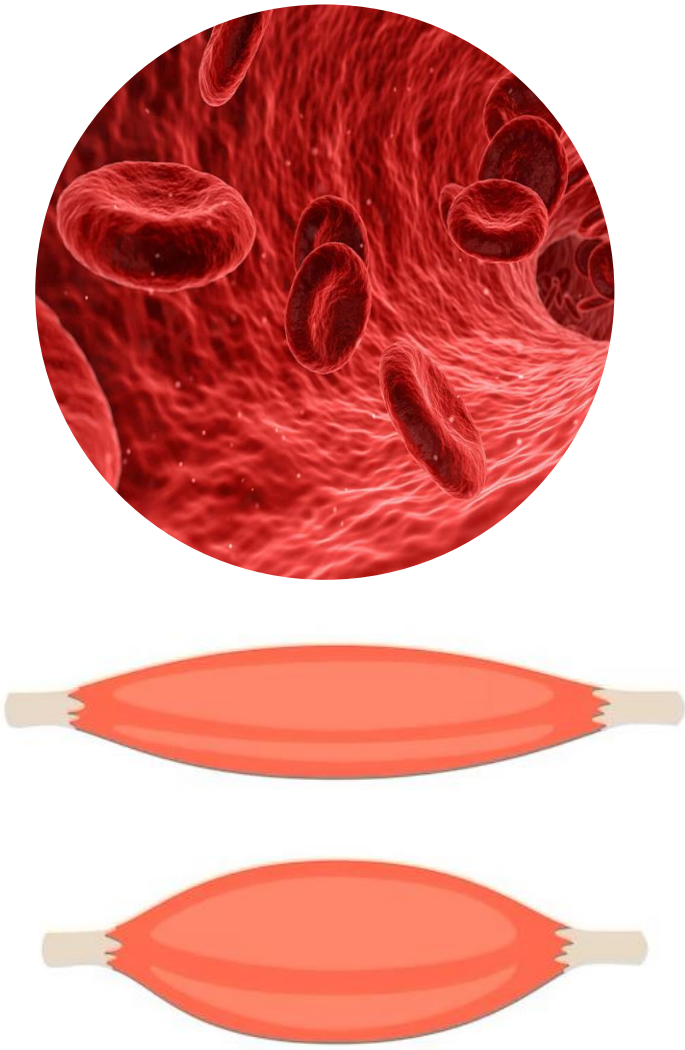


Figure 30 – effect of vibrator on muscles

18.3.5 Products with vibrator

18.3.5.1 VENOM GO by hyperice

- This is a revolutionary heat + vibration wearable with unmatched versatility and customization.
- There are 9 combinations of heat and vibration provided to soothe sore muscles in an instant.
- Heat and vibration spot treatment loosen and relax muscles and reduces stress and tension.
- It can go anywhere on the body with the sticky pad.

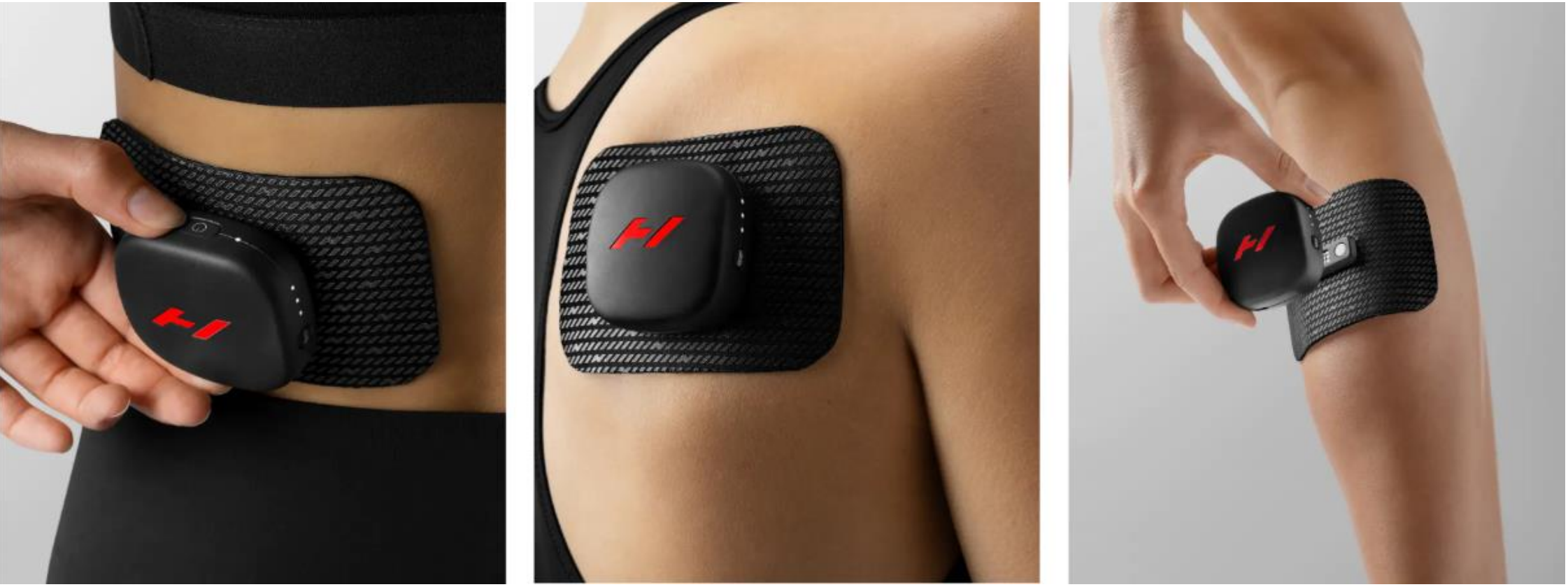


Figure 31 – working of venom go by hyperice

VENOM GO by hyperice Components.

Venom Go pod.

- Control your device and connect to pad.
- Control heat and vibration with specific settings
- Has a charging port.
- Magnets that connect to the pad after switching on
- Very small and compact
- Temperature provided varies from105 to 130 degrees.
- Vibration – long, repeated short vibrations and mix of both.
- 2-inch x 2 inch

Venom Go pad.

- Adhesive pad
- Has got magnetic connectors.
- Backing can be peeled off and Sticky pads can be stuck on to any part of the body.
- 1 pad can be used for 20 to 30 uses.
- 5-inch x 3 inch
- Vibration and heat get distributed equally throughout the pad.

Power supply

- USB-C cable to charge your device.
- Can be connected to the pod and charged.

Figure 31 – working of venom go by hyperice

18.3.5.2 Handheld electric massager

Has a vibrating motor inside that rotates to create the vibration.

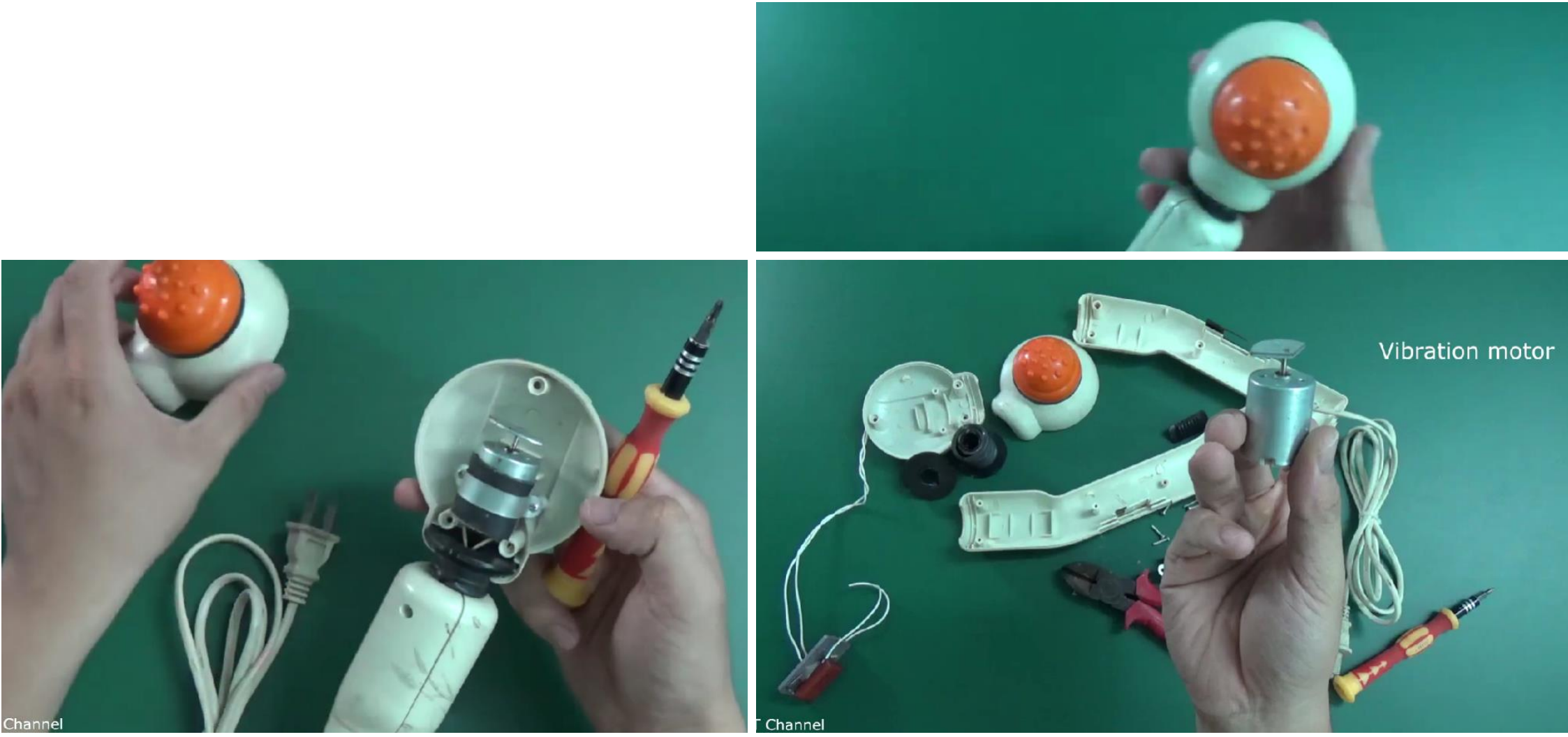


Figure 32 – exploded view of the handheld massager.

18.3.5.3 Rechargeable knee massager

Has a vibrating motor inside the pod that rotates to create the vibration.

Figure 33 – rechargeable knee massager

18.3.5.4 Heat pulse Knee massager

Has a vibrating motor inside the pod creates vibration
Velcro attachment that tightly fits the knee
Vibration is this evenly distributed

Figure 34 – heat pulse knee massager

18.3.5.5 Multifunctional Electric Head Massager Migraine Relief Insomnia Treatment Relief Stress Sleep Therapy Instrument Massager

Has a vibrating motor inside the pod creates vibration.
1 patch can be used for more than 50 time
USB port for charging, full charge can be used for 20 times
Electrode sheet (hydrogel pads) can be buckled into the buckle of the instrument and the protective film can be peeled off

Product name: head sleep device
material: ABS + compression belt
Overall size: 145*50*38mm
Net weight of the whole machine: 52g
Battery specification: 200mAh/3.7V
Charging output interface: standard V8 interface

Figure 35 – migraine relief massager

18.3.5.6 COMFIER heating pad for back pain

The back massager with heat is built in 4 powerful massage motors to deliver soothing vibrating massage.
This wrap around heating pad is flexible, with an adjustable strap to extend to up 58 inches to fit all sizes.

Figure 36 – back massager

18.3.6 How do Lazer projectors work??

What is a Laser Projection?

- Laser projection means **animations and graphics that are displayed on projection surfaces with a laser display.**
- For displaying such laser projections a show laser system needs galvanometer scanners that move the laser beam so fast that the eyes of an observer see an animated laser picture.
- The laser projector makes use **of mirrors, in addition to the laser, in order to provide high-quality projections.**
- By making rotating movements with these mirrors at a high frequency, one or more lines/shapes are projected with the laser light.

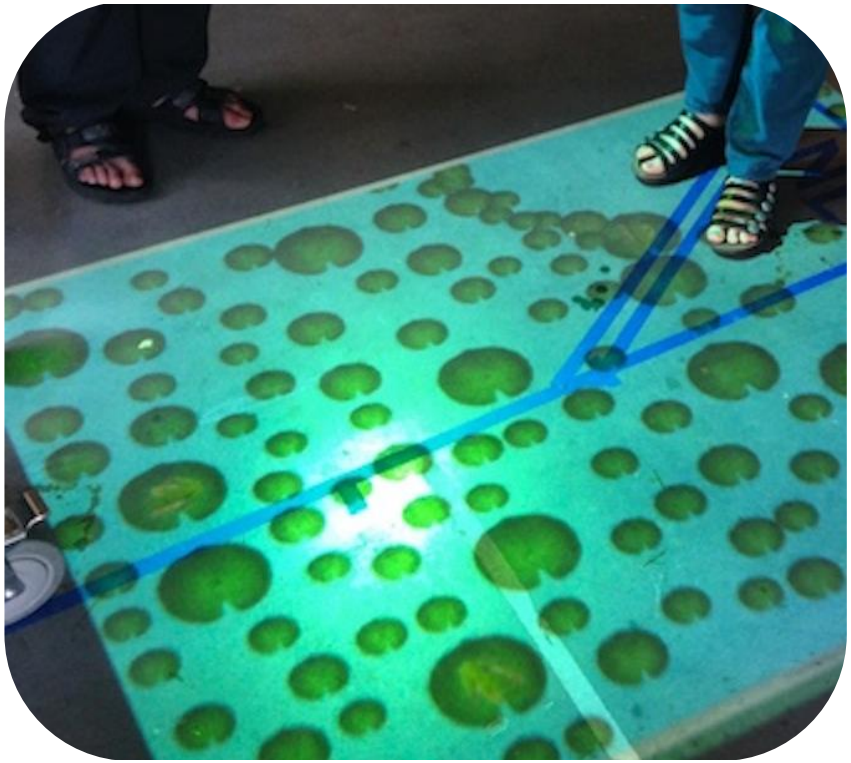
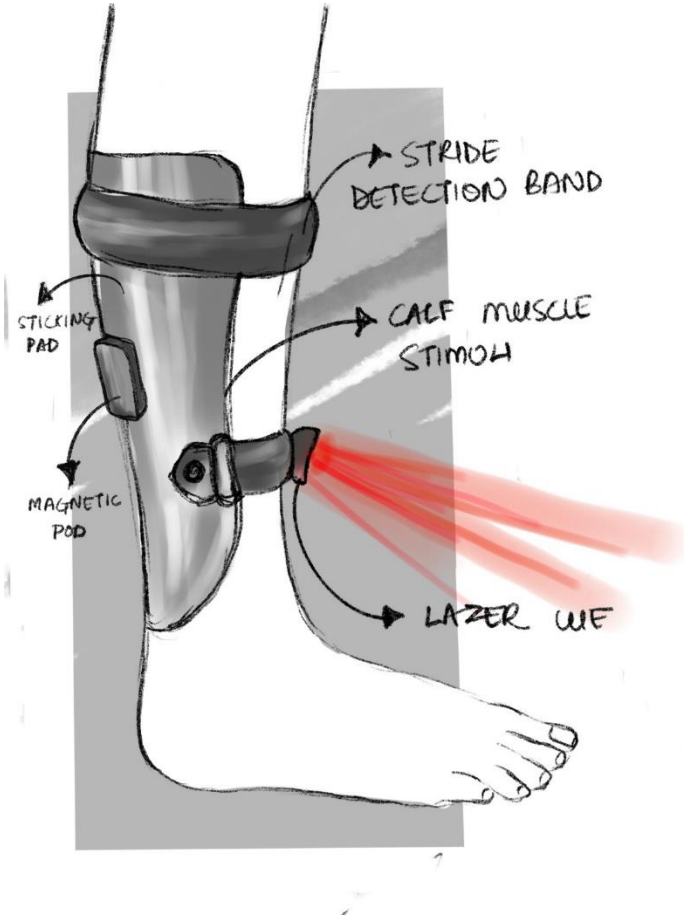
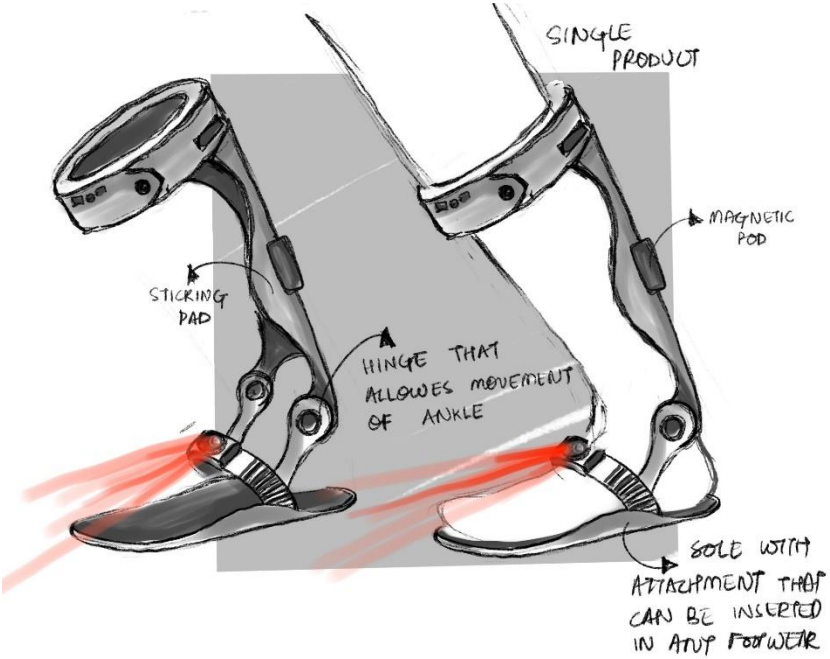


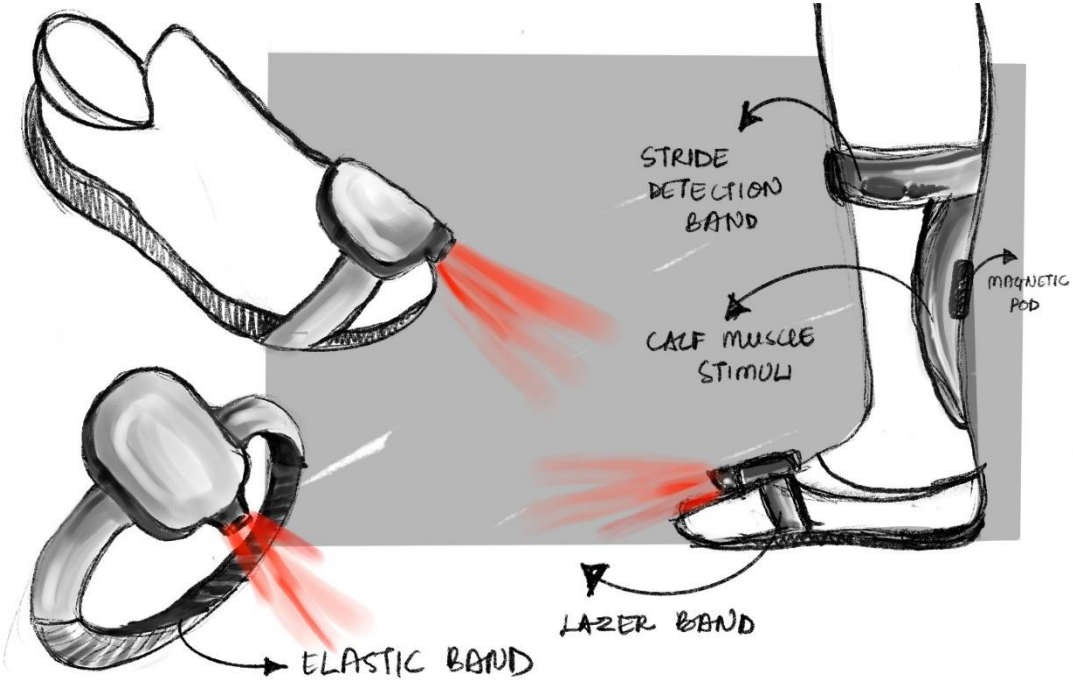
Figure 37 – laser projection visualization

18.3.7 Ideations for direction 3

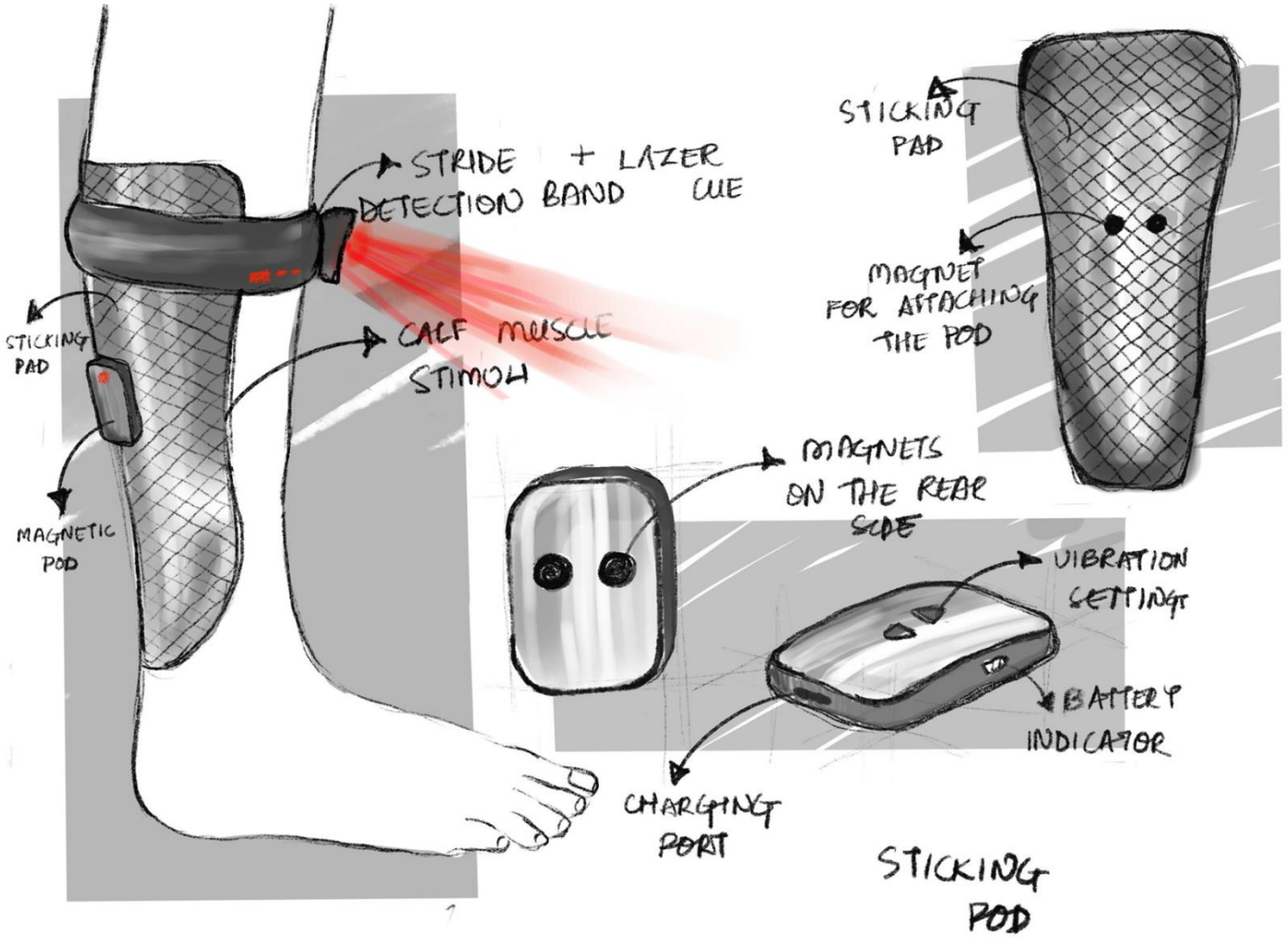
- Lazer band is worn over the footwear.
- Only this part is seen outside rest can be hidden below the clothes.







- The magnetic pod and sticking and can be stuck on the leg
- The stride detection band with visual projection should be worn above the clothes.



19. Evaluation of 3 Design Directions

	EYEWEAR + EARPLUG	NECKWEAR + EARPLUG	LEGWEAR + SENSORY STIMULI
PROS	• Fixed firmly with the help of a headband • Can be attached to the specs • A single product can cater to providing visual and auditory cues with a earplug attachment.	• A single product can cater to providing visual and auditory cues with a earplug attachment. • The visual cue doesn't get disturbed as its fixed in the neck and the laser is directly focused on the ground • An attachment to lift chin can also be provided along with the neckband to correct posture	• A single product can cater to providing sensory cue, and stride detection components in a single product • The visual cue doesn't get disturbed as its fixed to the leg and the laser is directly focused on the ground • Since its worn-on leg, it's not very noticeable • Distance of projection is less • Visual cue coming from leg enables the projection in an alternate pattern which is the most effective way to initiate a movement. • Doesn't seem like a device hence providing confidence and dignity to the user • Use of thin vibratory pads makes the device lightweight easily wearable
CONS	• Not suitable for patients with shivering and change in posture. • Can be an obstacle while using specs • Head band can be difficult to be fixed for ladies with hair • Stride length calculating band has to be provided as a separate product • Distance of projection to ground is lot	• Stride length calculating band has to be provided as a separate product • Distance of projection to ground is lot • Wearing this device can make the patient uncomfortable and hesitant as its easily visible.	

20. Position Finalization

Figure 38 – laser projection from waist

WAIST
projection distance is more.
Projection is not stable as it moves with user
Alternate projection is not possible
Useful in initiating the movement but cannot follow the projection.

NECK
Distance of projection is more.
Projection is not stable as it moves with user.
Alternate projection is not possible.

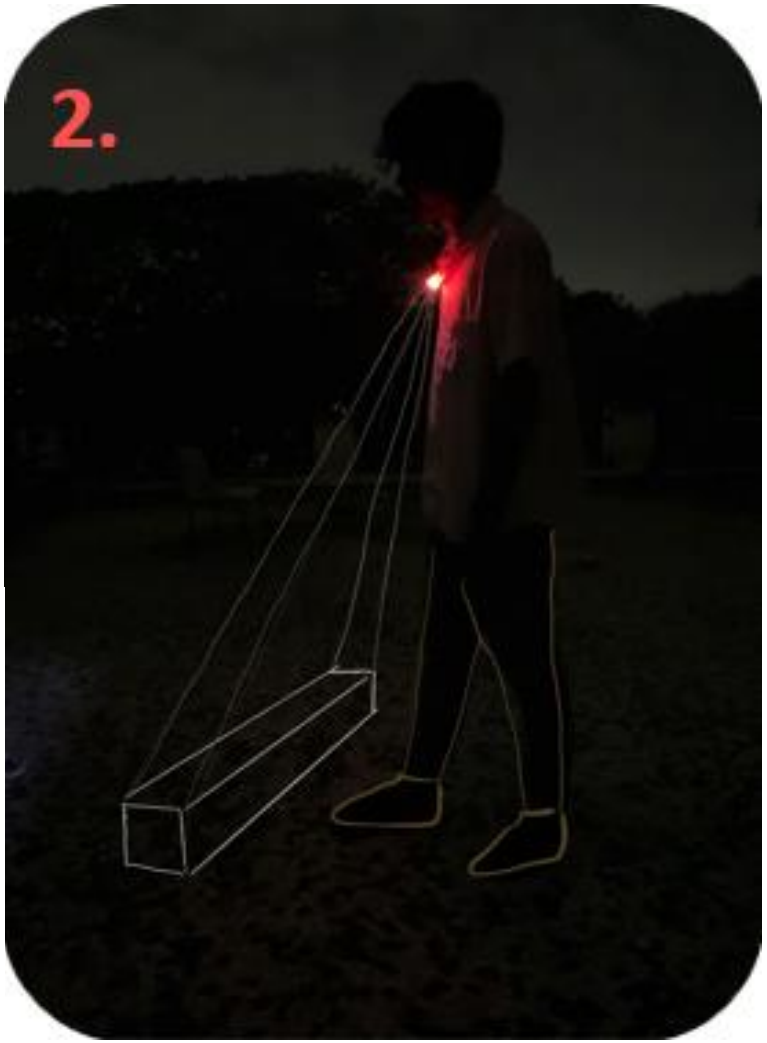
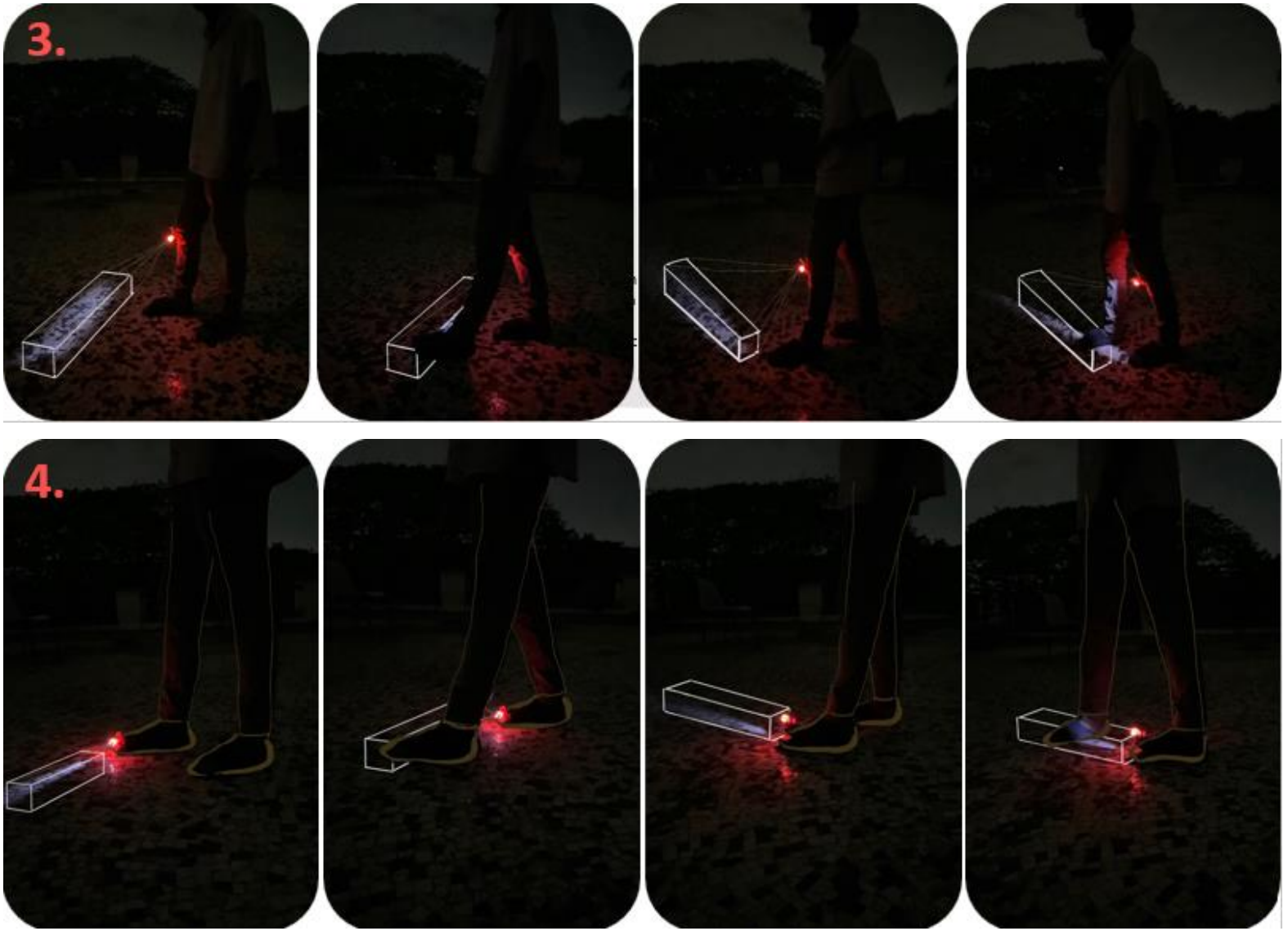


Figure 39 – laser projection from neck



BELOW KNEE
Distance of projection is accurate.
Alternate projection is possible
Position is not apt for all types of dresses.
.

FOOT
Distance of projection is accurate.
Angle can be adjusted.
Alternate projection is possible.
Can be attached to any footwear or walker.

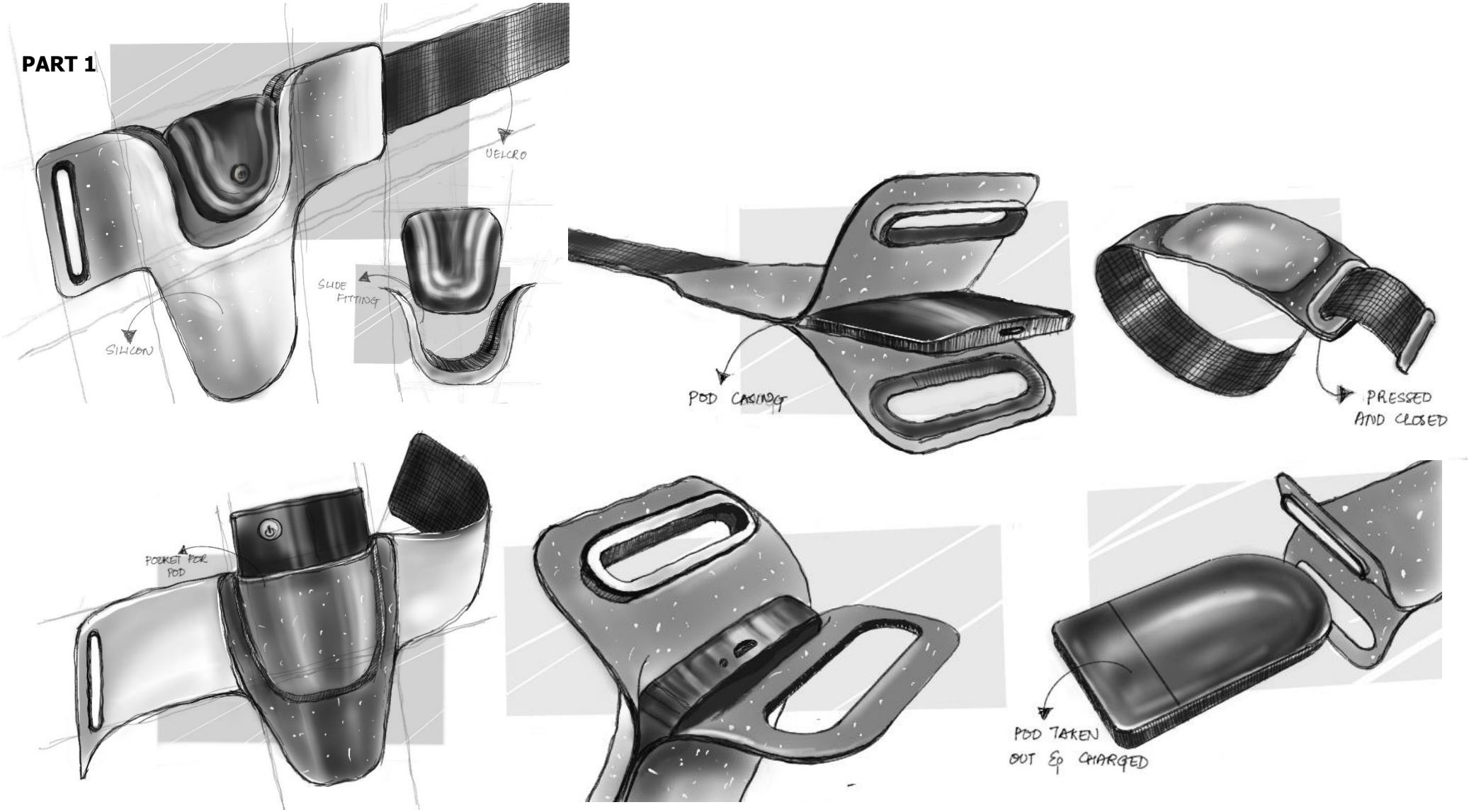
Figure 40 – laser projection from knee and foot

FOOT

Distance of projection is accurate.
Angle can be adjusted.
Alternate projection is possible.
Can be attached to any footwear or walker.

Figure 40 – laser projection from foot

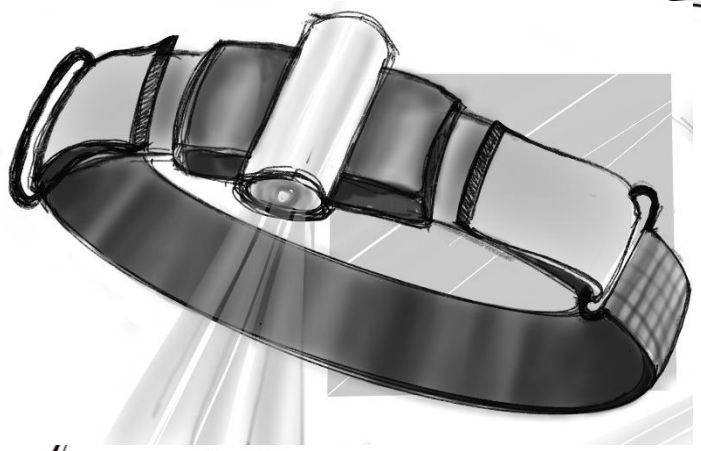
21. Design Direction 3 Ideations

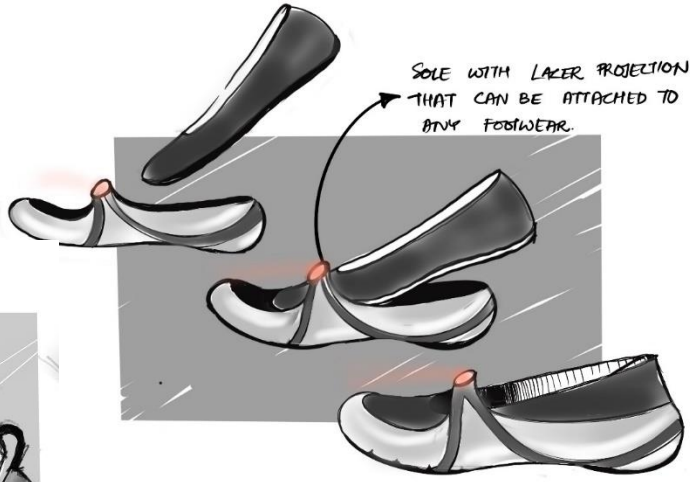


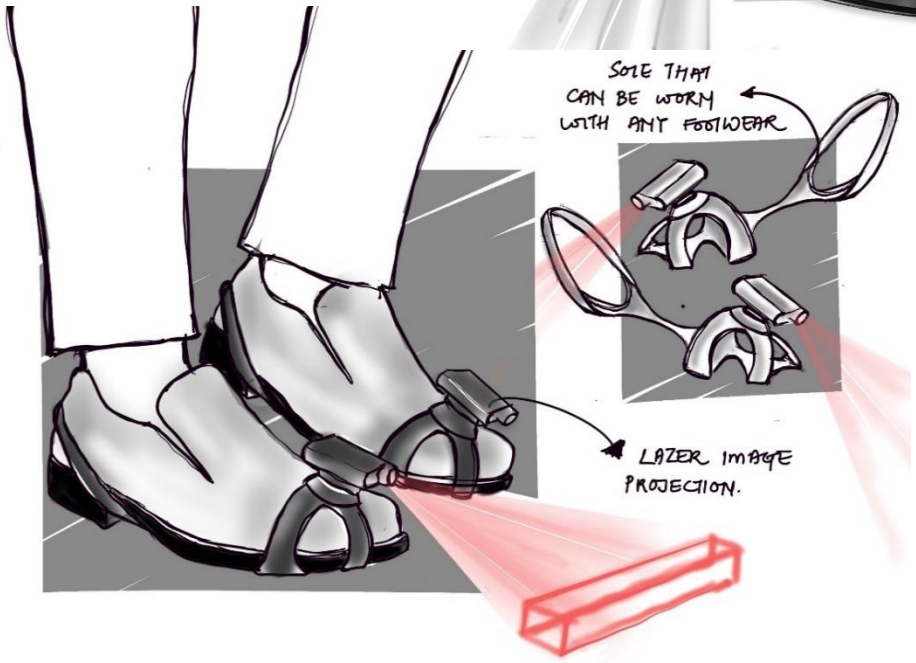
PART 2

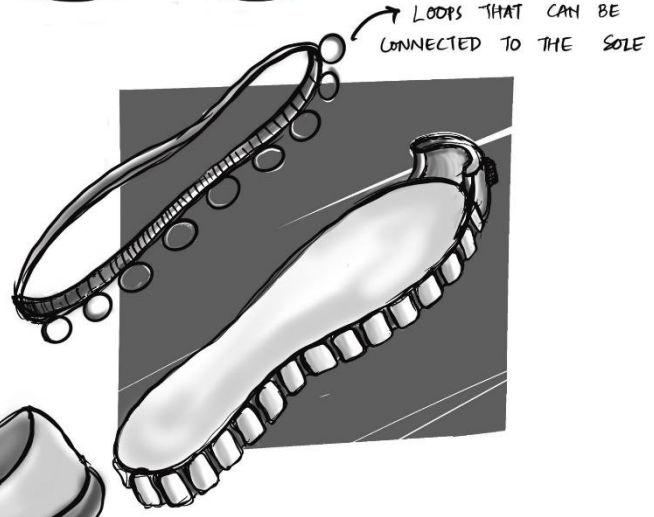
Components

- Clipping mechanism
- Lazer torch projecting 3d image



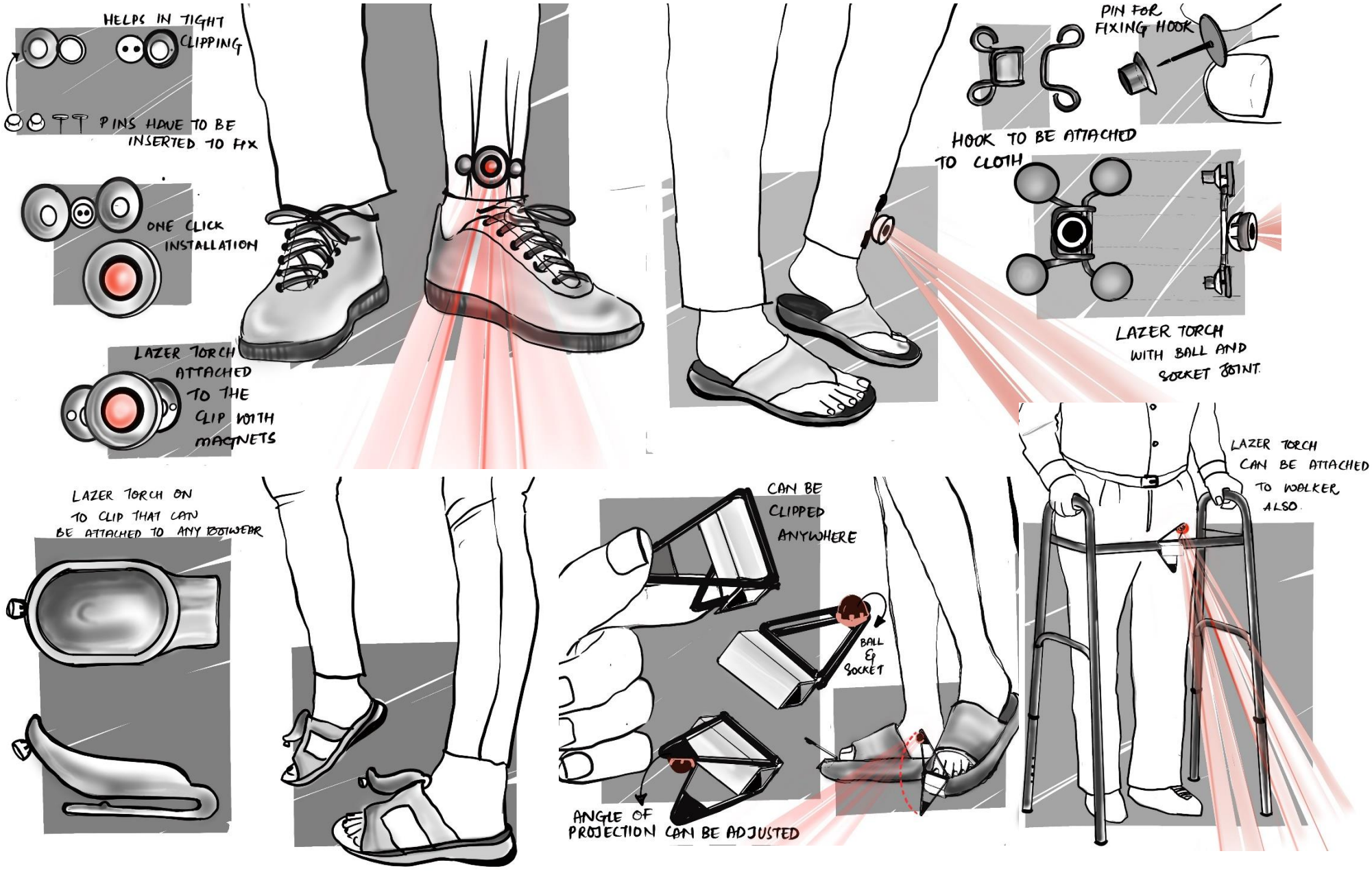






Drawback

- Wont be a universal product
- the and shape of all the foot and footwears differ


HELPS IN TIGHT CLIPPING
PINS HAVE TO BE INSERTED TO FIX
ONE CLICK INSTALLATION
LAZER TORCH ATTACHED TO THE CLIP WITH MAGNETS
PIN FOR FIXING HOOK
HOOK TO BE ATTACHED TO CLOTH
LAZER TORCH WITH BALL AND SOCKET JOINT
LAZER TORCH CAN BE ATTACHED TO WALKER ALSO
LAZER TORCH ON TO CLIP THAT CAN BE ATTACHED TO ANY FOOTWEAR
CAN BE CLIPPED ANYWHERE
BALL & SOCKET
ANGLE OF PROJECTION CAN BE ADJUSTED

PART 2

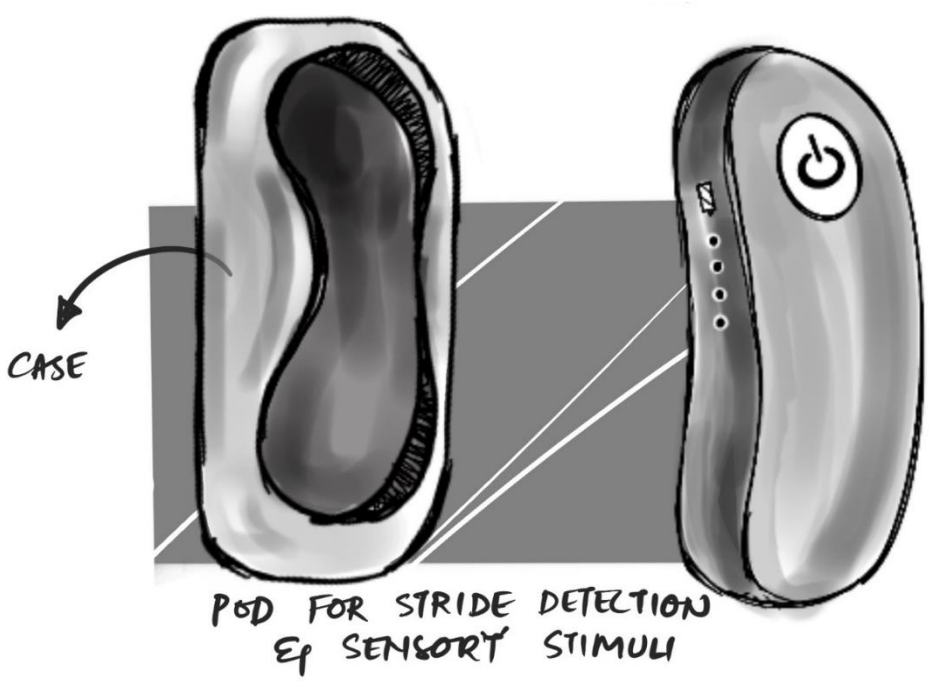
Should be able to clip to any footwear.

22. ELECTRONICS

22.1 Stride Detection + Sensory stimuli

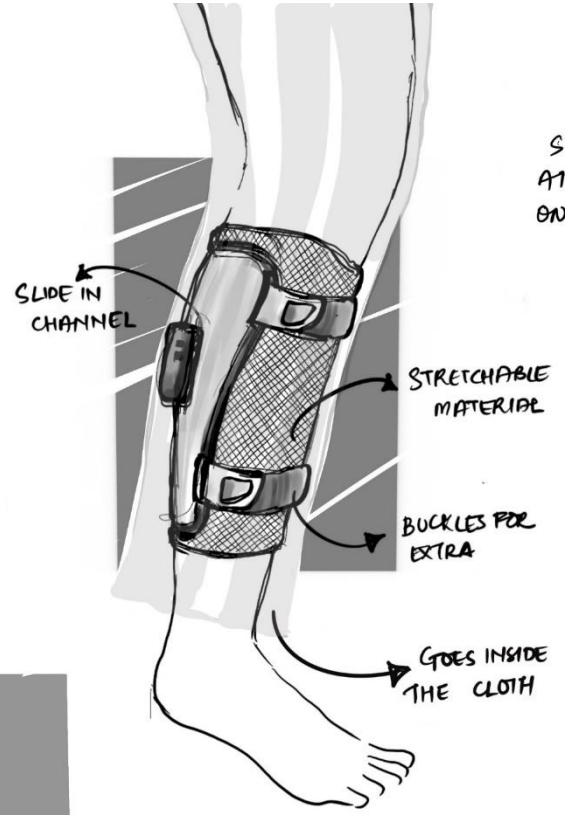
POD

- Combination of accelerometer and gyroscope
- Accelerometer: An accelerometer is a sensor that measures acceleration. It can be used to measure the movement of the foot or leg during a stride.
- Gyroscope: A gyroscope is a sensor that measures rotation. It can be used to detect changes in orientation of the leg during a stride.
- Microcontroller: A microcontroller is a small computer that can be programmed to process sensor data and make decisions based on that data. It may be used to receive data from the sensors and analyze it to determine stride length.
- Bluetooth module: A Bluetooth module may be used to transmit the sensor data wirelessly to another device.
- Power source: A power source, such as a battery (3ah, 4v), may be required to power the electronic components.
- USB cable slot
- Signal conditioning circuitry: Signal conditioning circuitry may be required to filter and amplify the sensor signals before they are processed by the microcontroller.
- Motor apparatus – to provide the necessary vibrations.
- Enclosure: An enclosure may be required to protect the electronic components from damage and to make the device more user-friendly.
- As thin as possible



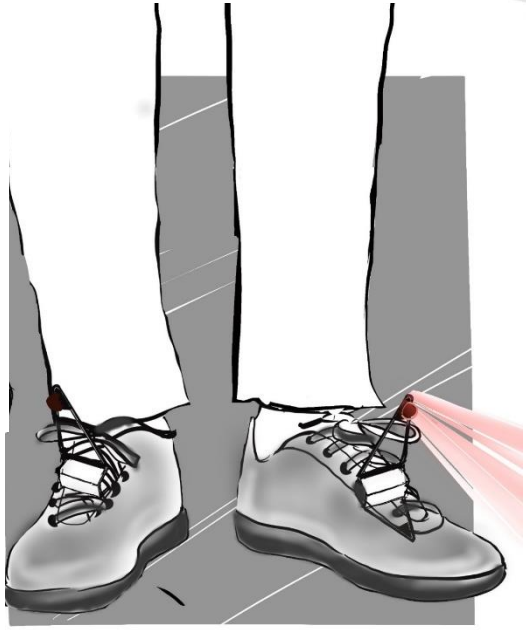
PAD

- pod attachment loop
- Equally distributes the Vibration.
- ability to absorb and evenly distribute the vibrations across the surface.
- Foam: Foam is a popular material for massagers because it is soft and compressible. It can be used to create a cushioning layer that absorbs and evenly distributes the vibrations across the surface.
- Rubber: Rubber is another material that is commonly used for massagers. It is durable and flexible, which allows it to absorb and distribute vibrations effectively.
- Silicone: Silicone is a soft and flexible material that is often used in massagers. It can be used to create a cushioning layer that absorbs and evenly distributes the vibrations across the surface.



LAZER TORCH

- Battery
- Lazer projection unit
- Signal receiving Micro controller.
- Bluetooth module to accept the data sent by the stride detection unit.
- To stop the projection when there comes an obstruction IR obstruction detector/ ultrasound sensor which is more accurate.



23. FINAL CONCEPTS

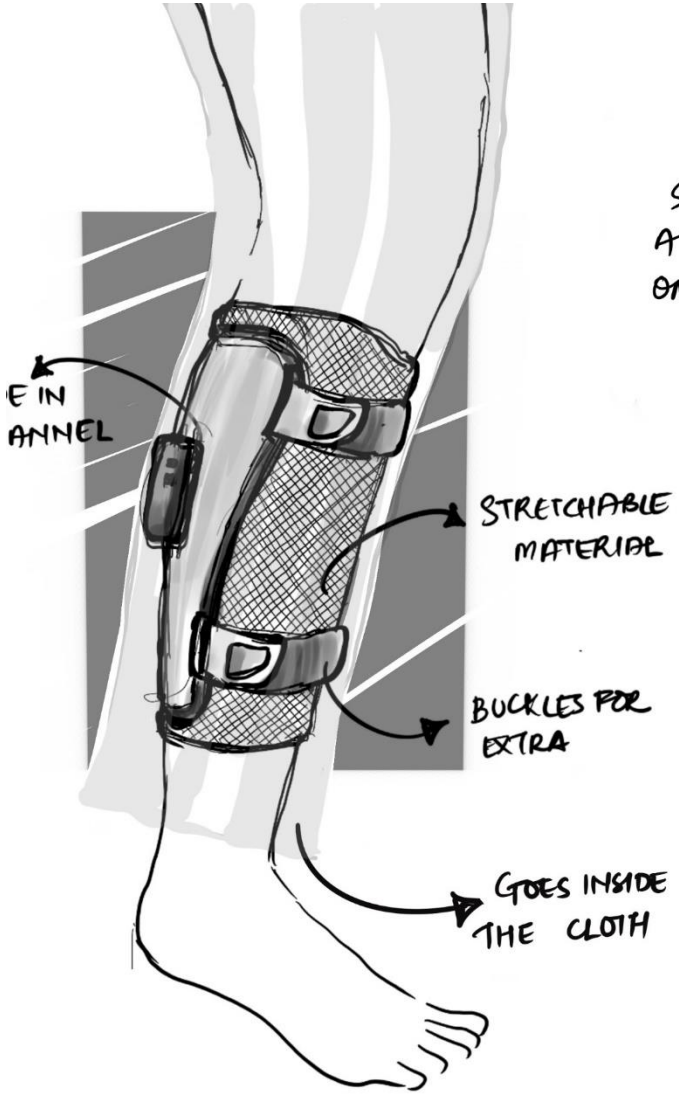
23.1 Concept 1 - Leg band

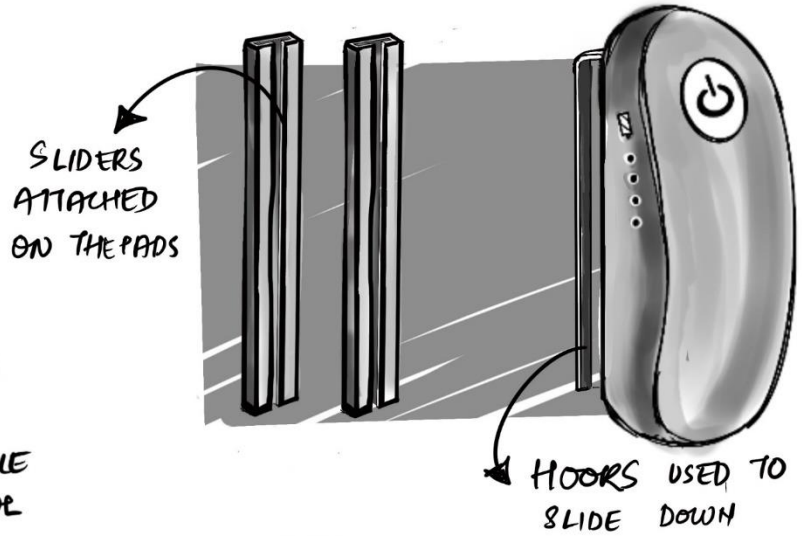
Figure 41 – initial rig model

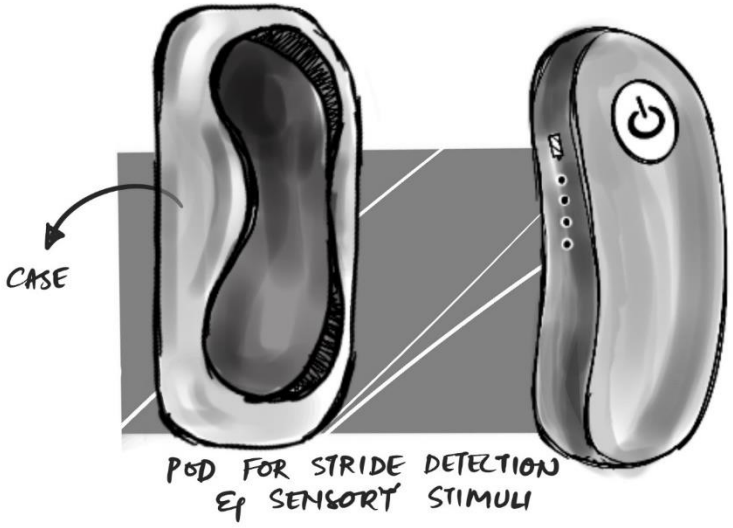
PART 1

Components

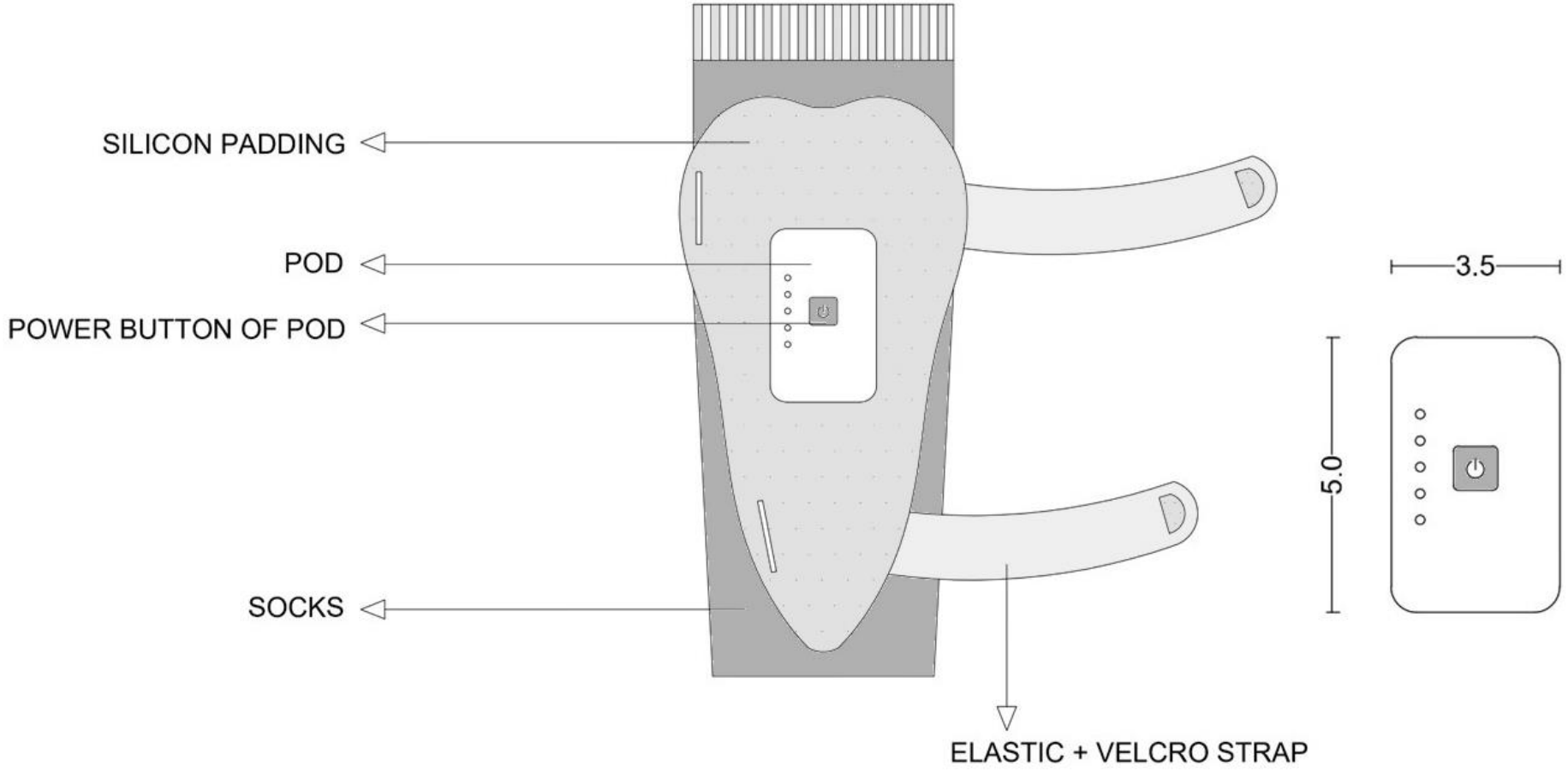
- Rechargeable pod
- Stride detection
- Sensory stimuli







DIMENSION DRAWING



HOW THE PRODUCT WORKS

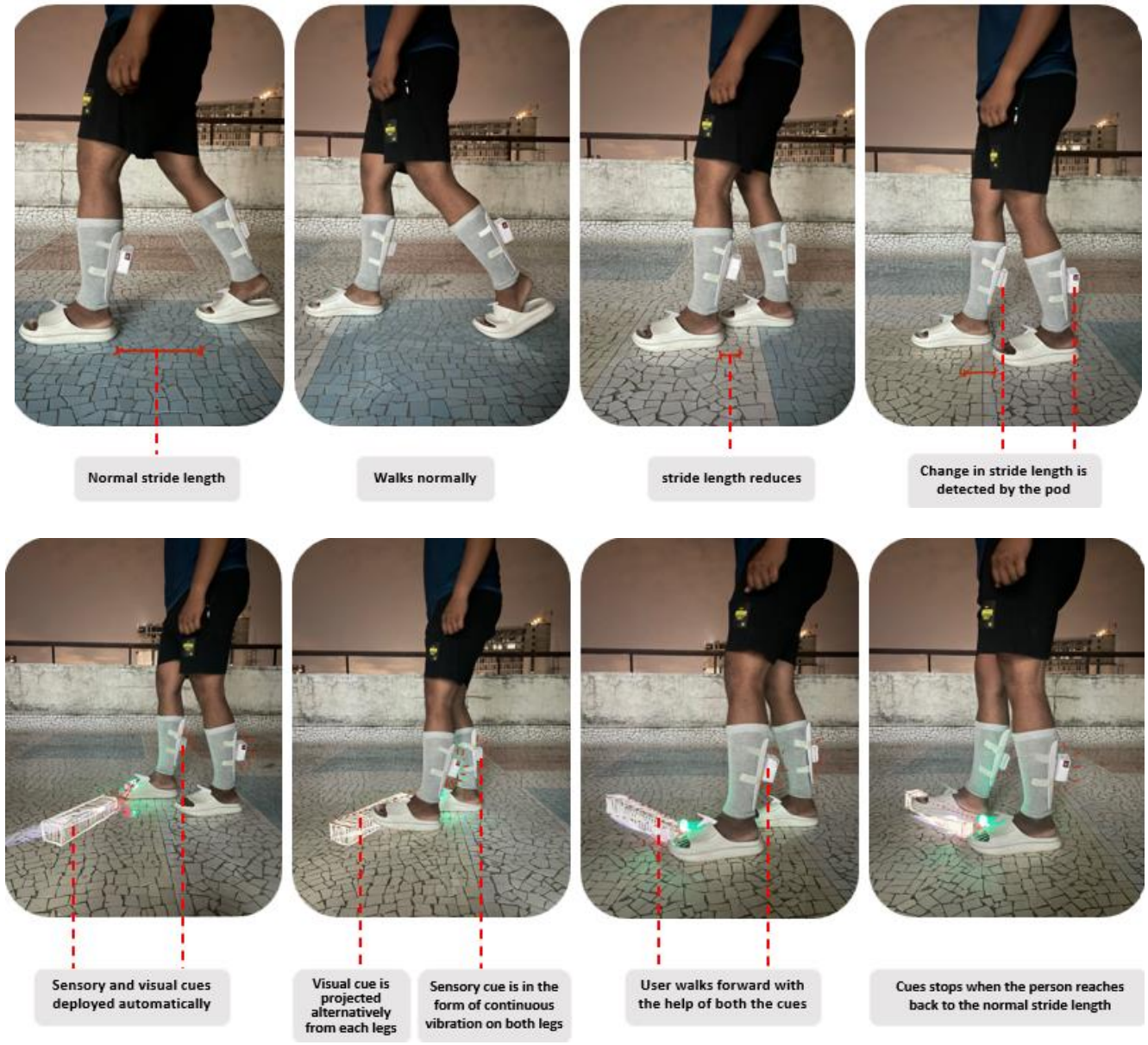


Figure 42 – how the product works

RIG MODEL SHOWING LAZER PROJECTION

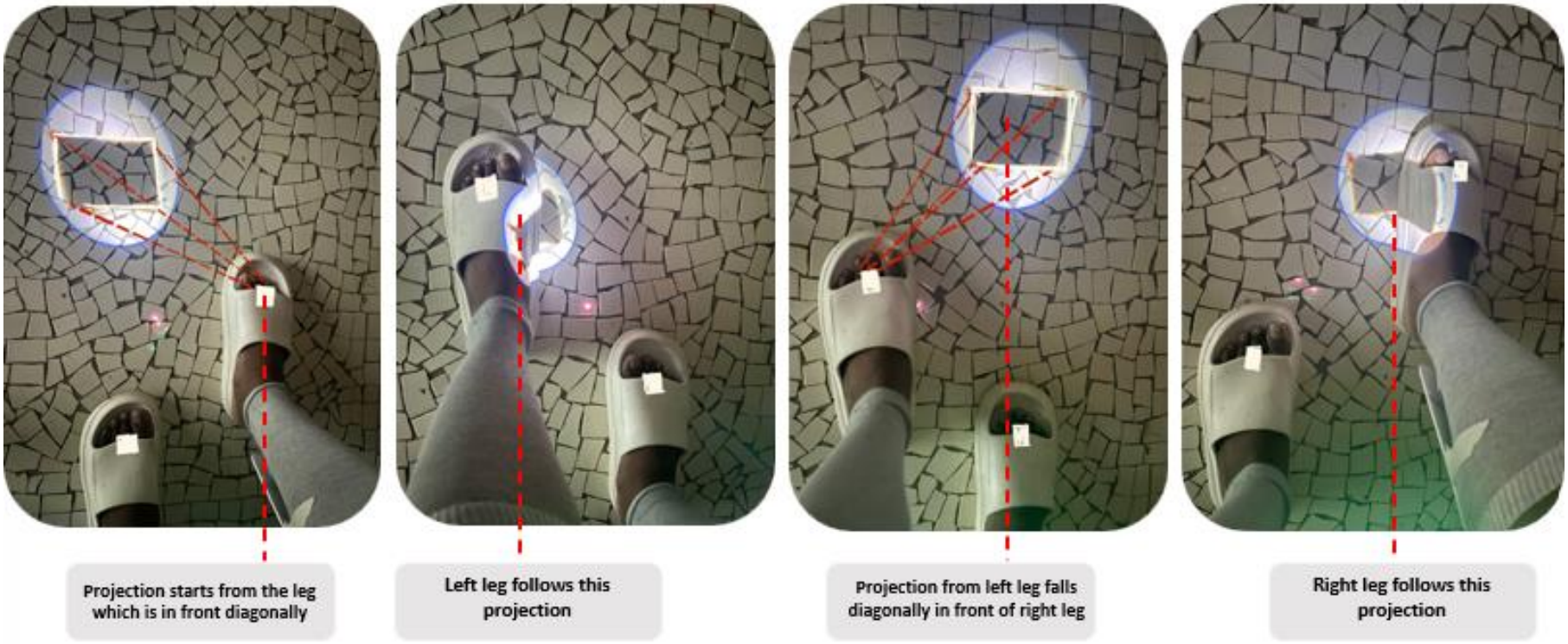


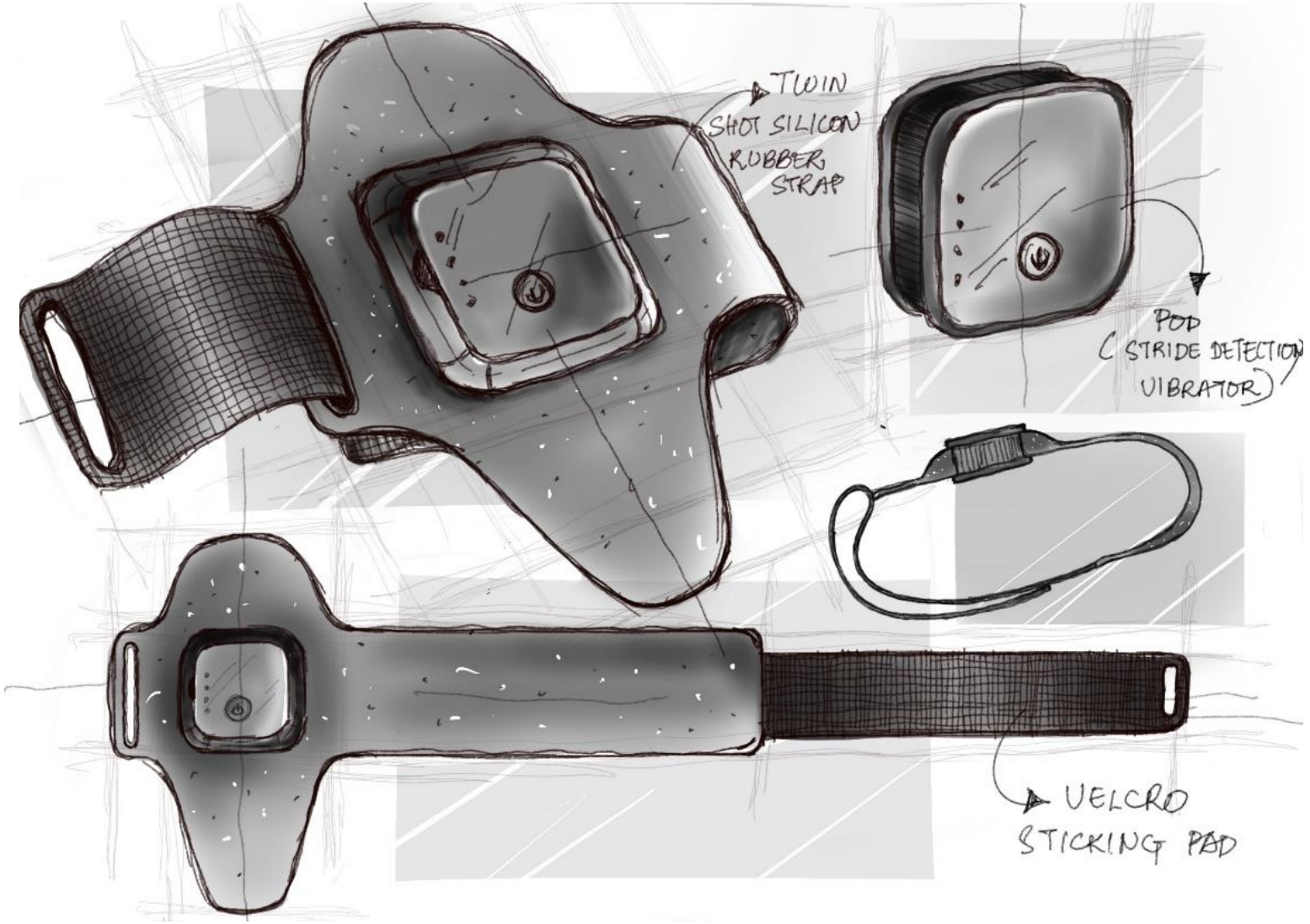
Figure 43 – laser projection

23.2 Concept 2 - Leg band

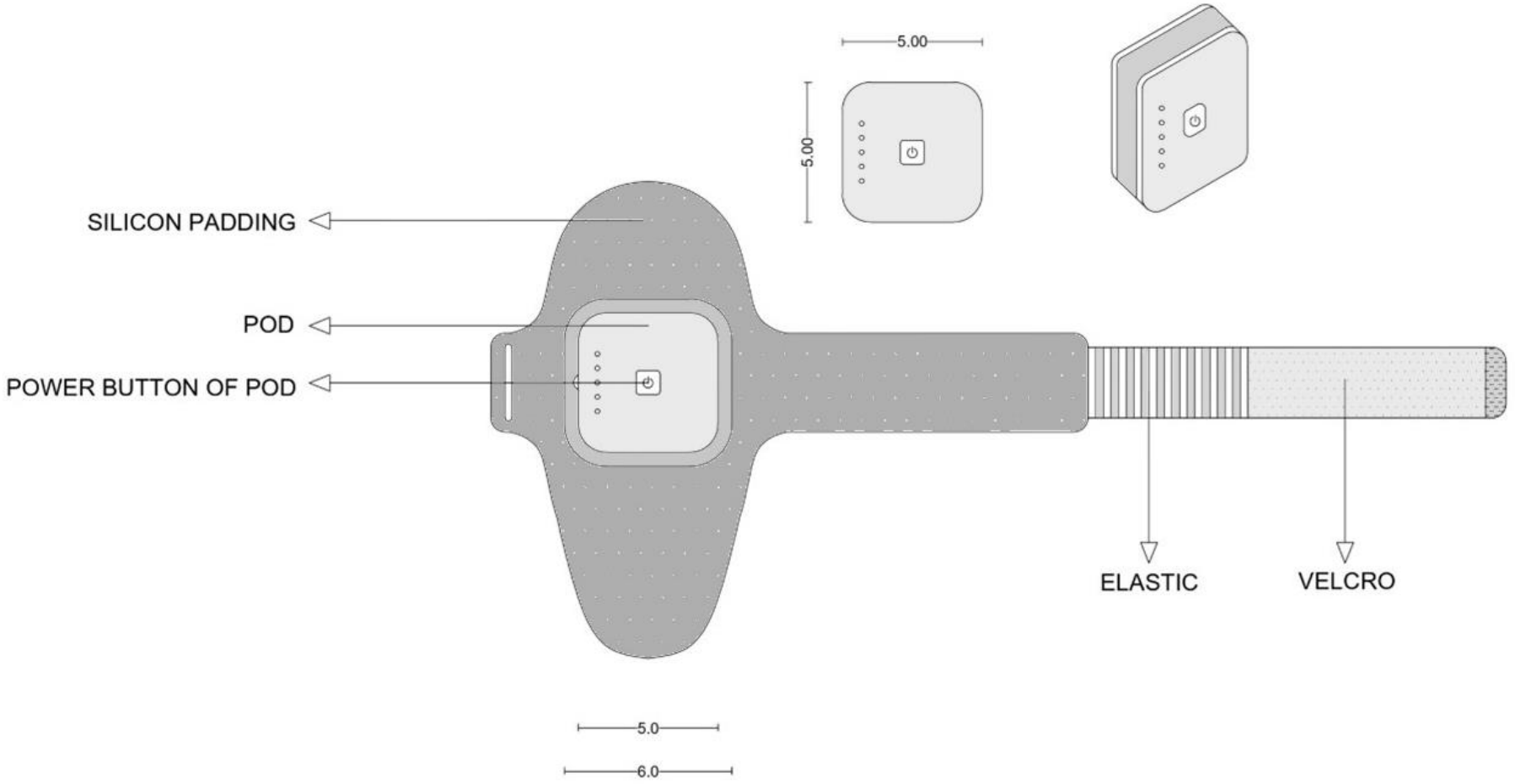
PART 1

Components

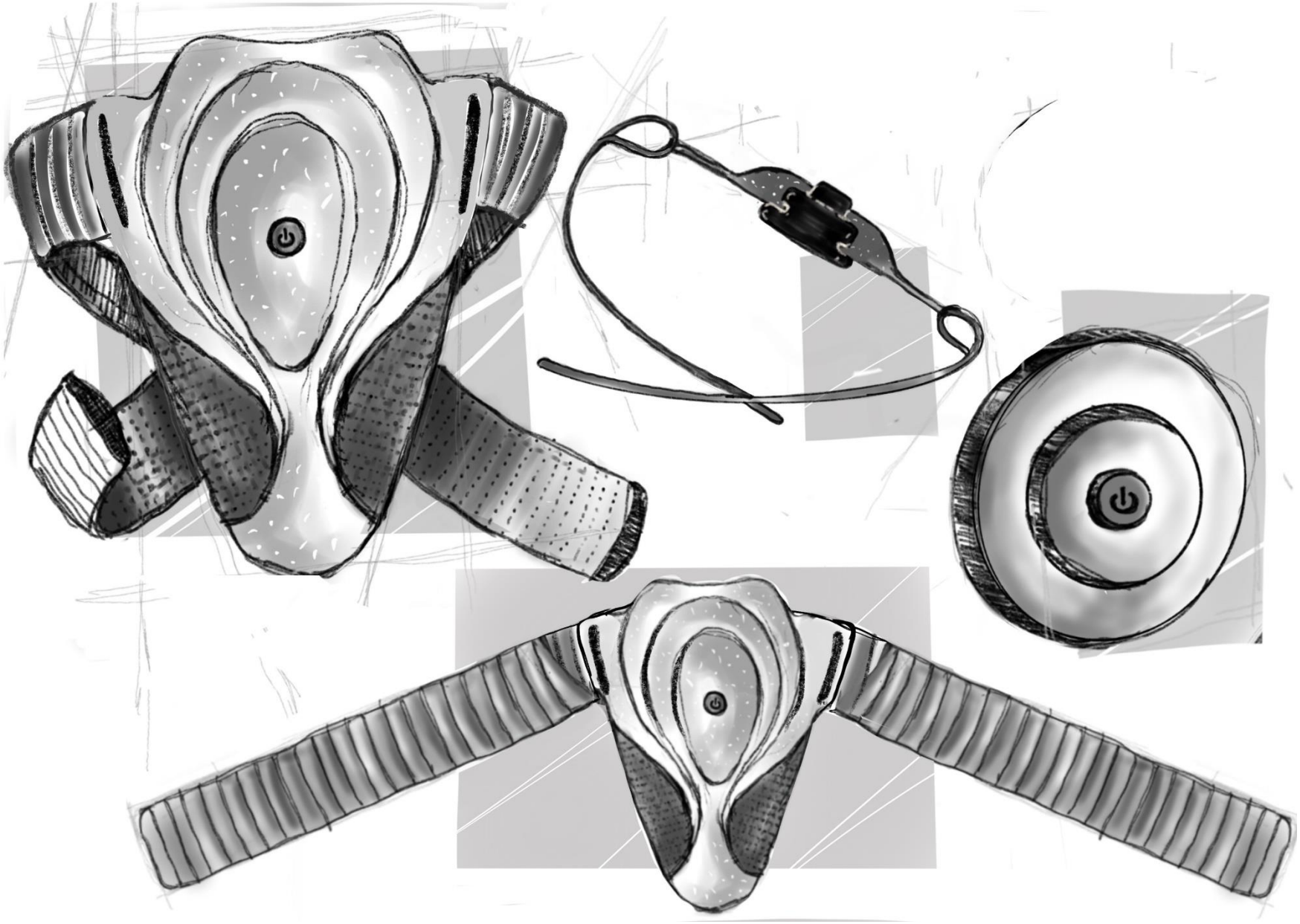
- Rechargeable pod
- Stride detection
- Sensory stimuli



DIMENSION DRAWING



23.3 Concept 3 - Leg band



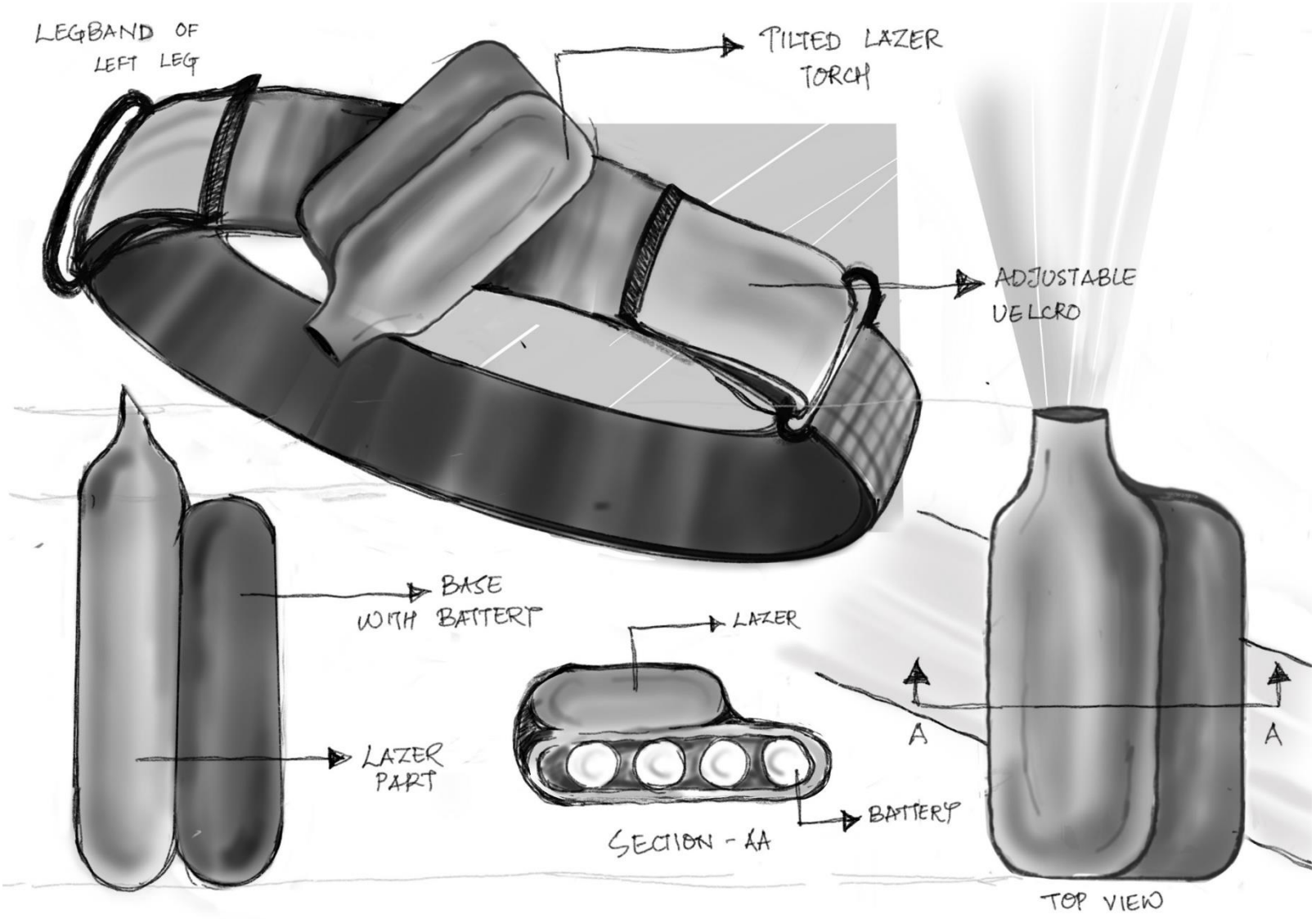
23.4 Comparative Analysis

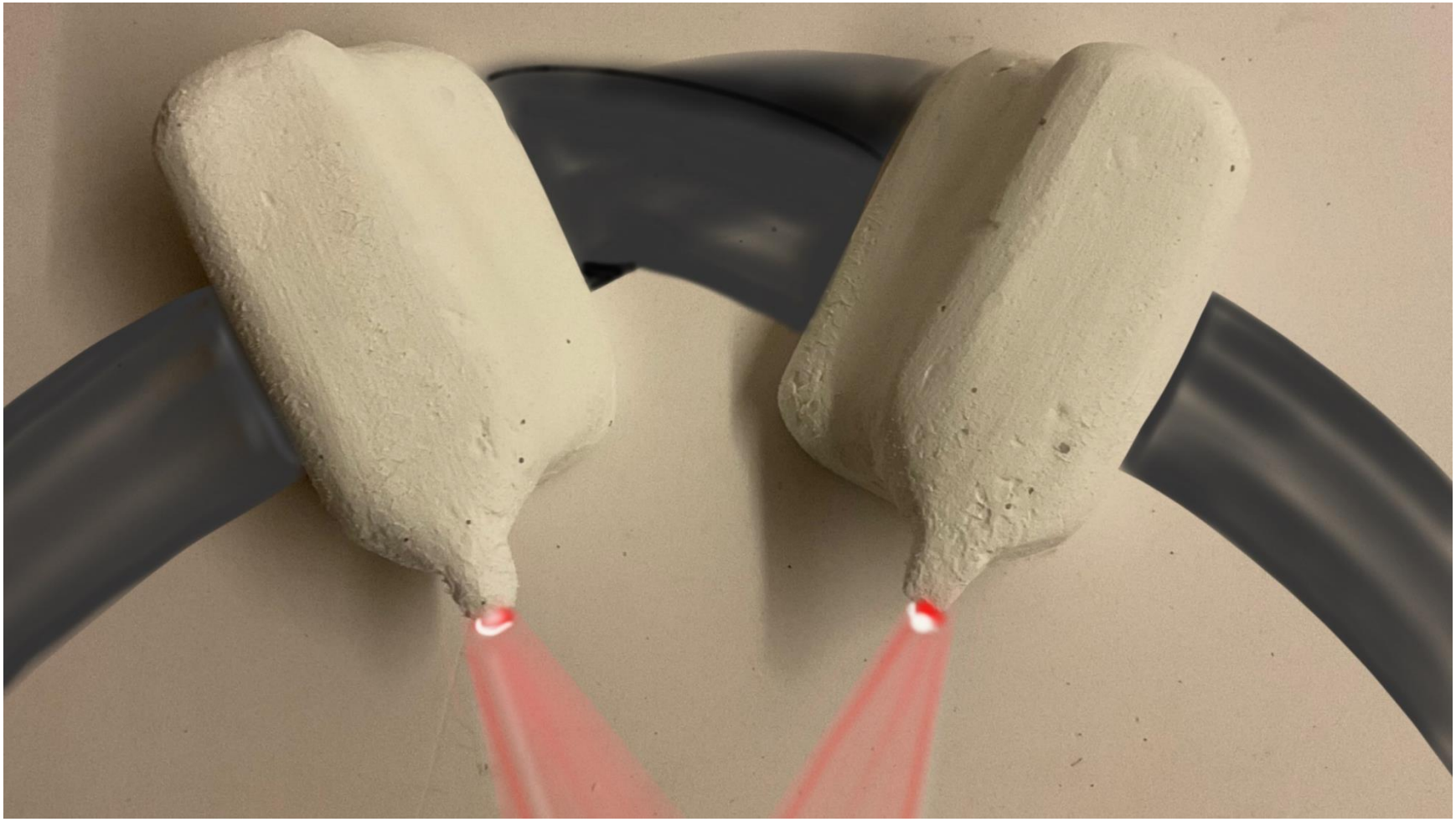
- Difficulty in wearing
- Wearing socks for a long period of time can cause irritation
- Size of the socks can be different for different people
- Difficulty in pulling out the Velcro strap through a thin slit
- POD not well protected

- Difficulty in pulling out the Velcro strap through a thin slit
- No support on the top and bottom part of the pad and thus not sticking on to the skin
- Chances of pod popping out from place due to pressure while walking

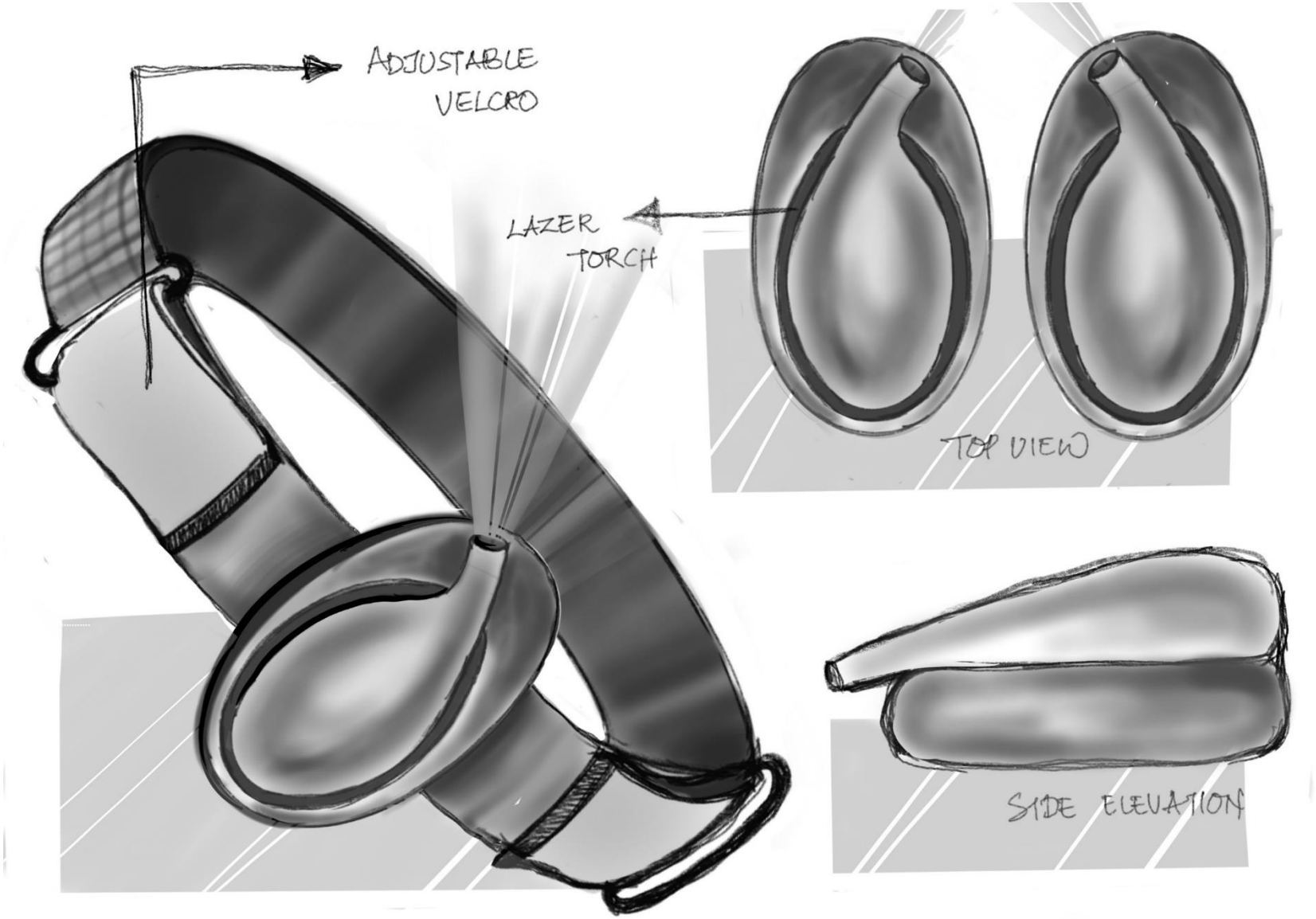
- Easily wearable due to the Criss cross sticking of Velcro
- Proper support on the top and bottom part of the pad thus proving evenly spread vibration to the calf muscles
- Pod is well protected inside the pad from inside thus giving maximum sensory stimuli and zero chances of getting displaced from its position

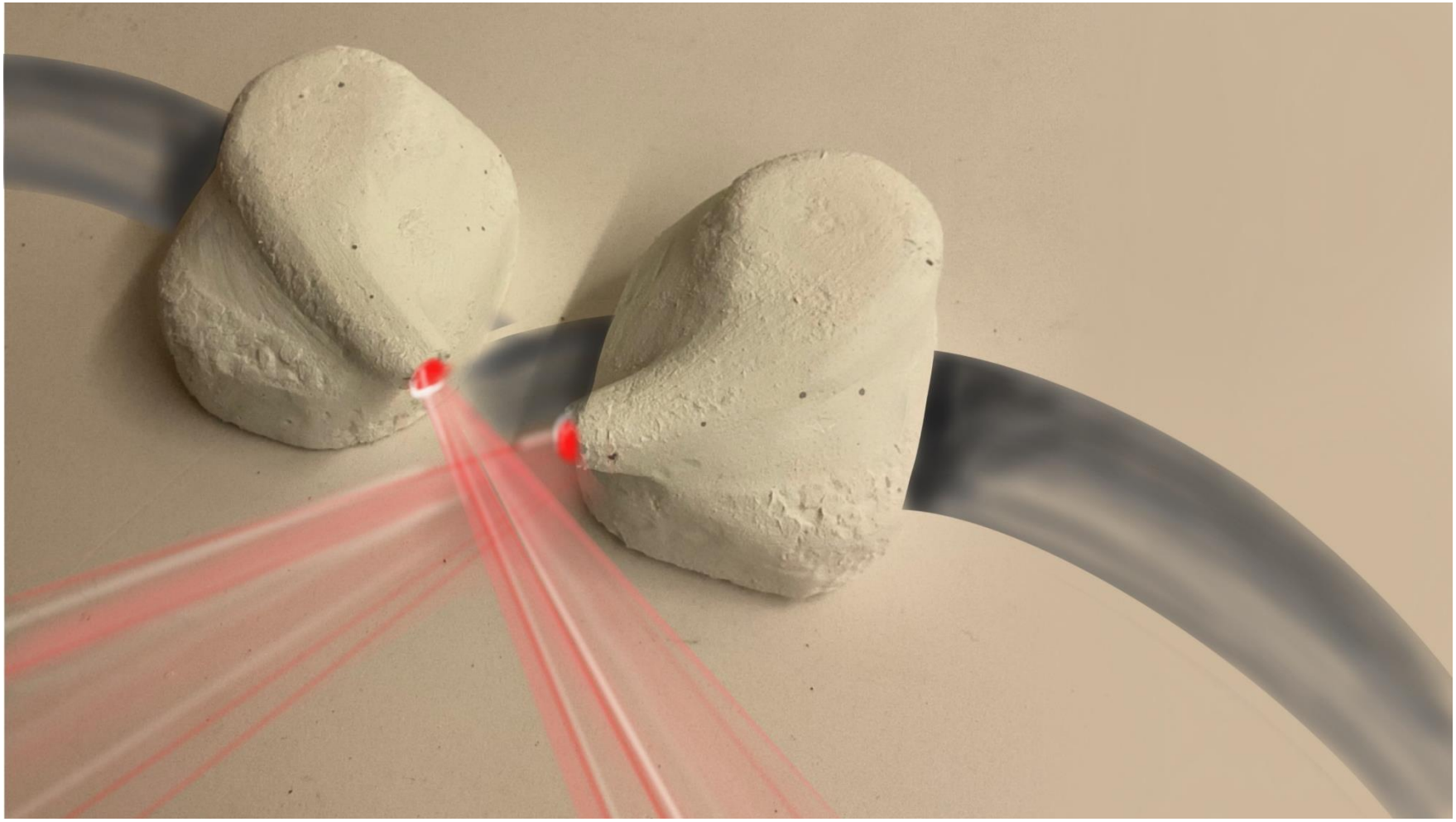
23.5 Concept 1 – Lazer Torch



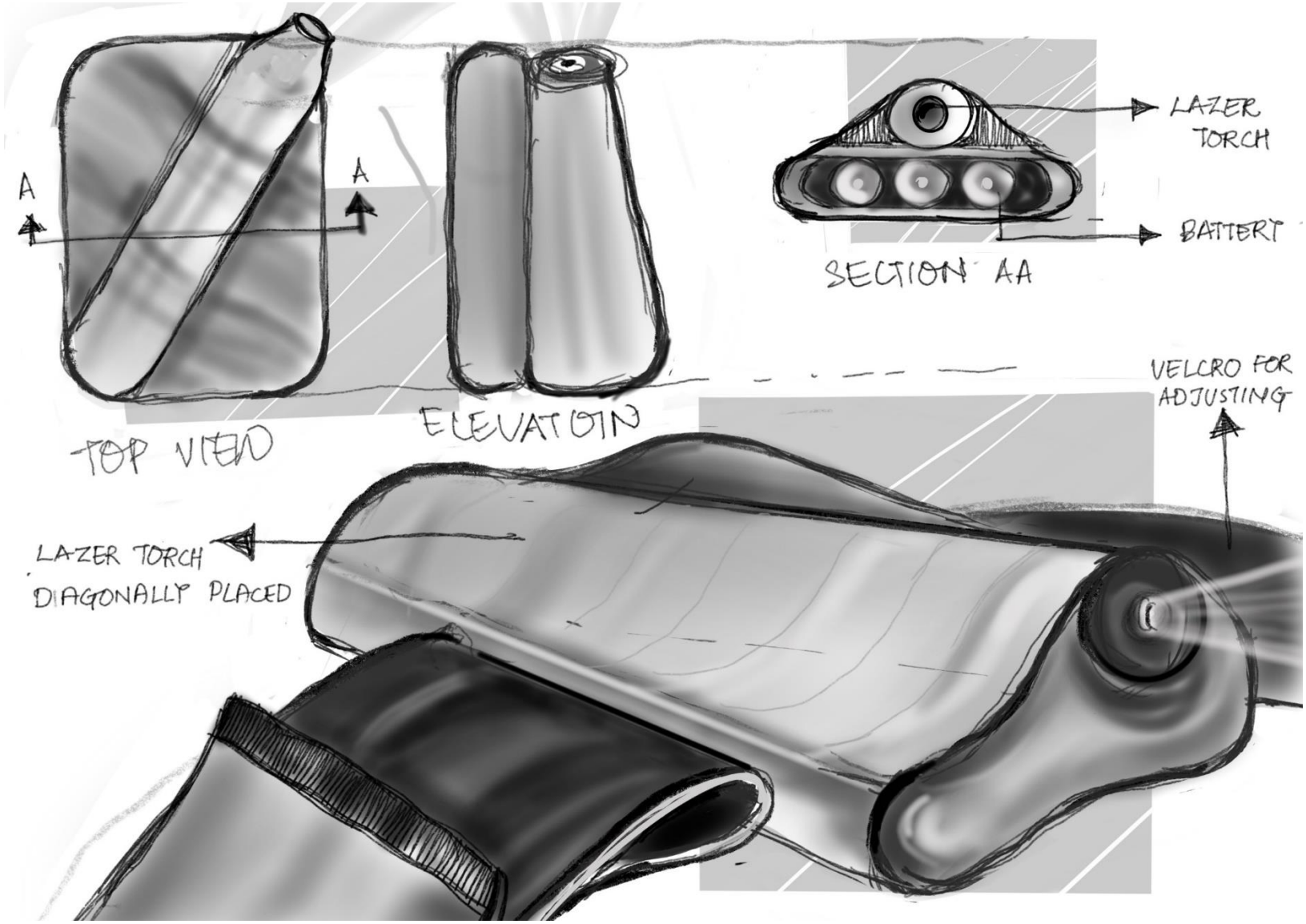


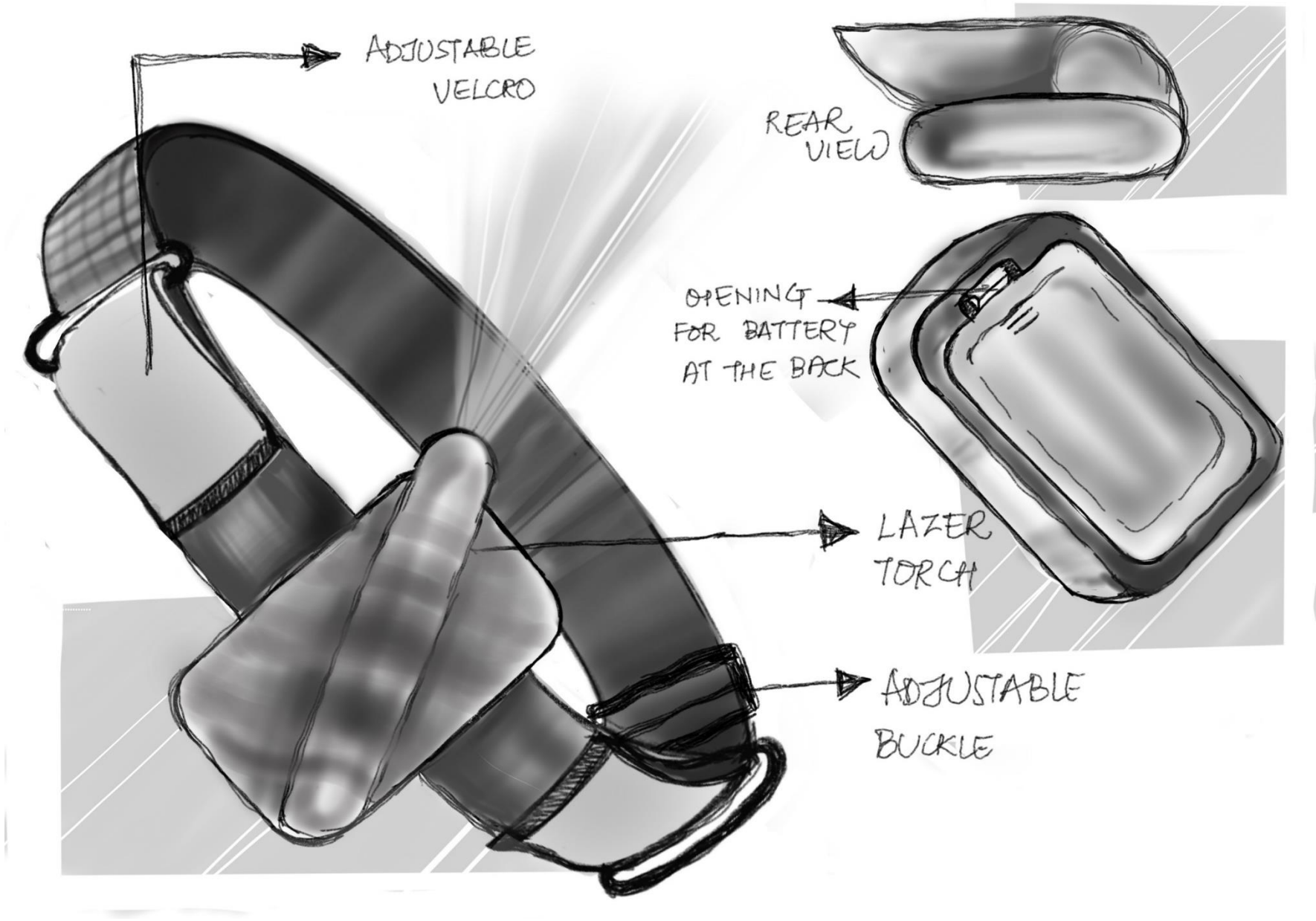
23.6 Concept 2 – Lazer Torch

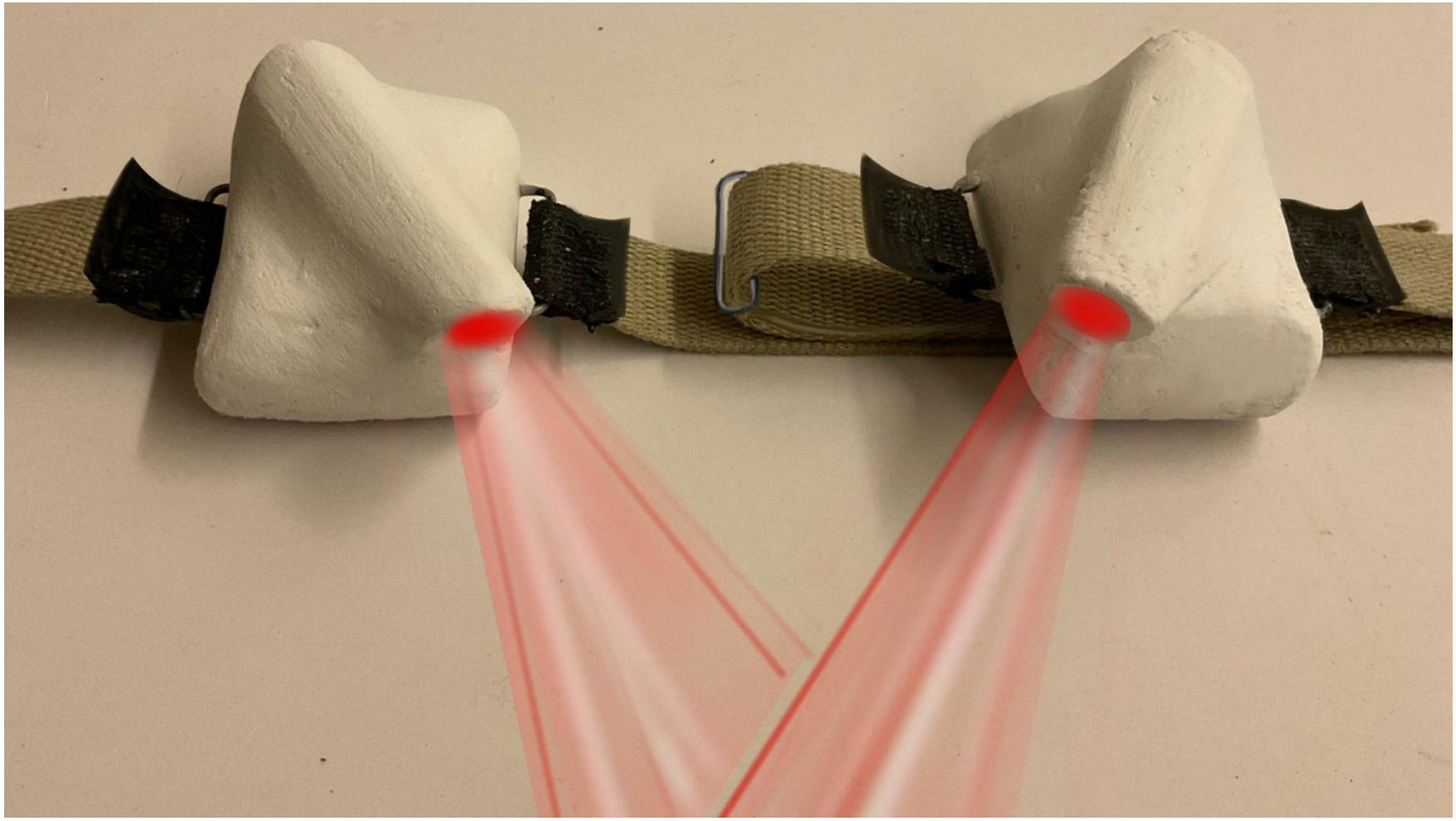


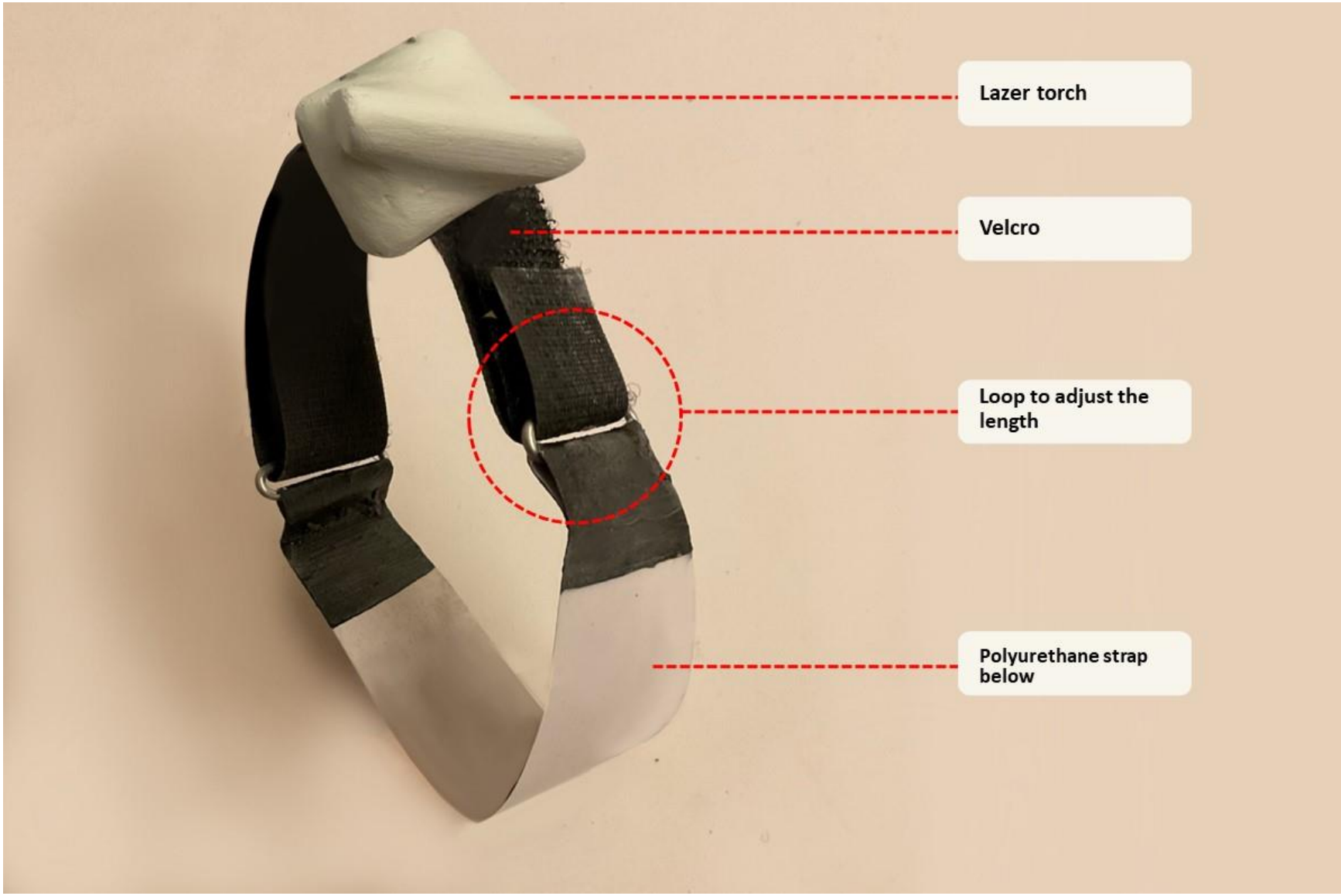


23.7 Concept 3 – Lazer Torch

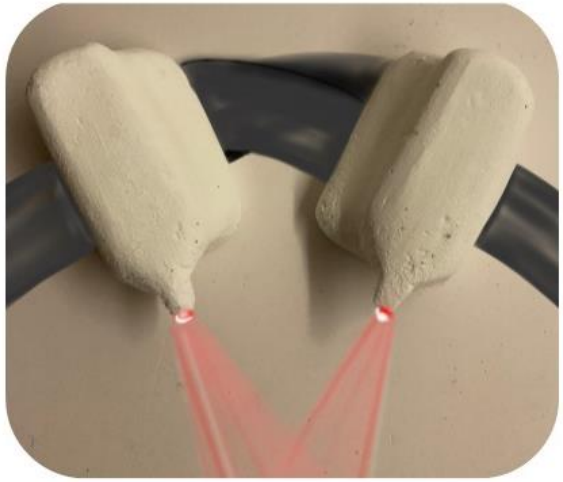



ADJUSTABLE VELCRO
REAR VIEW
OPENING FOR BATTERY AT THE BACK
LAZER TORCH
ADJUSTABLE BUCKLE

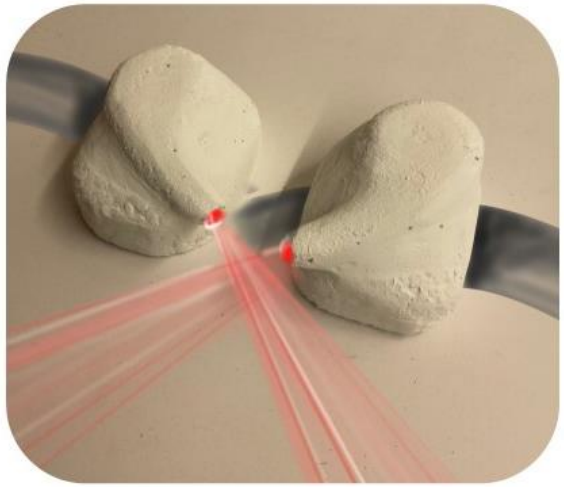



Lazer torch
Velcro
Loop to adjust the length
Polyurethane strap below

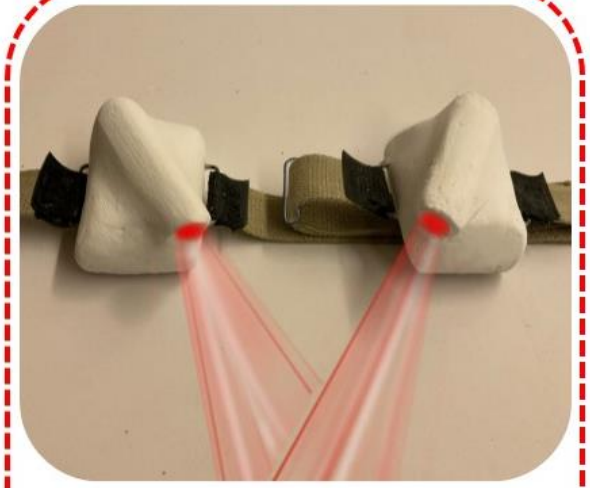
23.8 Comparative Analysis



- Difficulty in wearing
- Wearing socks for a long period of time can cause irritation
- Size of the socks can be different for different people
- Difficulty in pulling out the Velcro strap through a thin slit
- POD not well protected



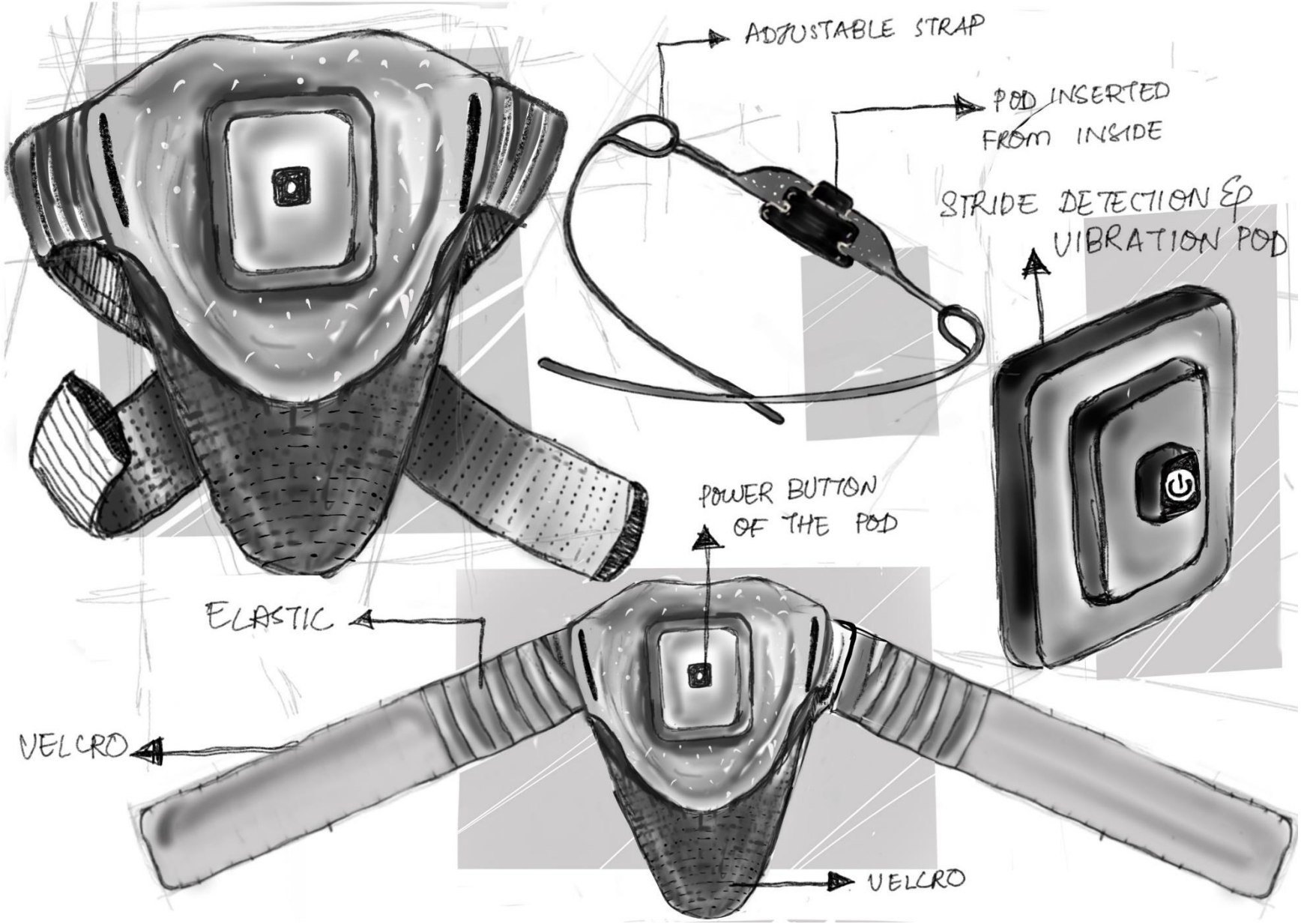
- Difficulty in pulling out the Velcro strap through a thin slit
- No support on the top and bottom part of the pad and thus not sticking on to the skin
- Chances of pod popping out from place due to pressure while walking



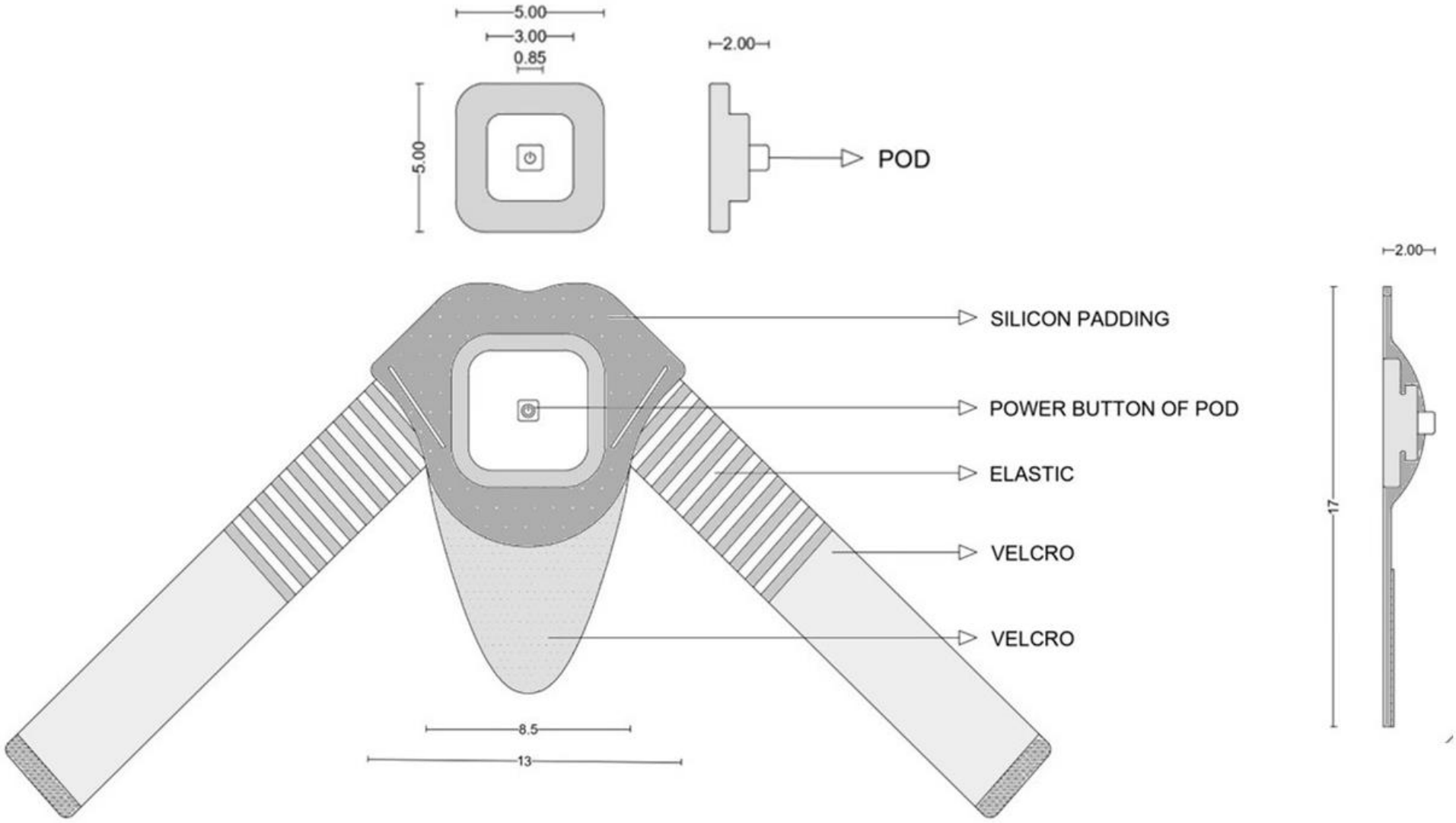
- Easily wearable due to the Criss cross sticking of Velcro
- Proper support on the top and bottom part of the pad thus proving evenly spread vibration to the calf muscles
- Pod is well protected inside the pad from inside thus giving maximum sensory stimuli and zero chances of getting displaced from its position

24. Redefined Final Design

Introducing a groundbreaking leg accessory for Parkinson's patients.
This innovative product consists of two parts: stride detection and cues providing parts (sensory stimuli and laser cues). The sensory stimuli provide targeted vibrations on the calf muscles. The laser cues emit visible markers on the floor, aiding navigation and overcoming freezing episodes.
With its ergonomic design and user-friendly interface, the leg accessory empowers patients, promoting independence and transforming lives.
Experience the future of Parkinson's care with this remarkable tool.


ADJUSTABLE STRAP
POD INSERTED FROM INSIDE
STRIDE DETECTION & VIBRATION POD
POWER BUTTON OF THE POD
ELASTIC
VELCRO
VELCRO

24.1 DIMENSION DRAWING



24.2 COLOUR PALETTE

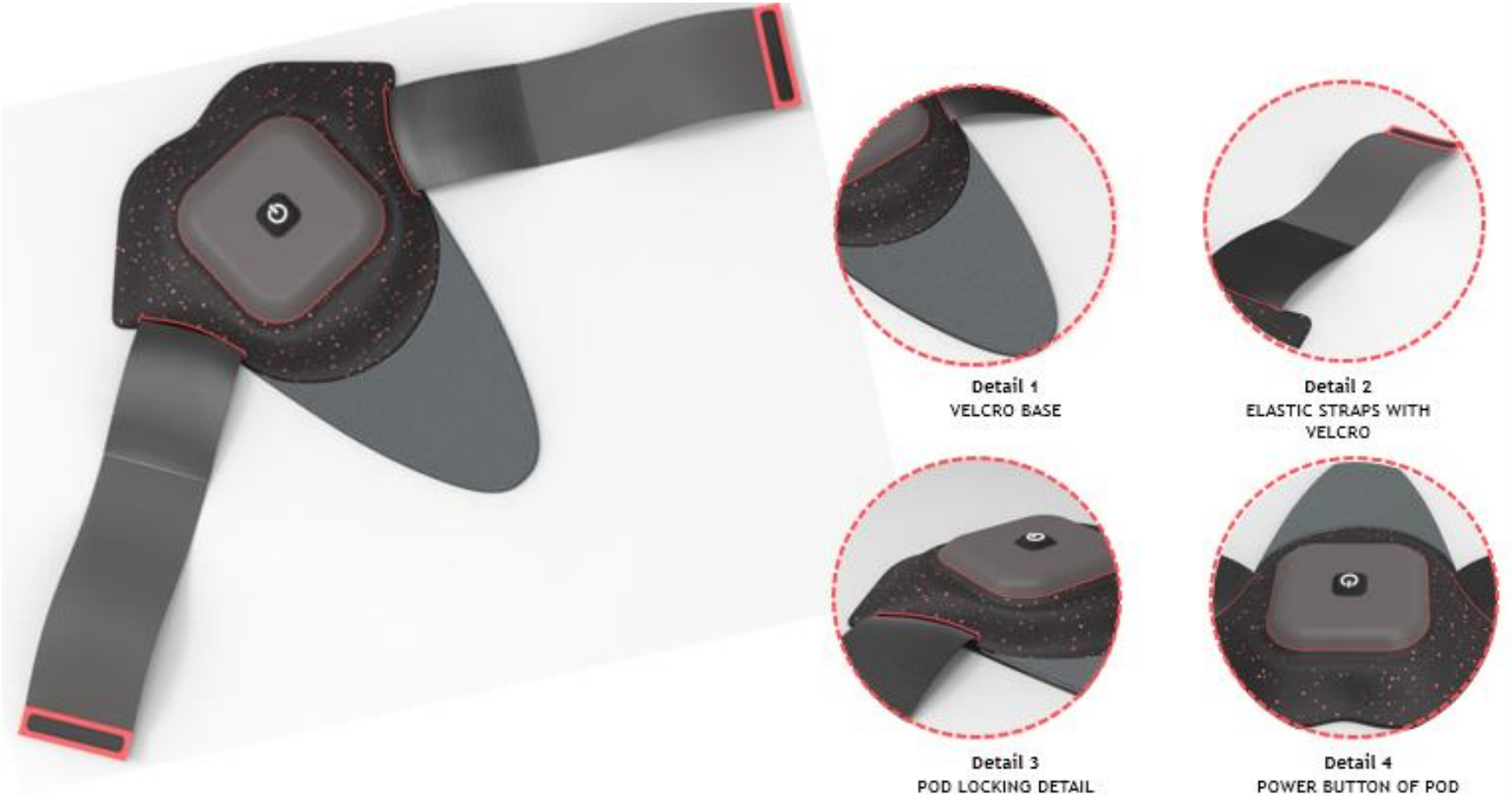
Sporty Elegance

- This option features a sporty color palette of dark grey, black, and orange.
- The dark grey represents strength, while black adds sophistication. Vibrant orange accents energize and inspire, making it perfect for those who lead an active lifestyle.
- With its sporty color scheme, the medical product encourages a sense of motivation and adventure.
- Parkinson's device that inspires confidence and empowerment.

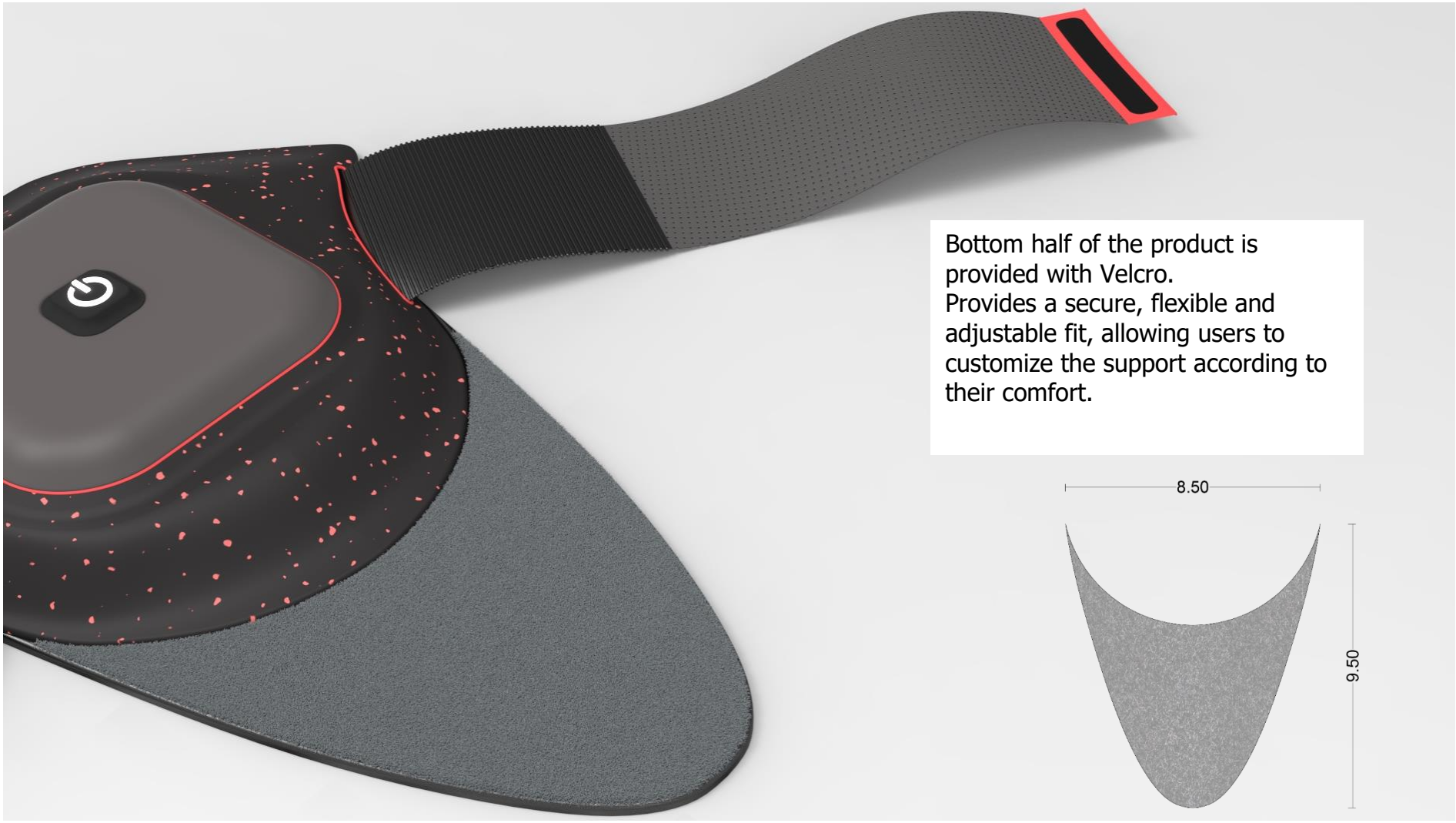
Fresh Versatility

- This option boasts a fresh and versatile color palette of teal blue, white, grey, and transparent.
- Teal blue promotes tranquility, while white and grey offer elegance.
- Transparent elements symbolize adaptability, making it seamlessly fit any style or routine.
- Embrace the versatility and modernity of this color scheme, empowering yourself to manage your health with confidence and style.

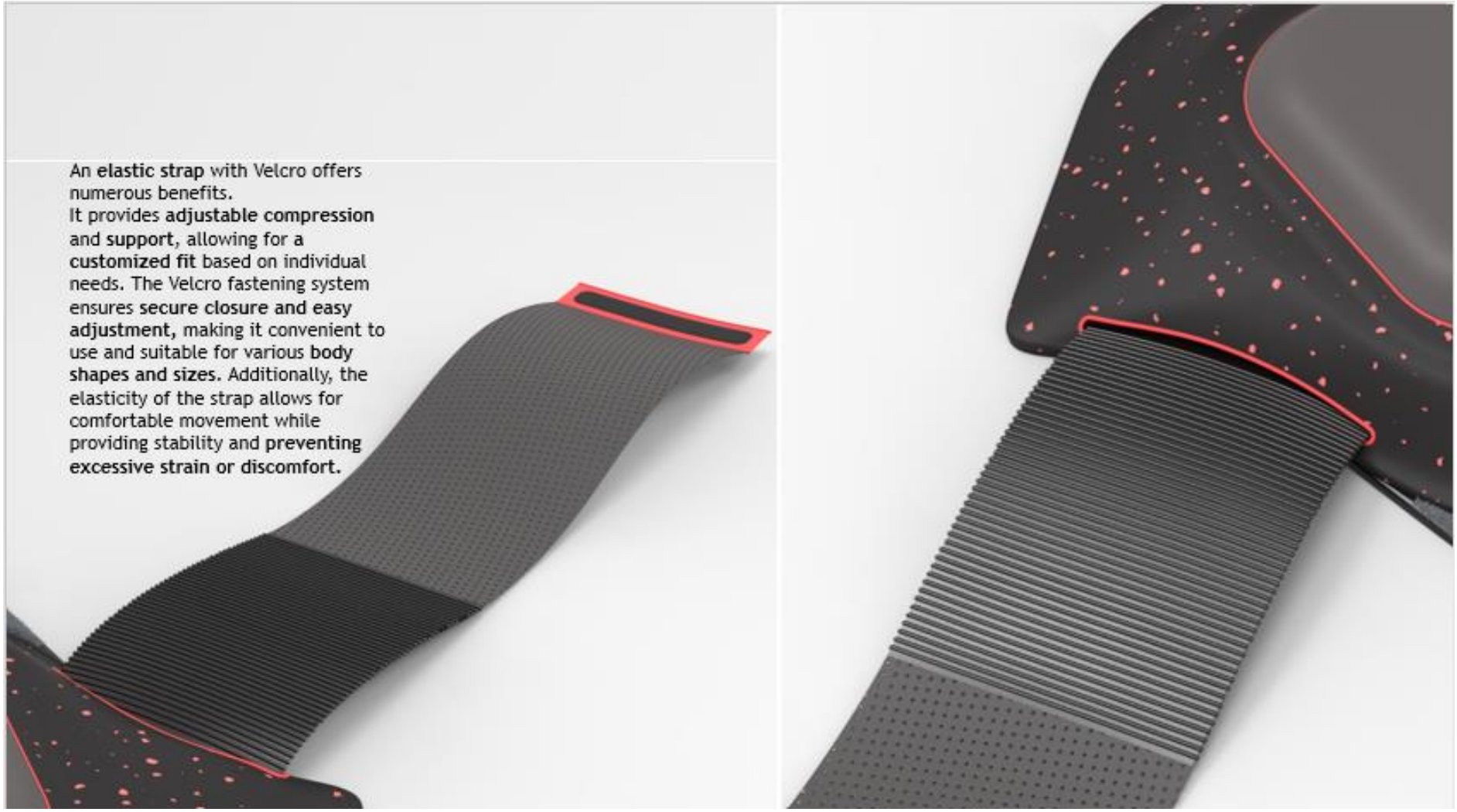
24.3 PRODUCT DETAILS – Part 1



24.3.1 Detail 1 VELCRO BASE



24.3.2 Detail 2 ELASTIC STRAPS WITH VELCRO



24.3.3 Detail 3 POD LOCKING DETAIL

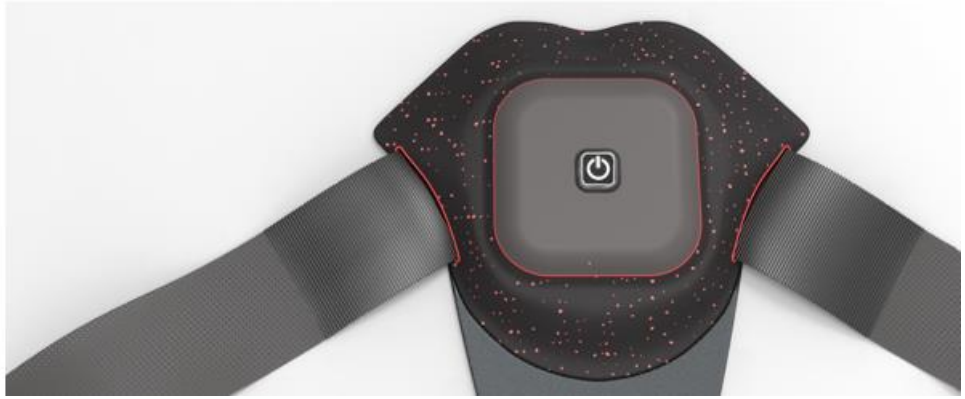
24.3.4 Detail 4 POWER BUTTON OF POD

When fully charged
100%

21 to 50 %

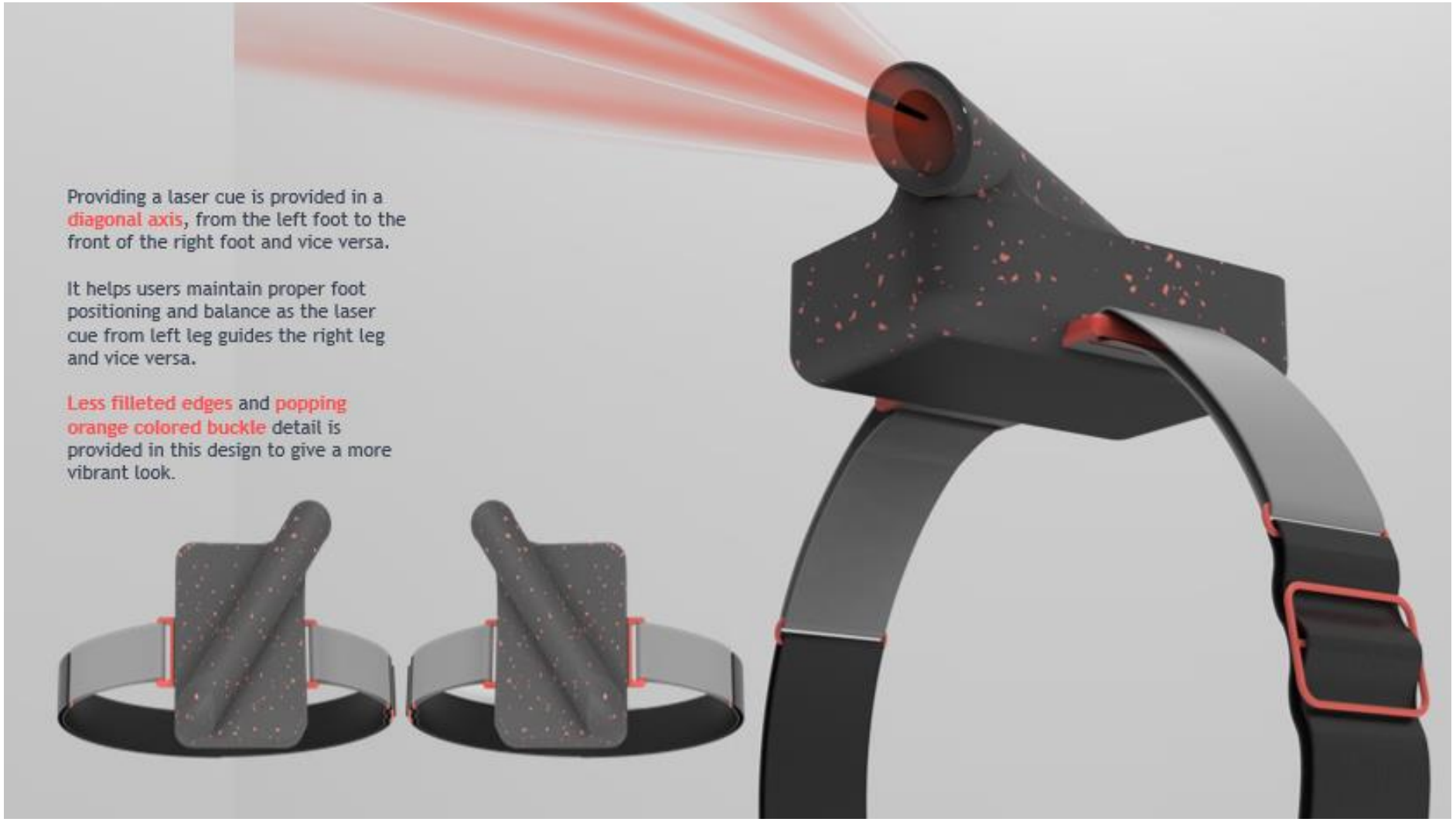
1 to 20 %

Power button placed outside the device for convenient control.
Sleek LED lighting for power icon offers visibility and clear indication of power status.
Lighting feature around the power button indicates pod charge level with color changes.
User-friendly visual cue for battery status, enhancing usability and proactive battery management.



24.4 PRODUCT DETAILS – Part 2

24.4.1 Detail 1 LAZER TORCH



24.4.2 Detail 2 ADJUSTABLE STRAP

Providing an adjustable strap for the laser torch around the foot offers multiple benefits.

It allows users to securely fasten the torch to their foot, ensuring it stays in place during movement and activities.

A combination of elastic and adjustable strap enables a customized fit for different foot sizes and shapes, ensuring comfort and stability while maintaining proper alignment of the laser cue. Elastic bands are provided connecting the adjustable nylon strap that adds and extra fit and stability to the product.

This feature enhances the usability and effectiveness of the laser torch as a visual alignment aid.

24.4.3 Detail 3 SPACE FOR BATTERY

24.4.4 Detail 4 NYLON STRAP

24.5 COLOUR VARIATIONS

24.6 TECHNICAL DETAILS

Stride Detection + Tactile stimuli

POD

- **Accelerometer + gyroscope = better motion understanding.** Accelerometer measures linear acceleration, while gyroscope detects rotational motion. Useful for gait analysis and **motion tracking.**

- **Microcontroller:** A microcontroller is a small computer that can be programmed to process sensor data and make decisions based on that data. It is used to **receive data from the sensors and analyze it to determine stride length.**

Accelerometer gyroscope chip

Microcontroller pcb board

- **Bluetooth module:** A Bluetooth module may be used to **transmit the sensor data wirelessly to another device**

- **Power source:** A power source, a battery (**lithium ion**) required to power the electronic components.
- **USB** cable slot

- **Motor apparatus** - To provide the necessary **vibrations**

- **Mosfet** - Transistor **controlling conductivity** based on voltage to enable vibration.

Bluetooth chip

Lithium-ion battery

Coin vibrator motor

mosfet

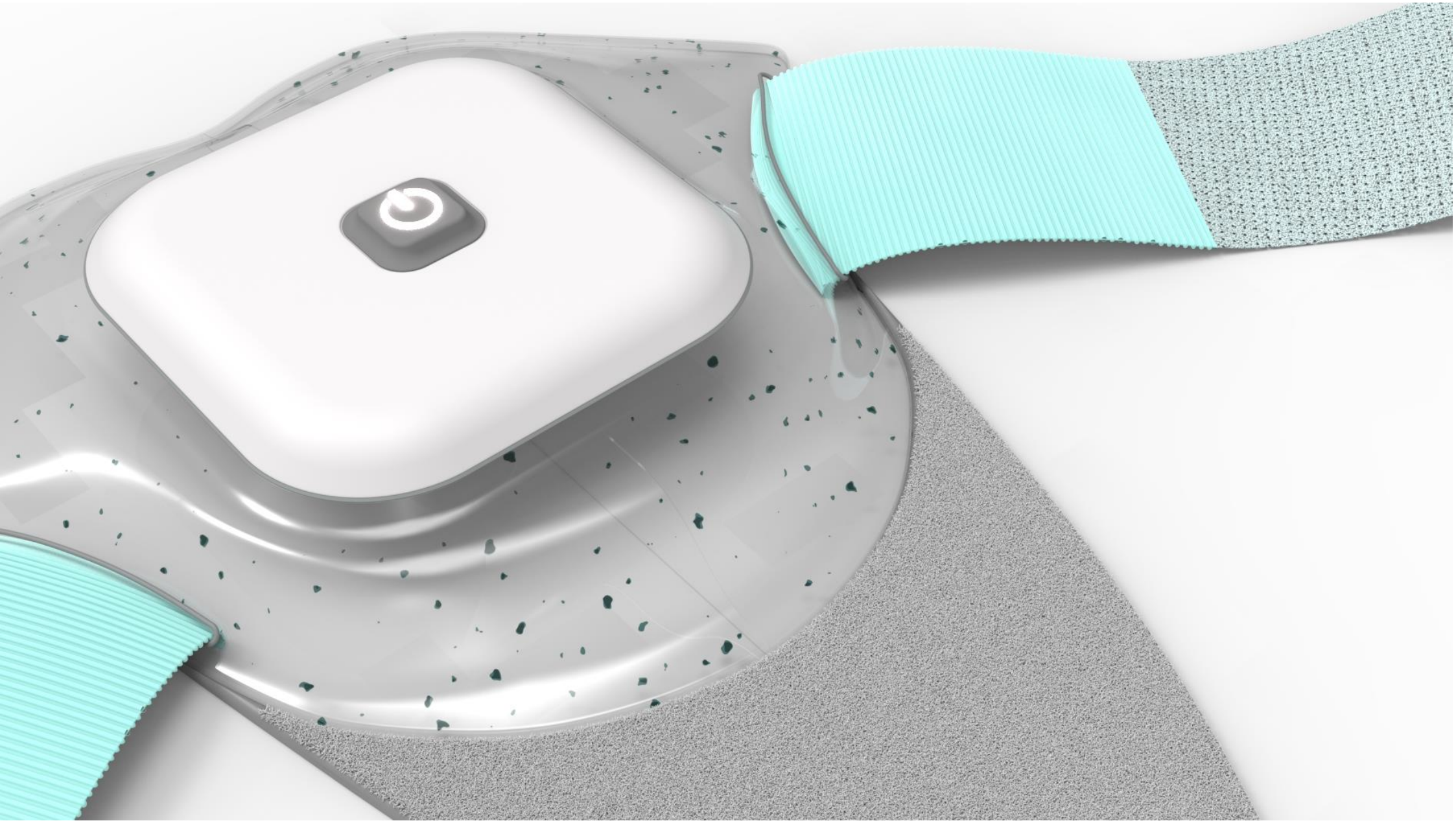
Lazer band - visual cue

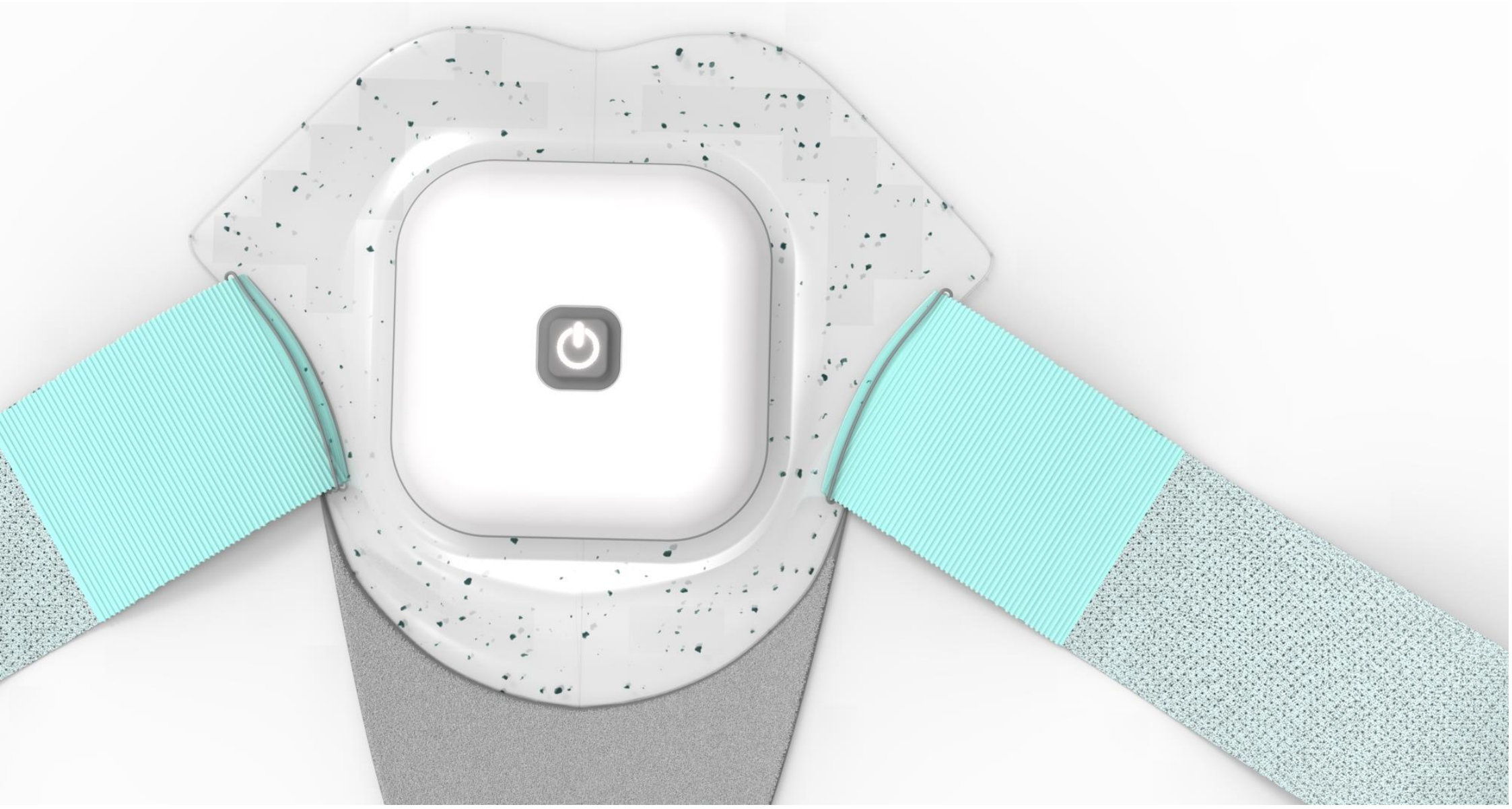
Battery cell

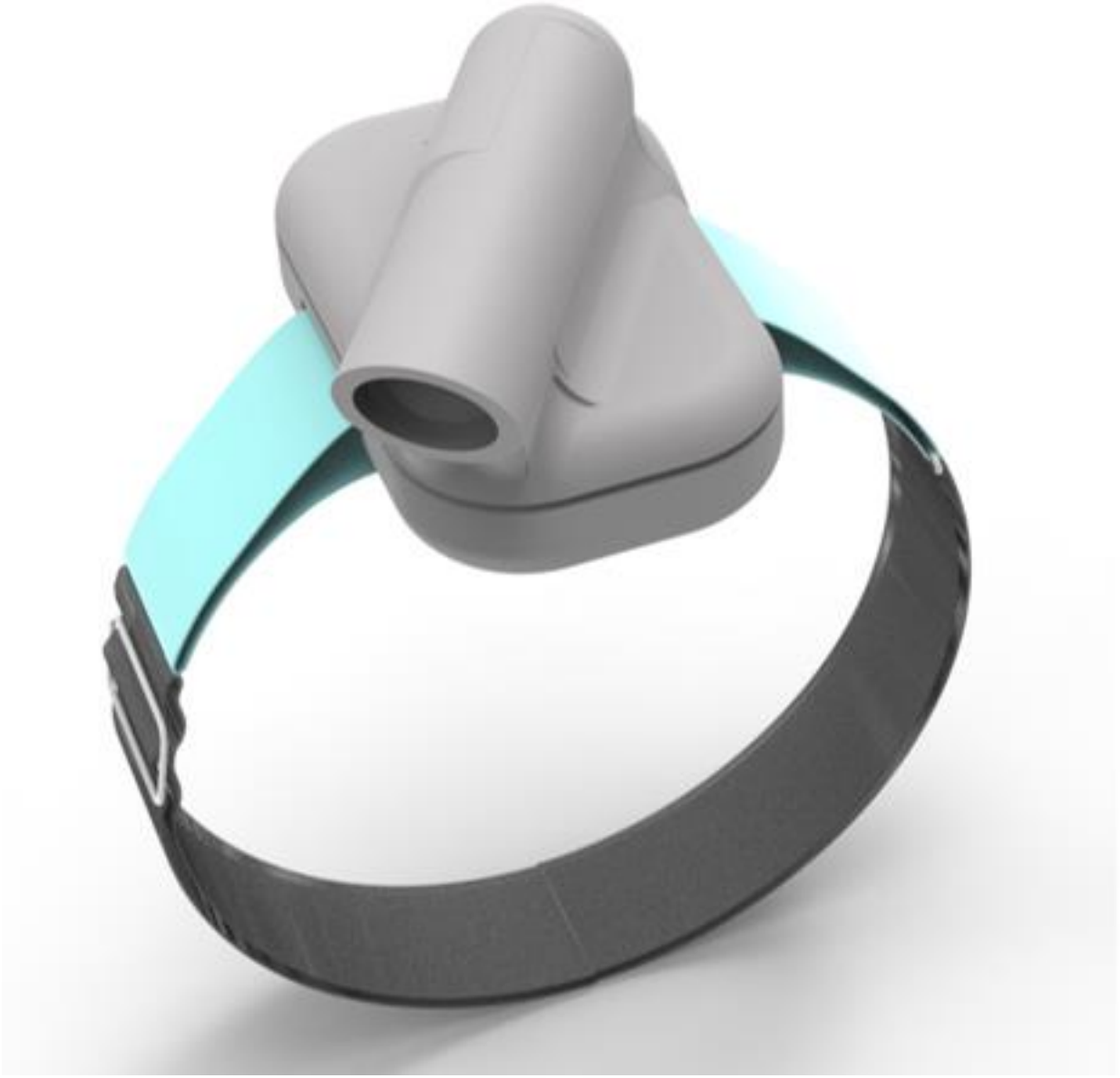
Lazer projection unit

Bluetooth chip

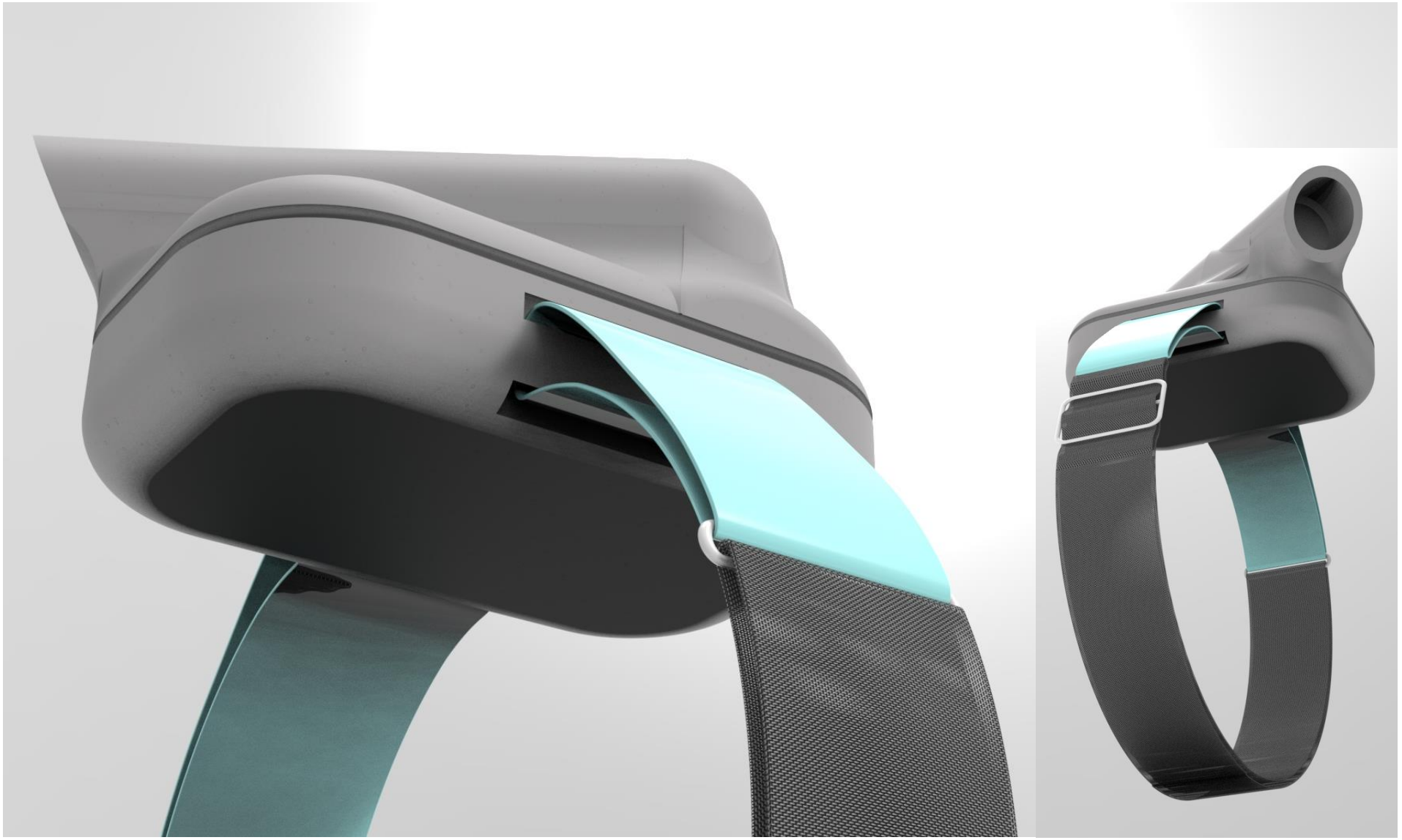
Ultrasonic sensor





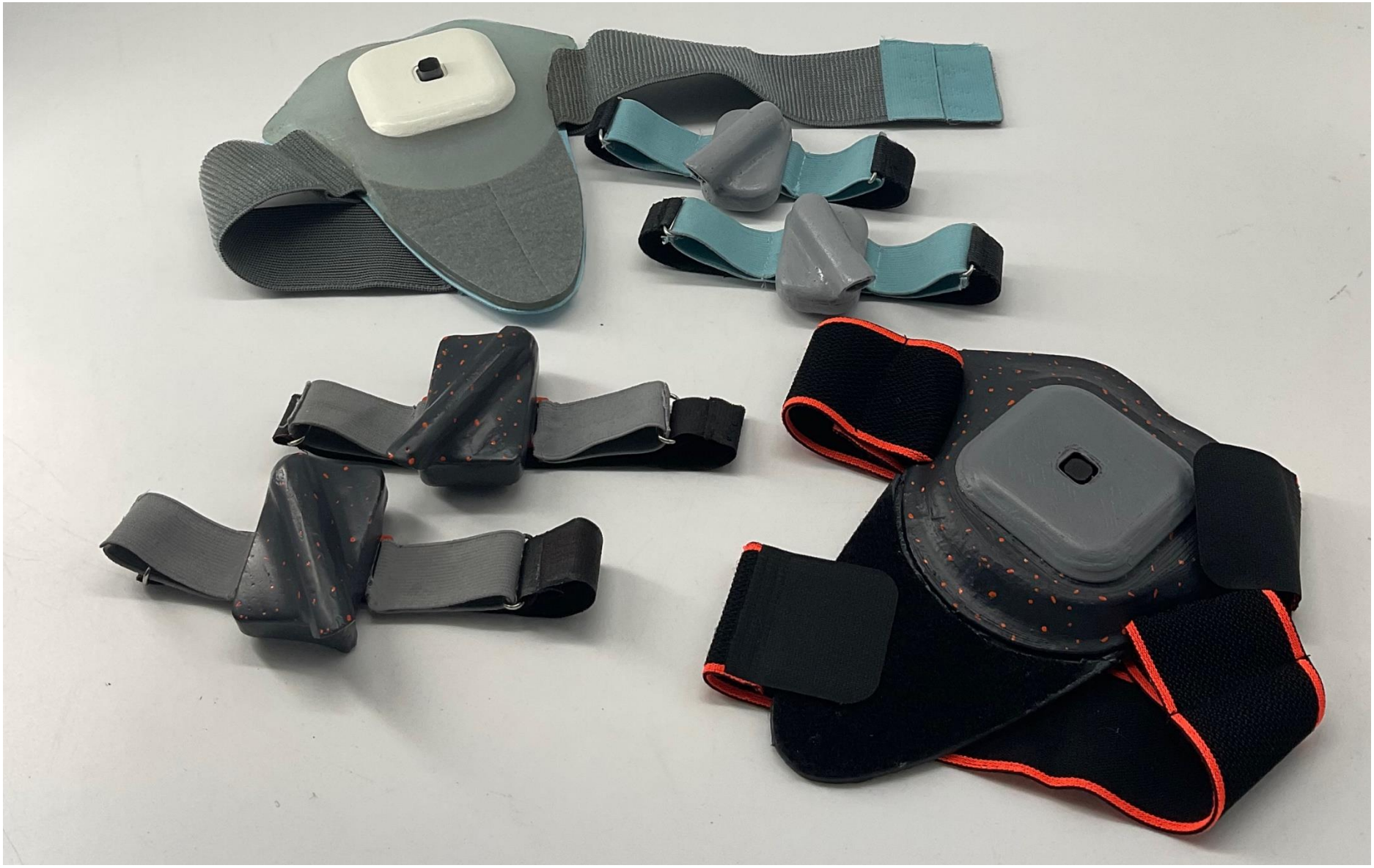


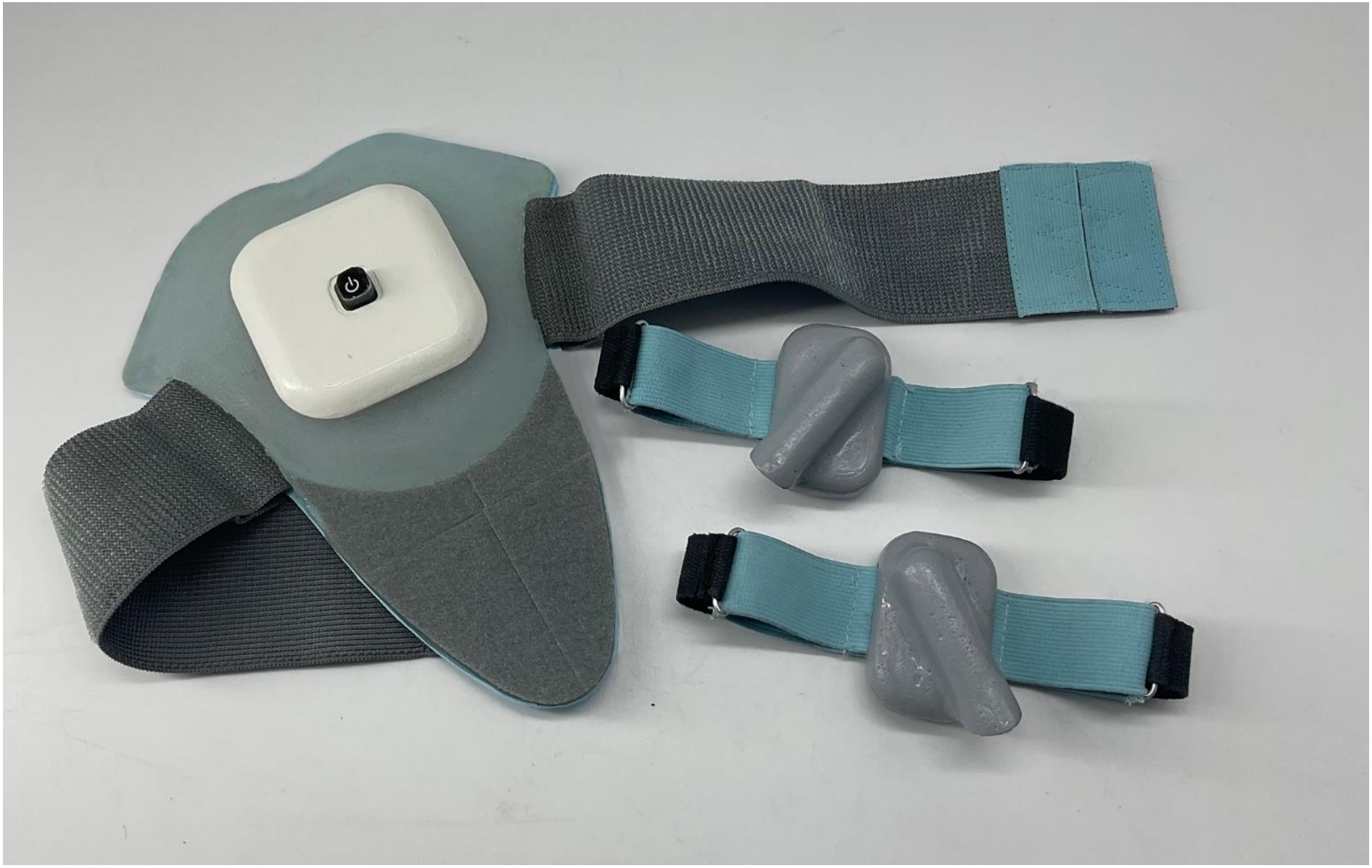
This option is provided with **soft filleted edges** and an **integrated band attachment** within the module.
The **absence of spot** texture allows for a **clean and minimalist** appearance, while the smooth edges enhance comfort and aesthetic appeal.
The integration of the band within the module maintains a cohesive and compact form, ensuring a visually harmonious device. These features **align with the fresh and versatile color palette.**



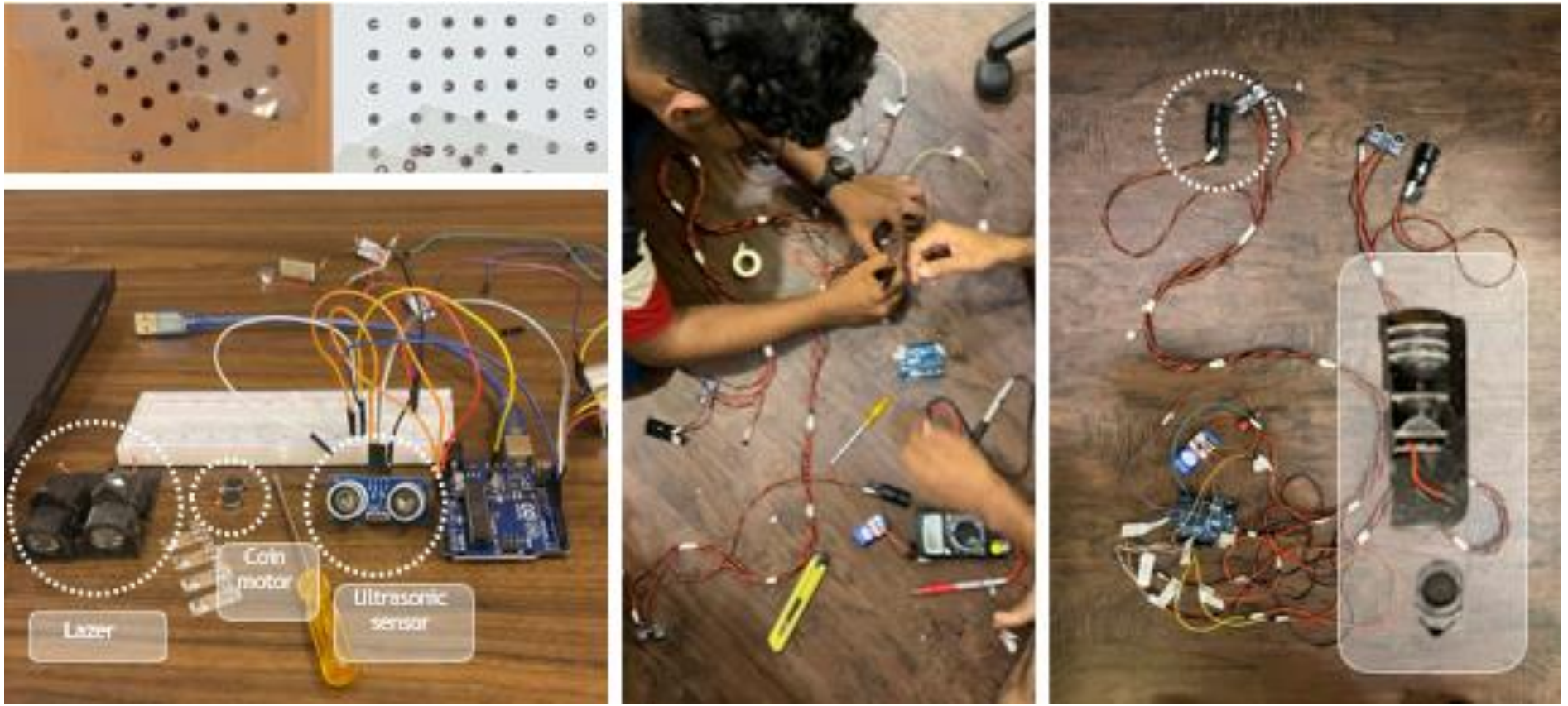
24.7 PRODUCT ENVIRONMENT

24.8 FORM MODEL – MAKING PROCESS





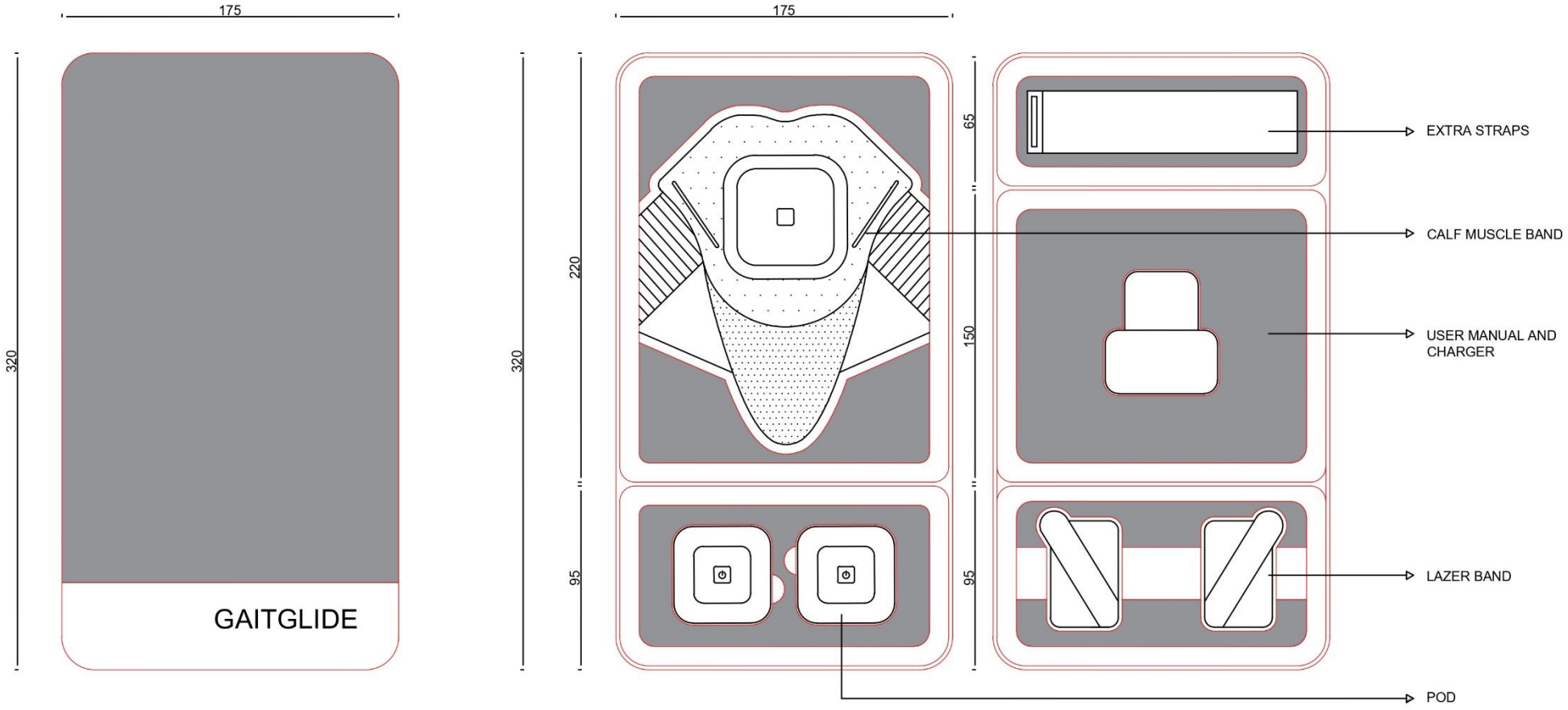
24.9 RIG MODEL – MAKING PROCESS




GaitGlide
STRIDE WITH CONFIDENCE

24.10 MATERIALS AND MANUFACTURING PROCESSES

24.11 PACKAGE DESIGN




GaitGlide
STRIDE WITH CONFIDENCE
GaitGlide


Gaitglide
STRIDE WITH CONFIDENCE

24.11 BRANDING

The term **"Gait"** refers to the **pattern of walking or movement**. Since the product focuses on **detecting and improving stride length**, the inclusion of "Gait" in the name accurately represents its core functionality. **"Glide"** suggests **smooth and effortless movement**. By **automatically deploying cues to overcome freezing episodes,** the product aims to provide a seamless and fluid walking experience. The term "Glide" conveys the idea of **overcoming obstacles and moving effortlessly.**
Overall, **"GaitGlide"** accurately represents the product's features, evokes a sense of smooth movement, and is easy to remember, making it a suitable branding name for a leg accessory that detects stride length and deploys cues to overcome freezing episodes.

11. Conclusion:

In summary, design interventions for reducing freezing of gait in Parkinson's disease have shown promising results. Wearable devices, virtual reality training, and environmental modifications have effectively improved mobility and quality of life for patients. Personalized approaches and interdisciplinary collaborations are crucial for optimizing outcomes. Continued research and implementation of these interventions hold great promise for enhancing the lives of Parkinson's patients.

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Thank You