Project 3

Final Stage

Biofeedback device for Brachial Plexus Injury Rehabilitation

Guide: Prof. Girish Dalvi

Angela R. S. (176330010)

Project Overview

Duration: April - July 2019

In this project we address the need for an easy-to-use biofeedback device and, an accompanying mobile app that can be used by both the therapist and the patient during Brachial Plexus Injury rehabilitation.

Need

Medical devices play a crucial role in providing holistic healthcare in today’s age. In India, many devices are imported. These devices are limited to few speciality centres, and out of reach to smaller districts.

There is a need to develop advanced, yet cost-effective solutions which are equivalent to the imported devices, and also appropriate to India in terms of local requirements and conditions.

Motivation

Dr. Chhaya (Right) and Dr. Bharti (Left) with the patient at KEM Orthopedic centre, Mumbai.
The patient is a 13-year old girl who was hit by a vehicle that caused this injury and left her with a paralysed right arm.

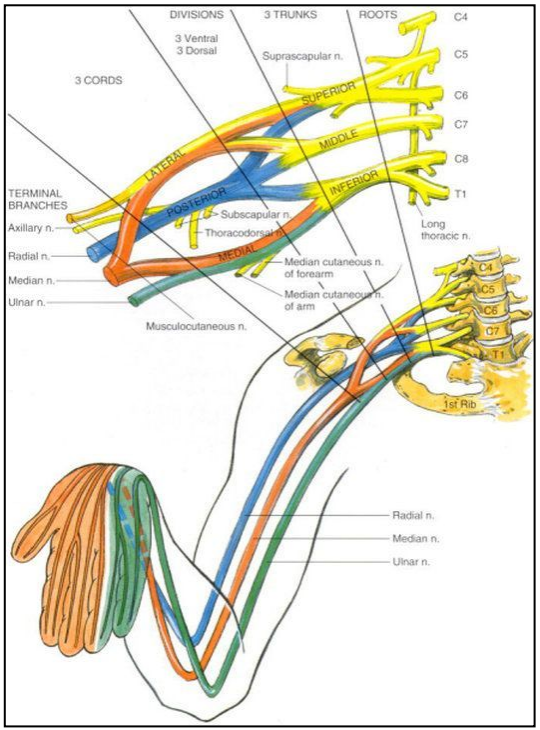
Dr. Chhaya Verma

HoD of Physiotherapy at TNMC and BYL Nair Hospital

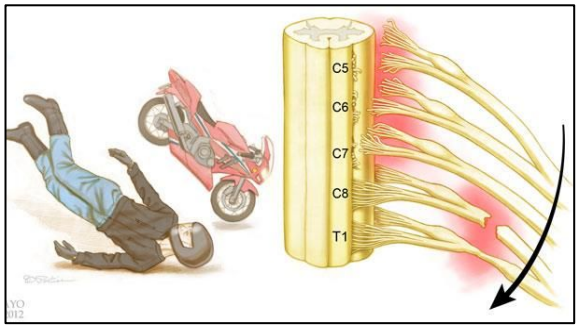
- Almost 30 years experience as a teaching faculty
- more than 10 years experience of working with adult BPI patients
- has published several papers in Indian and international journals over various aspects of BPI treatment and rehabilitation.
- Her qualitative approach in her studies, throws light on the impact of injury and an adult individual's perception and may thereby help to develop a more comprehensive and holistic approach towards patient care.

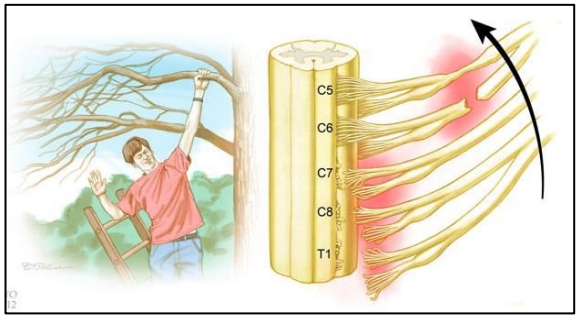
She told me about the need for having a cost-effective biofeedback technology that could be used for her patients who came from distant places for treatment.

What is Brachial Plexus injury?



What is the cause of the injury?





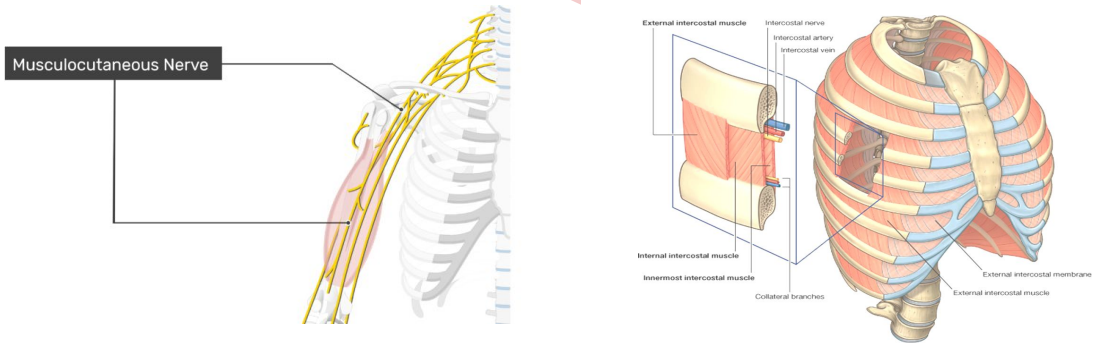
Disuse atrophy caused by the injury. (2-3 weeks of immobilisation)

Rehabilitation after nerve transfer surgery

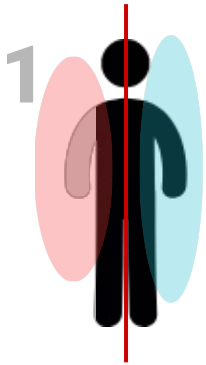
Nerve transfer surgery: ICN to MCN

Elbow flexion

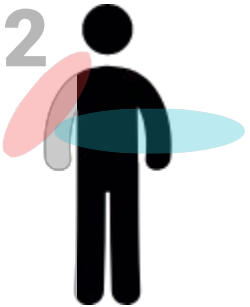
Inspiration and expiration



Neuroplastic learning

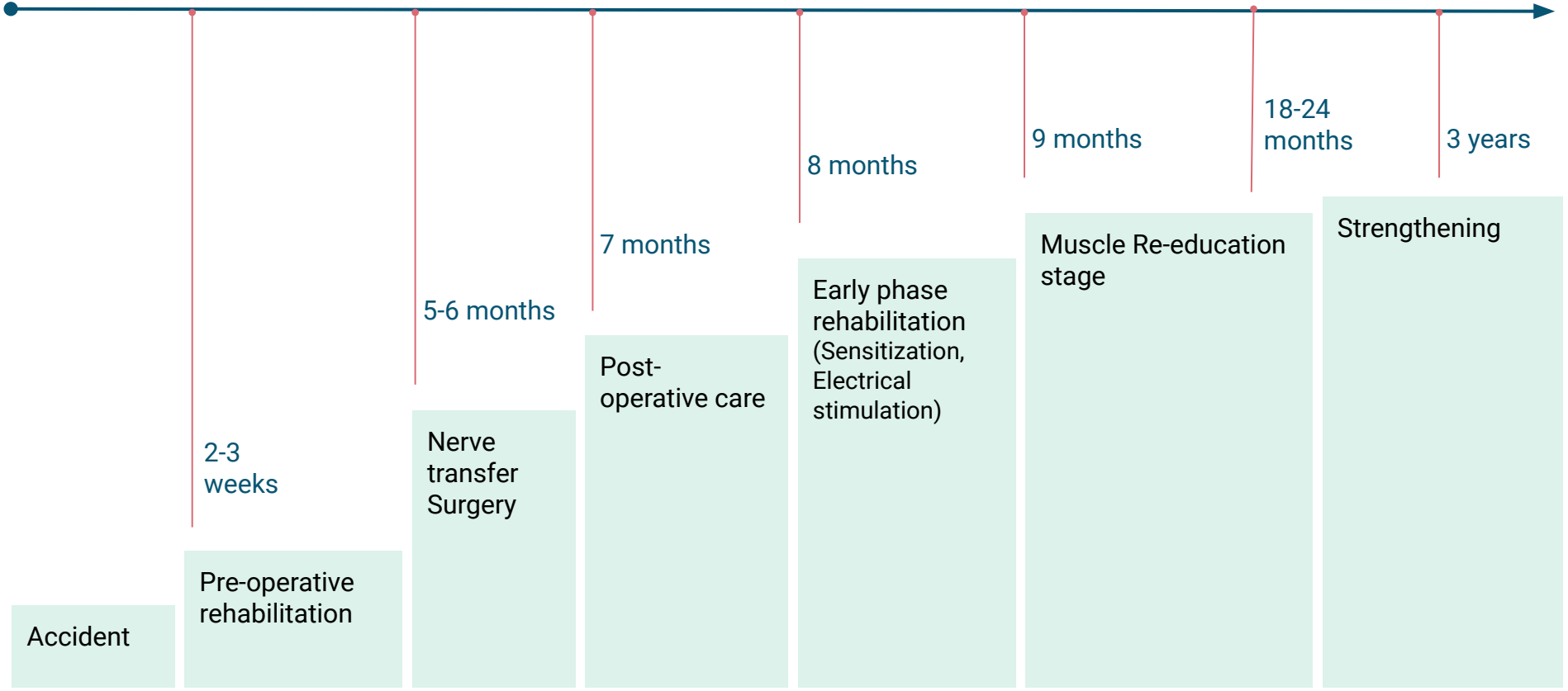


Bilateral Transfer of Learning

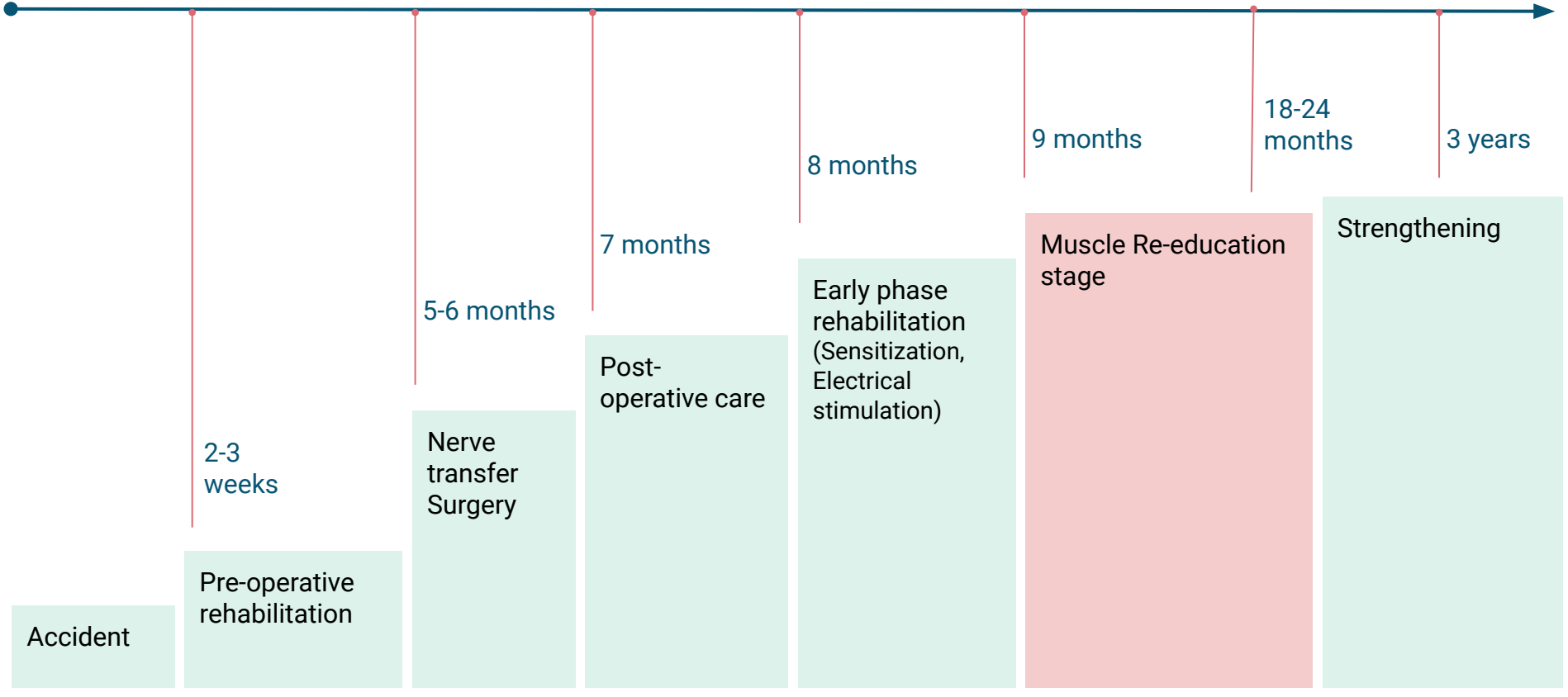


Bilateral Muscle Contractions of Recipient and Donor muscles

Rehabilitation Journey of a Patient



Rehabilitation Journey of a Patient



Muscle Re-education stage

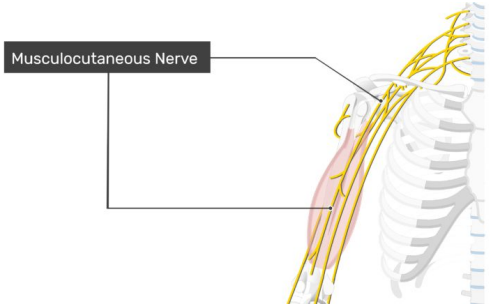
Association | **Dissociation**

Stage 1 | **Stage 2** | **Stage 3** | **Stage 4**

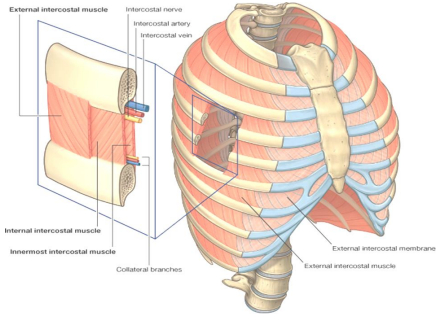
Contract **donor** and **recipient** muscles together.

Electrical Stimulation
Biofeedback

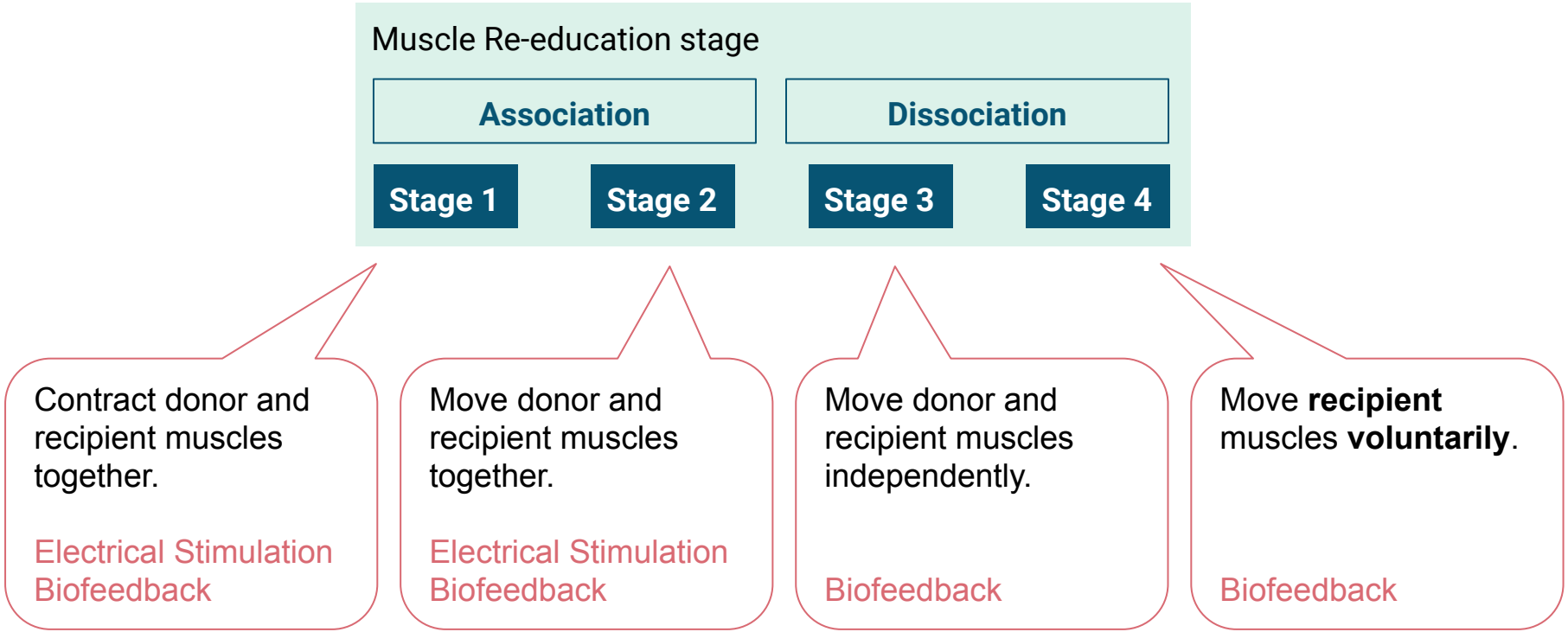
Recipient



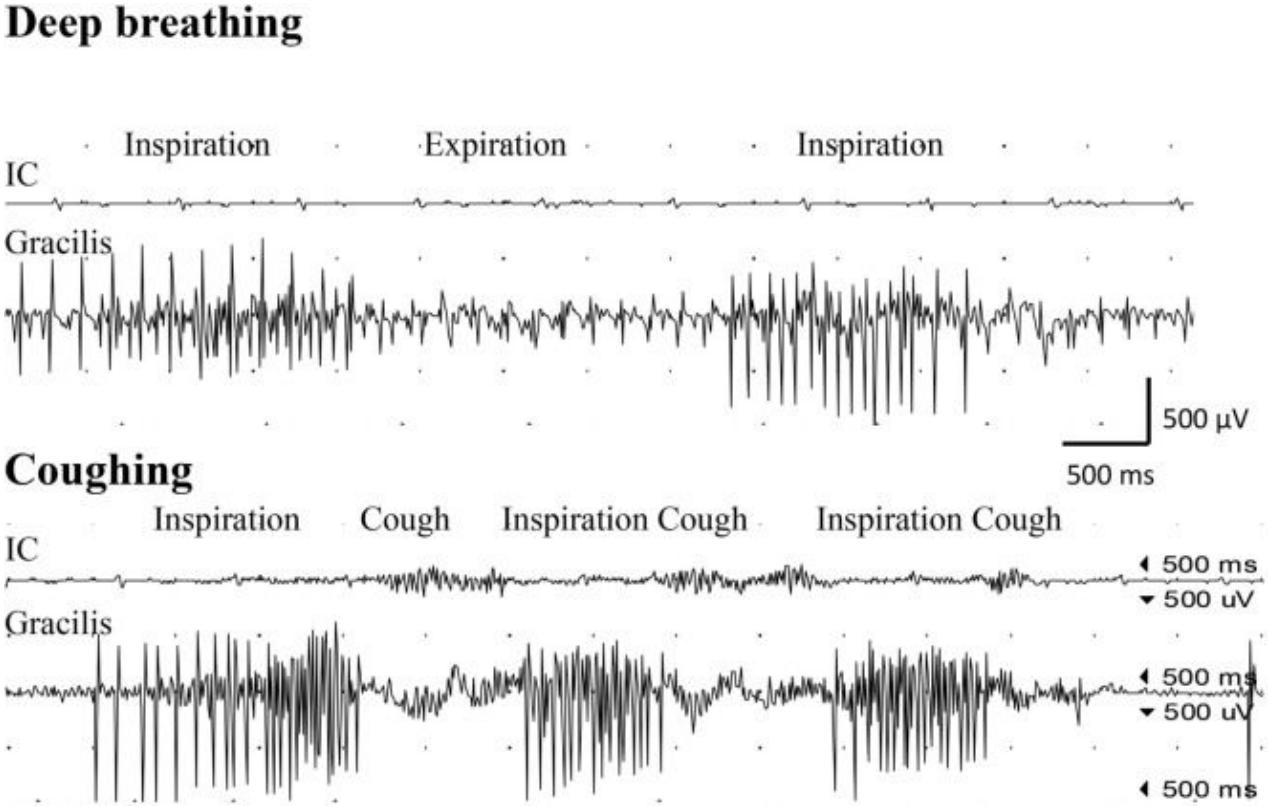
Donor



Biofeedback in BPI rehabilitation

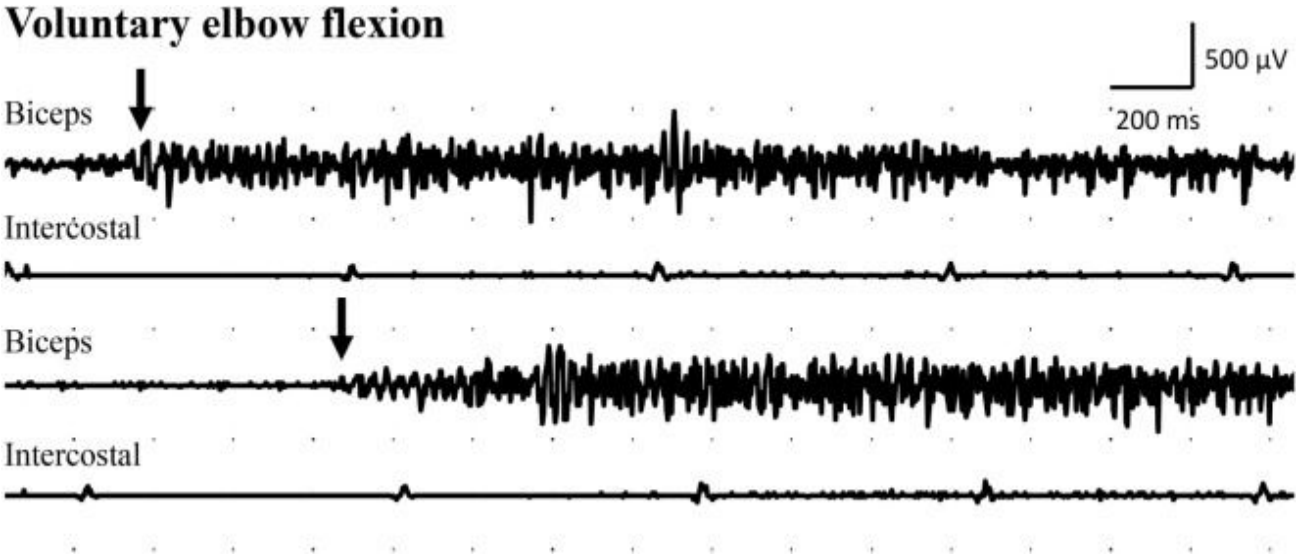


Association



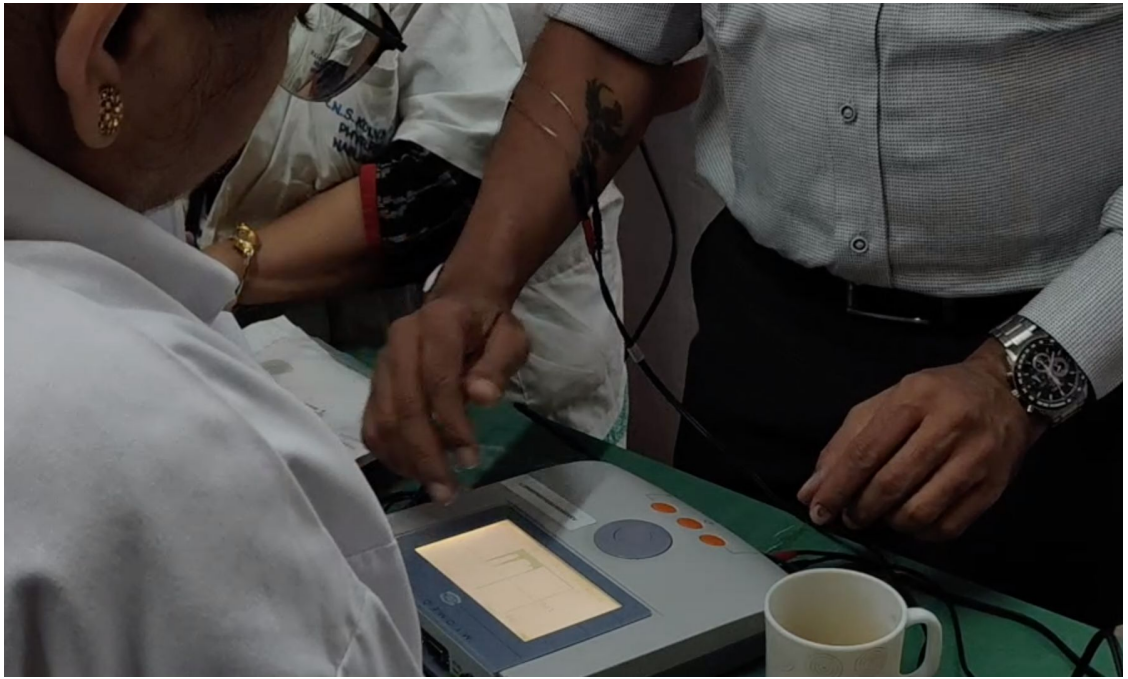
Bilateral Muscle Contractions of Receiver and Donor muscles

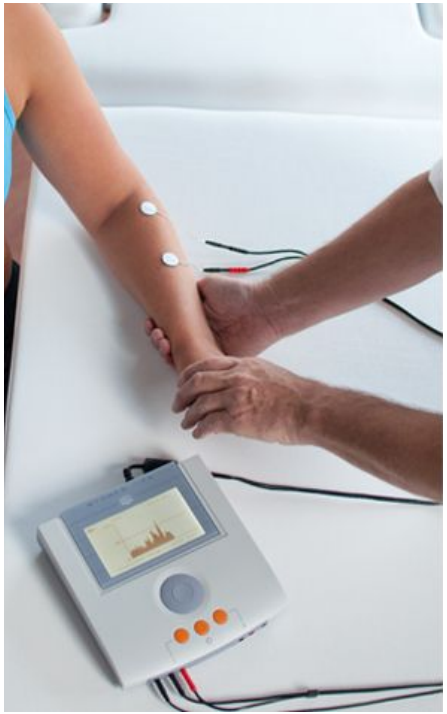
Dissociation



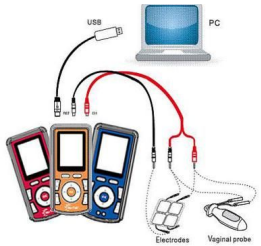
Bilateral Muscle Contractions of Receiver and Donor muscles

Use of EMG biofeedback in rehabilitation





©Enraf nonius - Myomed 134

Category/Products	OT Bioelectrica—Due	Nu-Tek EMG Biofeedback	BioZen products	Shimmer wearable sensor
				
Applications	Sports, ergonomics and rehabilitation.	Pelvic Floor Muscle Assessment and Training with Nu-Tek EMG ETS STIM Devices in clinics and for home use.	To show the user their physical level of relaxation. For clinicians and patients to use biofeedback in and out of the clinic.	High quality, scientifically reliable data to support researchers and academics in their data collection. Thus providing a proof of concept tool to those looking to develop commercial sensing applications.
Apps	PC and smartphones	PC and smartphones	Smartphones	App development in PC for PC and smartphones
Wearable	Yes	**No**	Yes	Yes
User UI physical buttons—Physical/Touch	No	Yes/-	No	No
Display	No	Yes	No	No
Communication	Bluetooth, wired	wired	Bluetooth-coupled sensors	Bluetooth, wired—dock

Category/Products	Enraf-Nonius Myomed 632X	myoMUSCLE™ Software Module	Ultium™ EMG — Sensor module only	flexerGo by Healer Tech
				
Applications	patient to exercise safely, which efficiently promotes recovery	An all-in-one analysis, enabling detailed insight for performance enhancement, injury recovery or research metrics.	Flexibility to accurately capture the most interesting aspects of human movement. The system features new, patent-pending set of “SmartLeads”, which transform the EMG device into an intelligent sensor for virtually any type of biometric and physiological data, from any type of hardware.	It provides clinical grade movement readings for biofeedback, neuromuscular re-education, and strength-power output. Application covers in the following areas: Biofeedback, Therapeutic exercise, Neuromuscular re-education, Pediatrics developmental delay, Postoperative rehabilitation, Sport performance, Injury rehab, Motion tracking, Skills development, Stroke rehab, Spinal Cord Rehab, Traumatic Brain Injury, Pediatrics sensory integration.
Apps	PC—through a programmed USB-stick	PC and smartphones	PC and smartphones	Tablet based
Wearable	**No**	**No**	Yes	Yes
User UI physical buttons—Physical/Touch	Yes/-	-/Yes	No	No
Display	Yes—large	Depends on PC monitor, smartphone	No	No
Communication	Bluetooth, wired	Bluetooth, wired	RF	Bluetooth

Challenges during Patient-education

Think & Feel?

I am applying all my strength.

Why I am not able to move the arm?

When will I be able to move my arm?

Doctor is asking me to pull. the arm

See?

Doctor taught me the exercise by holding my arm.

Doctor is asking me to lift from the elbow.

Doctor taught me how to do correctly. I should remember all the steps.

I have to place my arm like this, turn it like and lift it like this.

Hear?

I do this exercise 400 times a day.

I want to go back home for few days.

I am feeling tired now.

Say & Do?

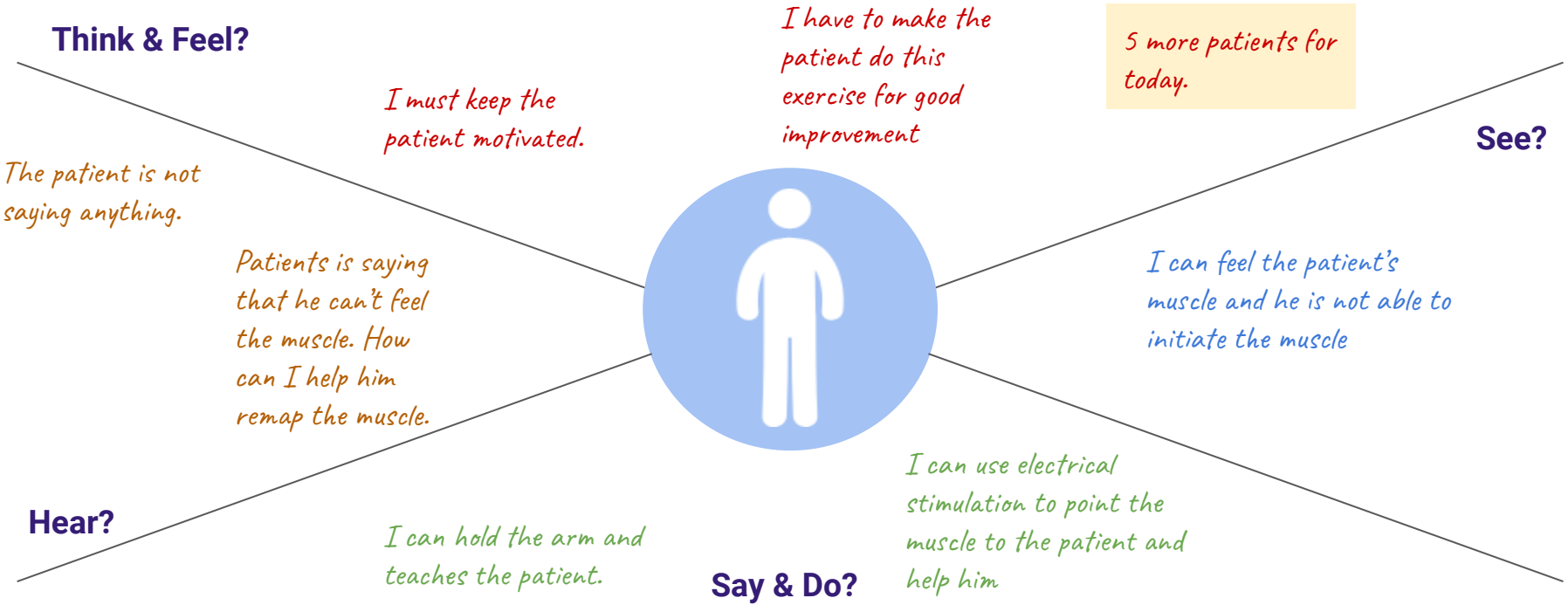
Pain

- Rehabilitation period is longer than 1.5 to 2 years
- Without surgery and rehabilitation the arm is rendered useless.

Gain

- Receives counseling and support from therapist
- Good patient-therapist relationship helps in staying motivated.

Therapists during Patient-education



Pain

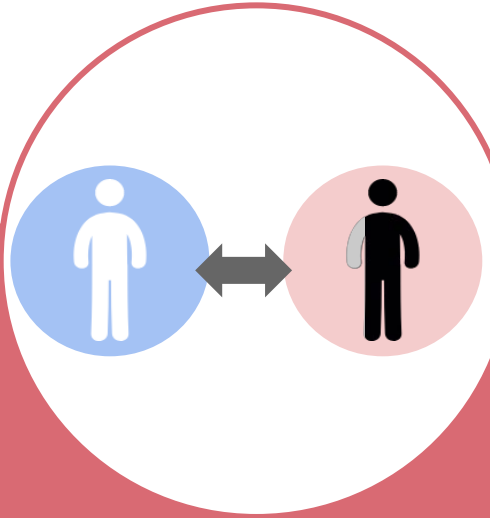
- Communicating the exercise requirements.
- Effectively sensitizing the patient of the little effort they are able to put.

Gain

- Electrical stimulation machine helps the patients to get sensitized of their muscles
- Therapist can sense and tell if the muscle is activated or not.

In the beginning, these injuries can be overwhelming.

Communication is important as it can be hard for the patient to absorb all the information.



Biofeedback helps patients stay motivated and assess their progress.

Persona

Name: Sarita Dehkar (F)
Age: 40

Marital Status: Married
Children: 1 (Female, 17yo)

Education: B. Pharm
Occupation: House-wife

Address 1: D-109, Saraswat colony, Chinchwad, Pune (Home address)

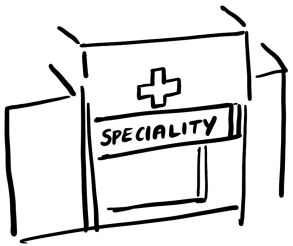
Address 2: Flat no. 11, B Wing, Diamond Society, GS Road - Thane (Sister's home)

Date of Injury: 22 May, 2017
Cause: Road accident (Patient was driving a two-wheeler. Patient was not wearing a helmet.)

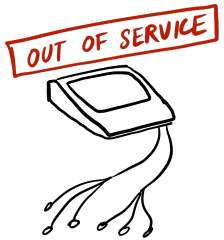
Injury: Right arm (Right hand dominant)

Date of Surgery: 4 October, 2017
Surgery Details: Neurotization nerve transfer surgery
1. SAN to SSN
2. ICN(4,5) to MCN

Rehabilitation Challenges



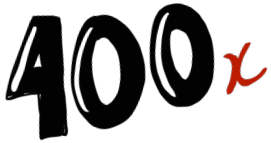
Patient Referral - Long distance travels



Unexpected system failures

Therapist feedback is subjective.

1 hr per session
Once a month



400 repetitions per day
20 reps/hour

1.5 to 2 years have passed

8-9 months more

Muscle Re-education stage

Association | **Dissociation**

Stage 1 | **Stage 2** | **Stage 3** | **Stage 4**

Biofeedback device and an smartphone application that is specific to the requirements of BPI rehabilitation

Mobile phones are ubiquitous and sensors are inexpensive.

Requirements of an app for BPI rehabilitation

1. Each patient's case would be unique based on no. of surgeries and type of surgery.
2. The therapist has to decide the exercises based on the type of surgery that the patient has undergone.

We identified all the common nerve transfer surgeries to include in the app.

Requirements of an app for BPI rehabilitation

Exercise requirements:

1. Each surgery type has a donor action and recipient action associated to it.
2. Muscle re-education program is as follows:
    a. Patient does the recipient and donor action together.
    b. Patient does only the recipient action without the donor action.
3. Patient uses biofeedback during the exercise.

We identified step by step instructions that the app must deliver to the patient to setup the sensors and the exercise themselves.

MyoBit Biofeedback solution

Stage 3 (Pre-final)

UX

Ecosystem
Use scenarios

Technical

Device
- Accuracy
- Calibration
- Connectivity
- Sensor development

Identity

Product name
Brand attributes
Color scheme
Logo
Typography

UI

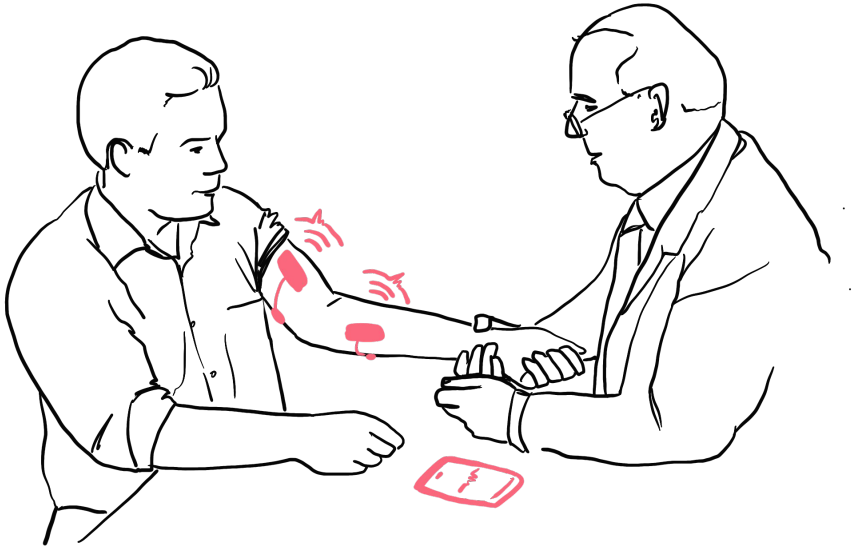
Application
- Feature list
- Info-Architecture
- UI wireframes

Evaluation

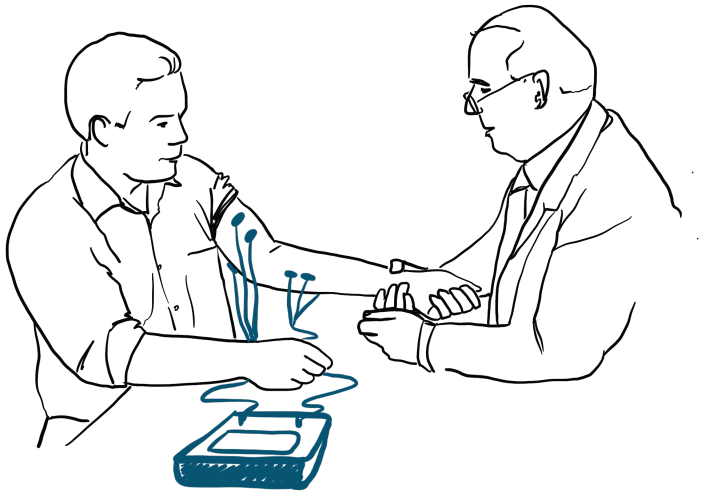
Expert Evaluation

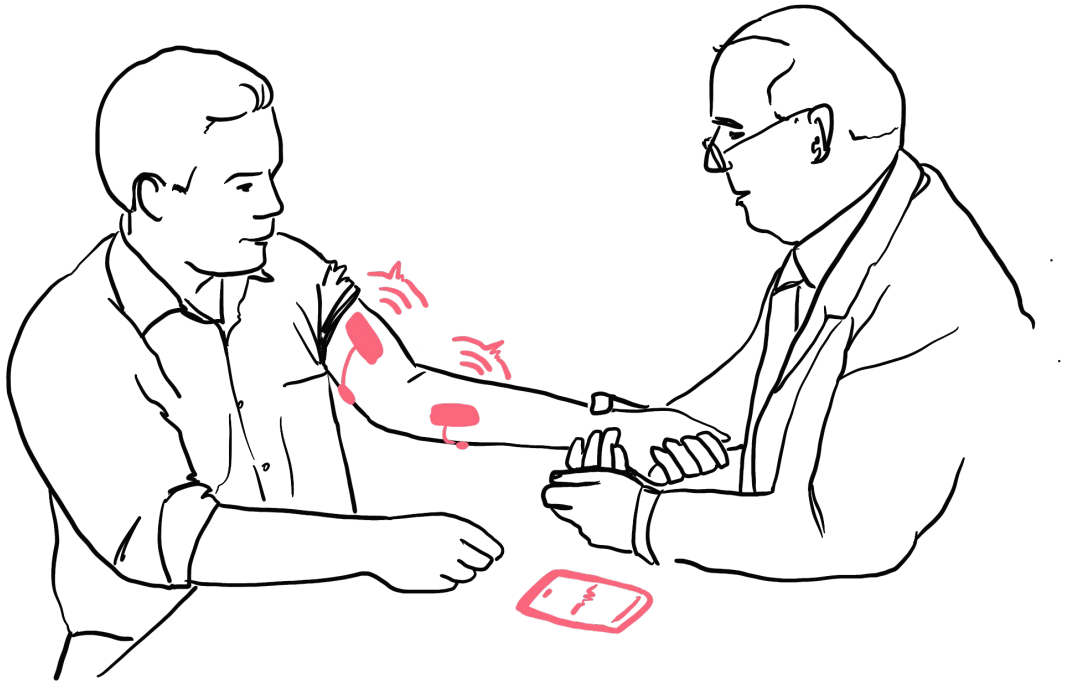
MyoBit use case

Ecosystem
Use scenarios

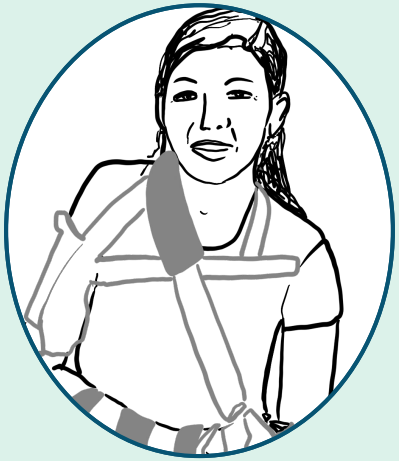


Product Concept





MyoBit use case



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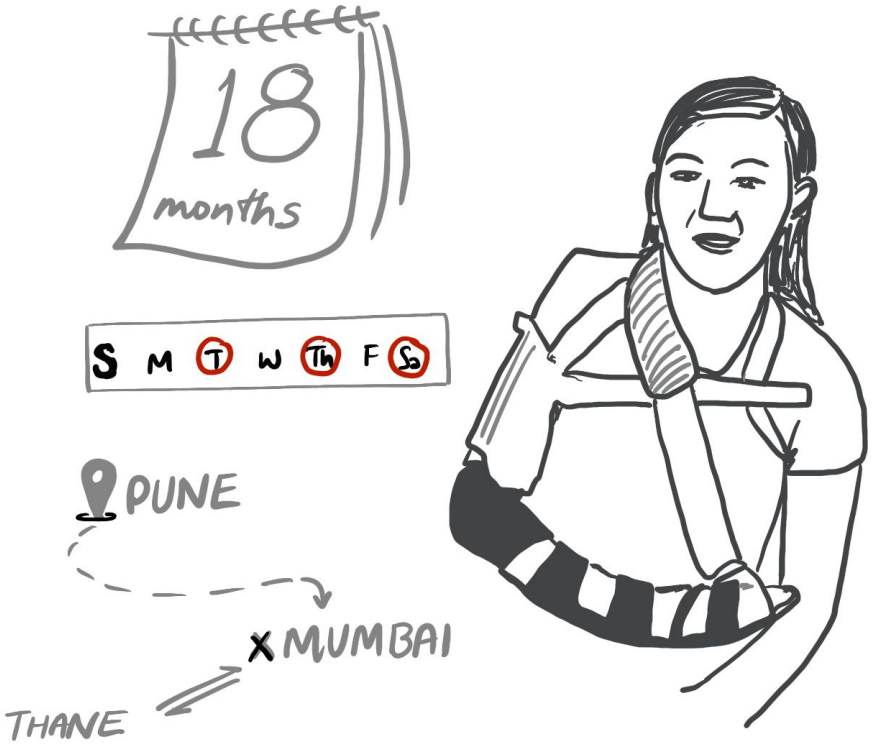
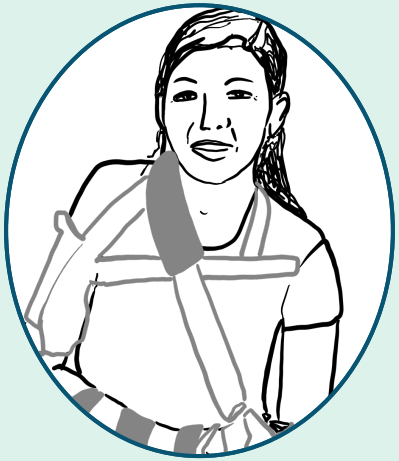
Age: 40
MRC Muscle Grade 1



MyoBit use case



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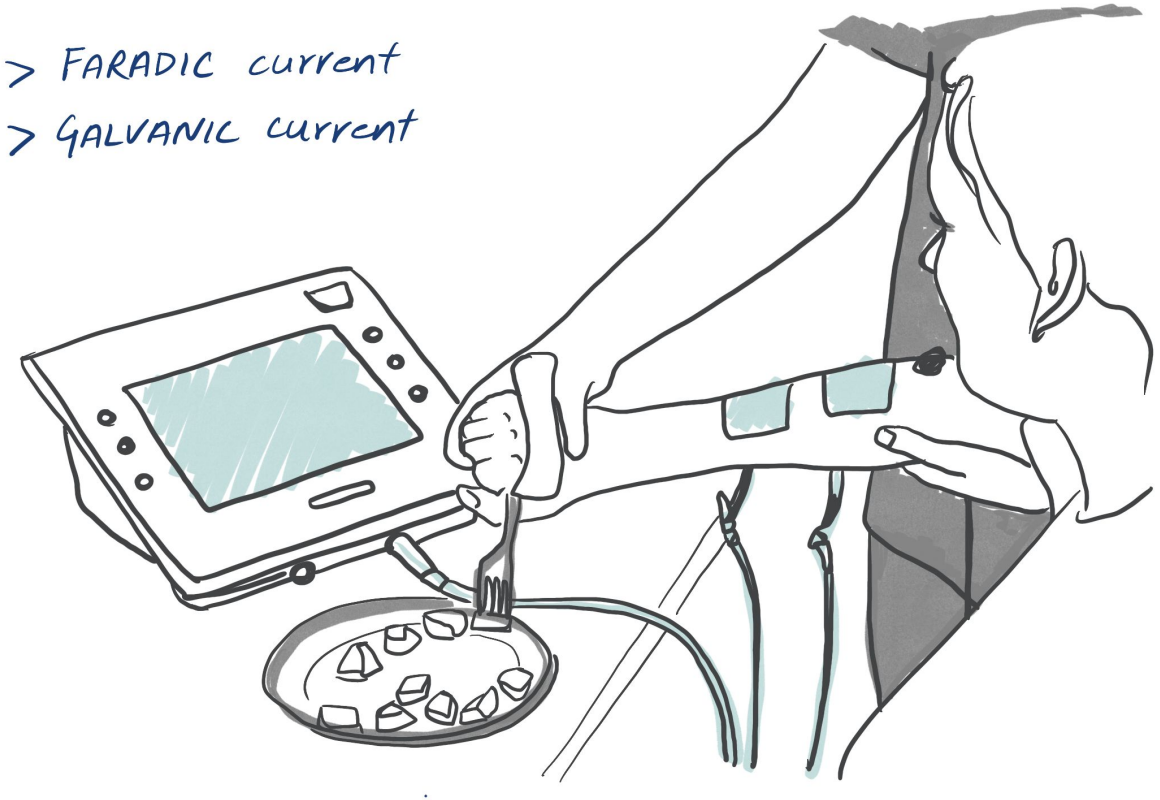
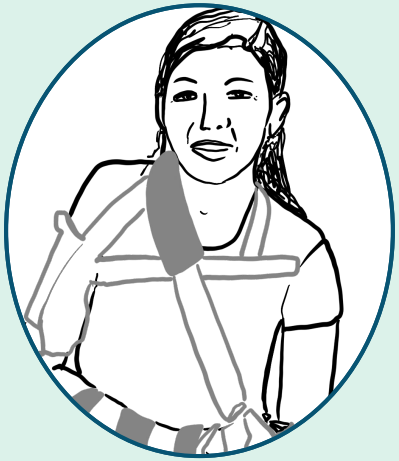


MyoBit use case



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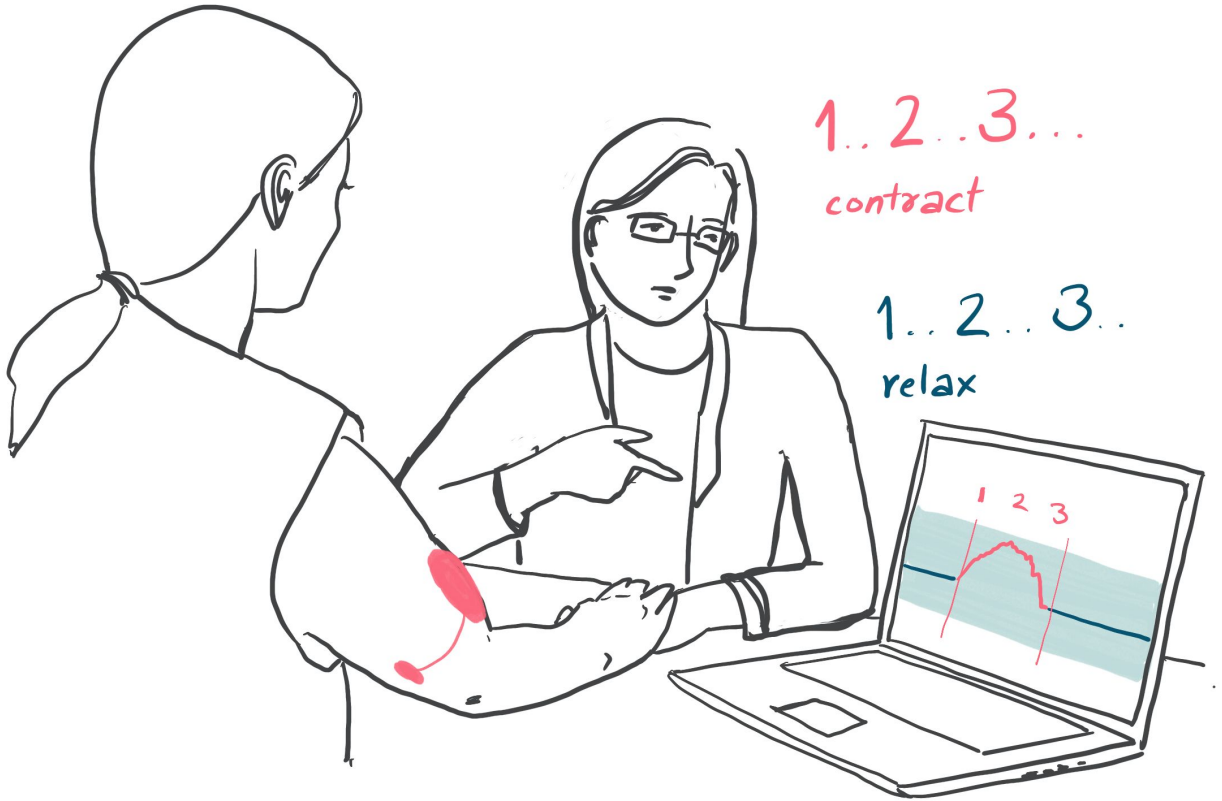

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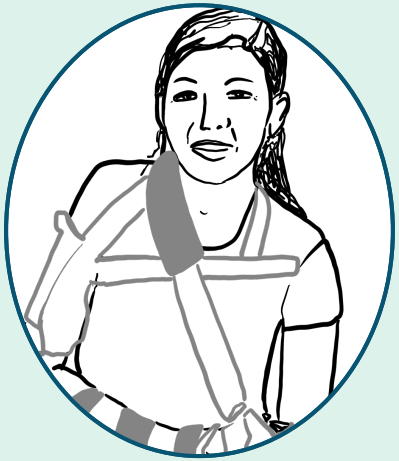

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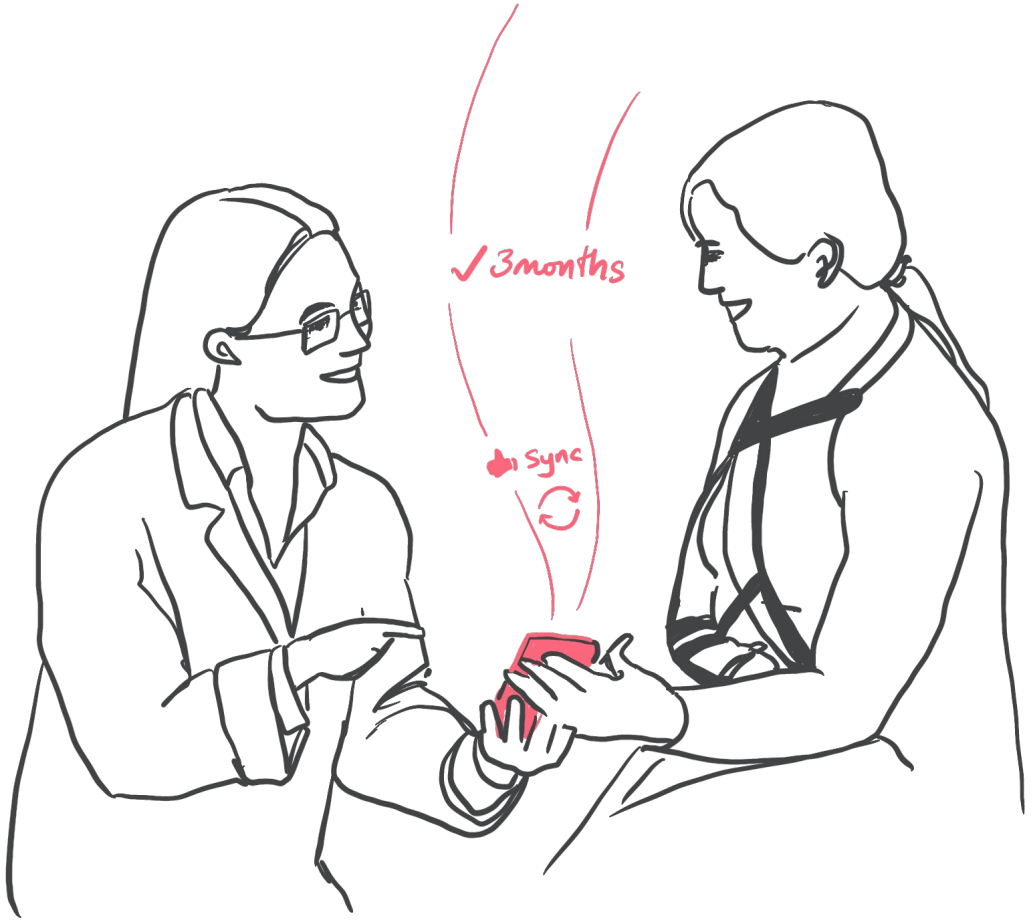
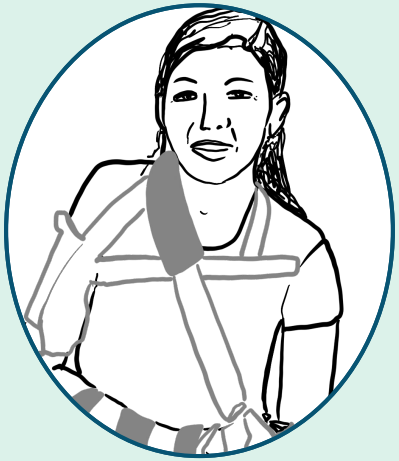


MyoBit use case



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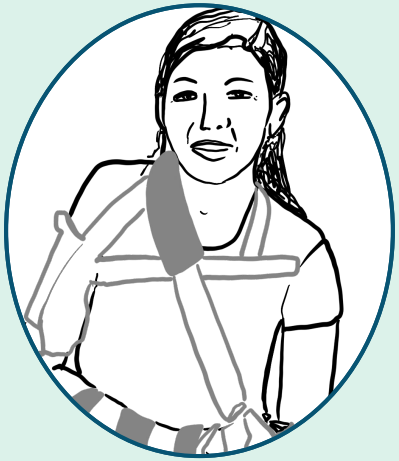

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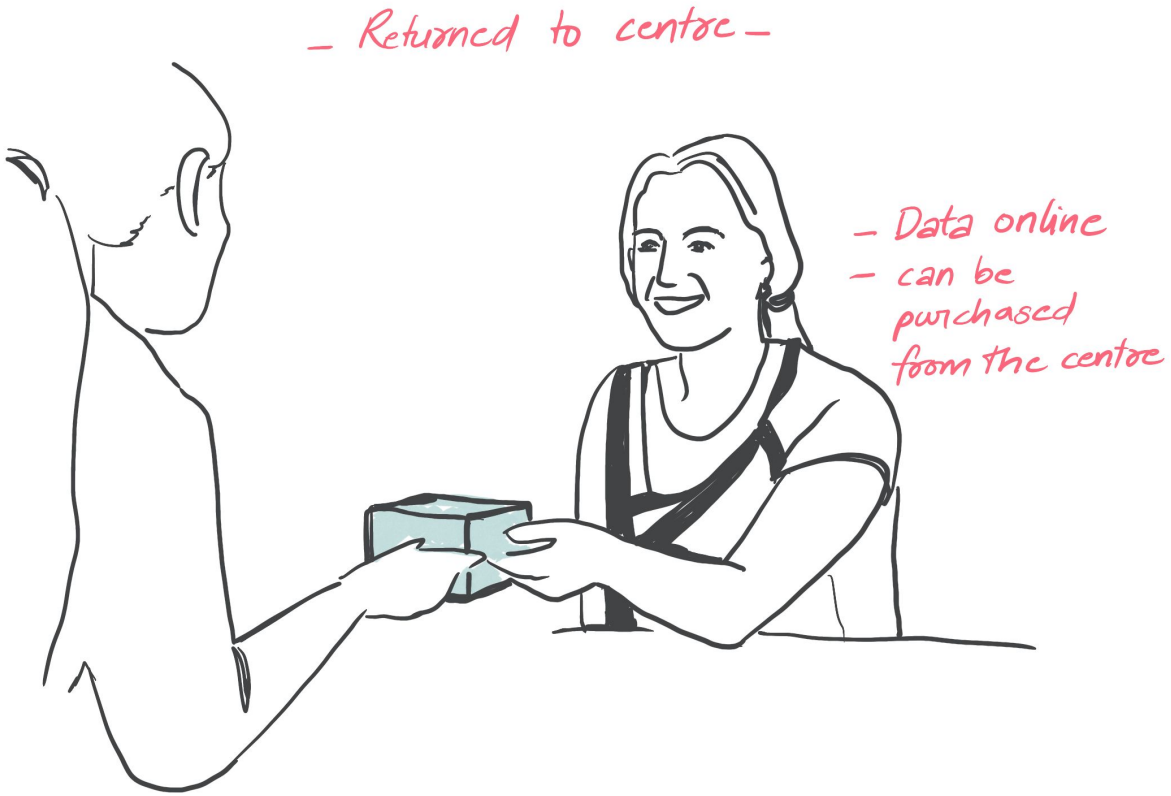
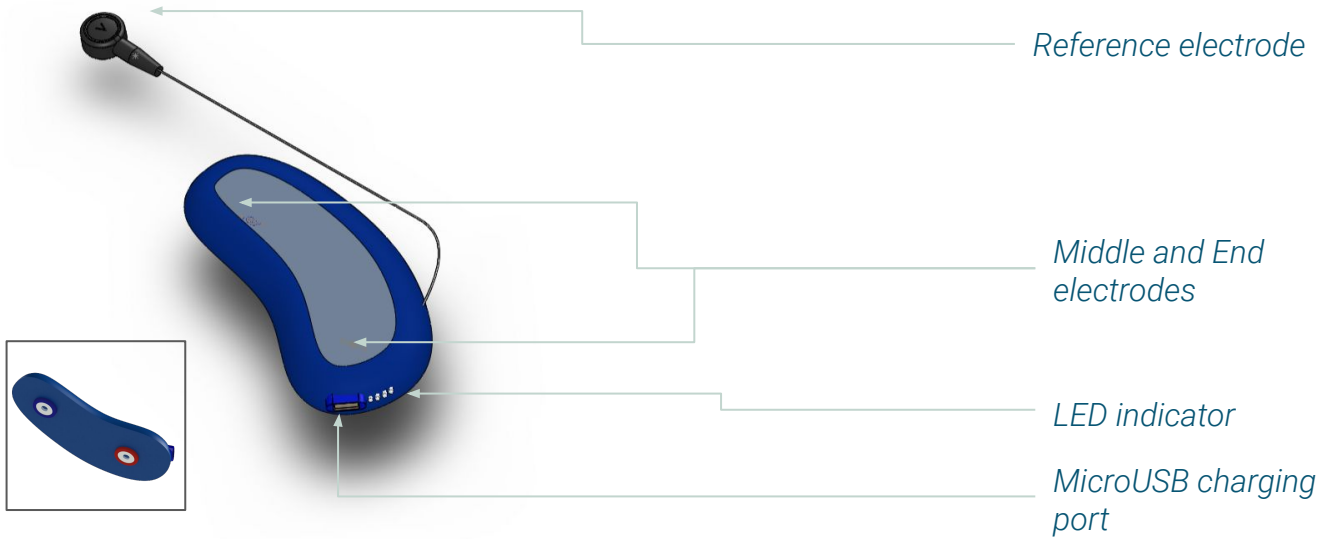


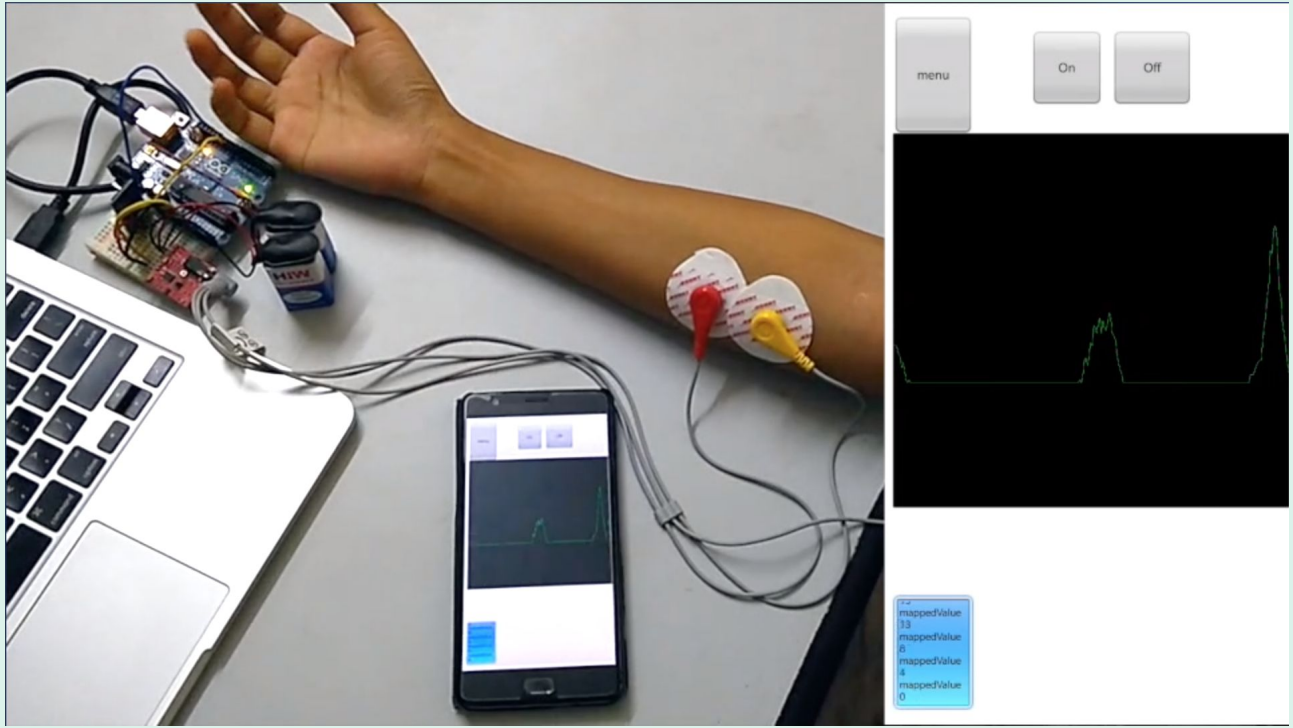
Proposed form for single sensor unit

Device

- Accuracy
- Calibration
- Connectivity
- Sensor development



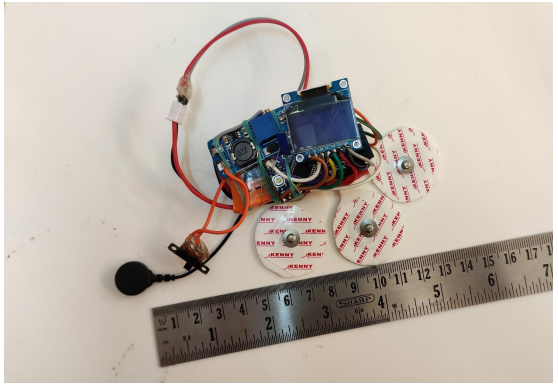
Proof of Concept

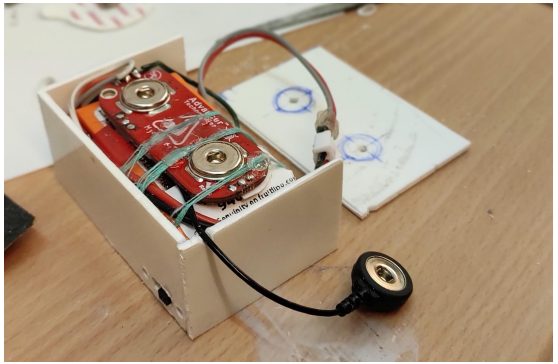


Switch to video

DDS 2019 - (22 & 23 June)

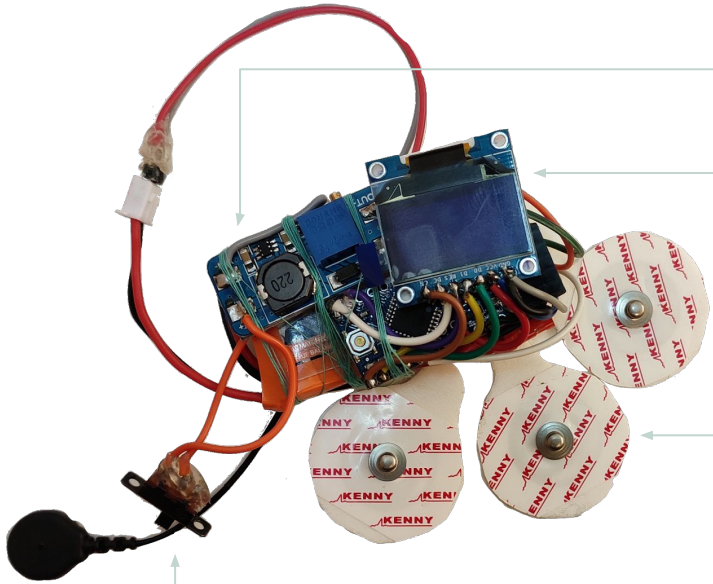
- Presented the wireless prototype
- Features
  - Bluetooth communication
  - OLED Display
  - Micro USB Rechargeable Battery
  - Easy to put EMG sensor





Device

Accuracy
Calibration
Connectivity
Sensor development



Battery and microcontroller+BT+Charger sandwiched

OLED screen

Electrode patches

Switch

MyoBit

Product name
Brand attributes
Color scheme
Logo
Typography

MedicoMat *FlowHRV* *JawBone* *Garmin* *AliveClinical*
FlexerGo *FitBit* *MiBand* *ReHand* *mTrigger*
DrPhysio *HearthMath* *2Breathe* *EnrafEnouis*

MyoPhyz ExerGo **MyoBit** PhysioCare

Stage 3

UX | Technical | **Identity** | UI | Evaluation

- Product name
- Brand attributes
- Color scheme
- Logo
- Typography

MyoBit

Culture

Caring
Localised
Family
Community
Positive
Transparent
Adaptable
Flexible
Economic
Goal-oriented

Customer

Suburban
Disability
Trauma
Long-term recovery
Depressed
Financially strained

Voice

Empathetic
Motivating
Bright
Honest
Witty
Reliable
Friendly
Counsellor
Strict
Supportive
Empowering
Encouraging

Feel

In Control
Achievement
Positive
Progress
Healthy
Comfort
Hopeful
Taken care of
Empowered
Understood
Able to accept change
Willingness
Determination

Impact

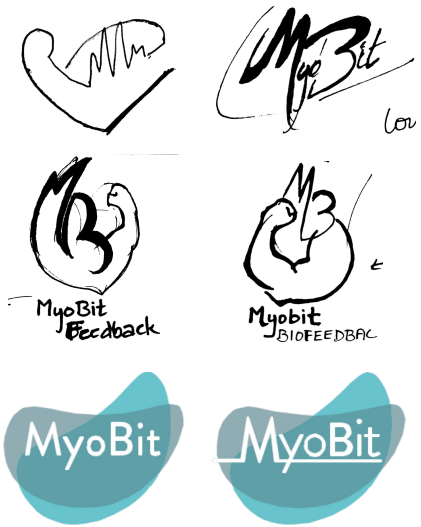
Energised
Confident
Positive
Self-Image
Save expenses
Satisfied
Community growth
Healthy
Awareness
Knowledgeable about the condition

x-Factor

Gamified
Exotic
Entertaining
Spiritual
Localised

Logo

Product name
Brand attributes
Color scheme
Logo
Typography



Stage 3

UX | Technical | **Identity** | UI | Evaluation

MyoBit Stylescape

Product name
Brand attributes
Color scheme
Logo
Typography

Evaluation

In the mobile application prototype, we evaluated -

1. Navigation flow
2. Relevance of having two modes - Quick setup mode and Custom setup
3. Interactions for setuping the sensor units and paring them with the mobile application
4. Interactions for choosing one sensor unit and assigning it the target muscle.
5. Selection mechanism for assigning the target muscle for a sensor unit.
6. Relevance of having a horizontal bar graph for visualising real-time biofeedback
7. Relevance of having a marker for maximum action potential displayed by the muscle.

Feedback was taken for each of the above criteria in the application prototype.

Thank you