Sensors embedded in a garment for stroke rehabilitation

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Future model of stroke rehabilitation

- Drive for cost-effective rehabilitation
- Targeting recovery
- Change in attitudes from dependence to independence
- Early Supported Discharge (ESD)
- Rehabilitation at home
- Improving assessment

The dose of UL treatment after stroke is unacceptably low

- Patients do very little in hospital
- Julie Bernhardt reported that patients are only active 13% of the day. And ALONE 60 % of the day
- Not the best environment to promote neuroplasticity
- Animal studies - need 400-600 reps of reach tasks
- On average patients achieve 32 reps in a therapy session
- Strong evidence that high dose of therapy is effective
- Incorporating high intensity of repetitive task practice
- Varied and goal orientated

What our patients tell us..

- ‘Recovering from stroke is like watching paint dry – its difficult to keep motivated when you don’t seem to be improving’
- ‘I want to practice at home, but I’ve no idea whether what I am doing is right’

Assessment and treatment are two sides of the same coin

- The patient and therapist need the same data
- …during the performance of functional tasks
- but presented in different ways
  - The therapist needs rich accurate data on which to make clinical decisions
  - The patient needs a limited data set presented in a simple, interesting way – maybe related to a game or a task

Sensors can..

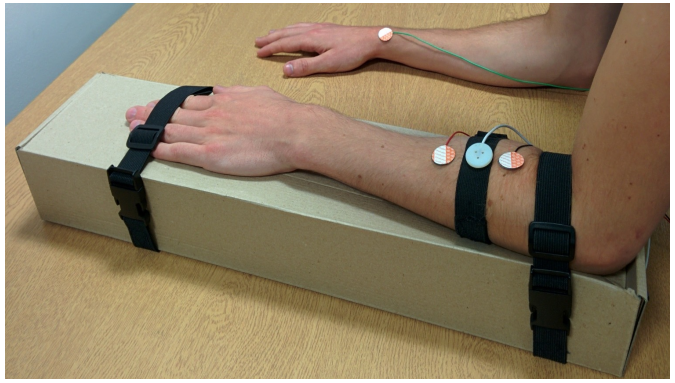
- Monitor quality and amount of movement and provide feedback
  - Clinical decision-making – choice of treatment
  - Detect changes in response to treatment
  - As feedback to motivate, guide and encourage – real time and summary and sometimes interacting with computer games
- Platform for remote monitoring

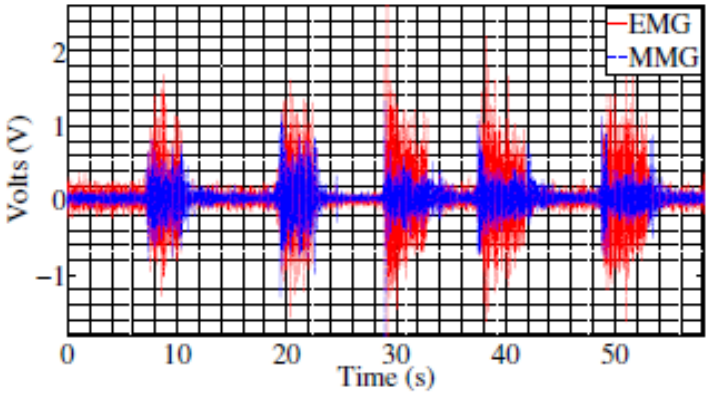
Mechanical Muscle Activity with Real-time Kinematics (M-MARK)

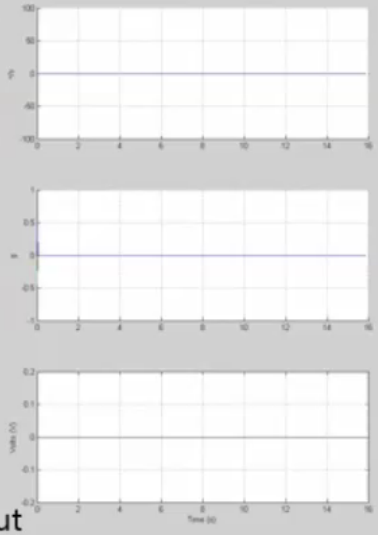
A novel combination of existing technologies to improve arm recovery following stroke

University of Maryland School of Medicine
Physical Therapy and Rehabilitation Science
Imperial College London
University of Southampton
NHS National Institute for Health Research
maddison Product Design
North Bristol NHS Trust
tactiq
Portsmouth Hospitals NHS Trust

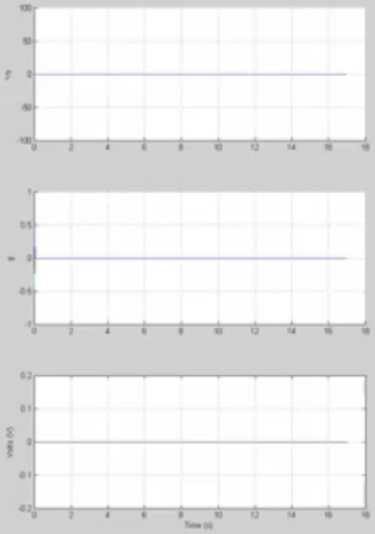
Translating the idea into reality





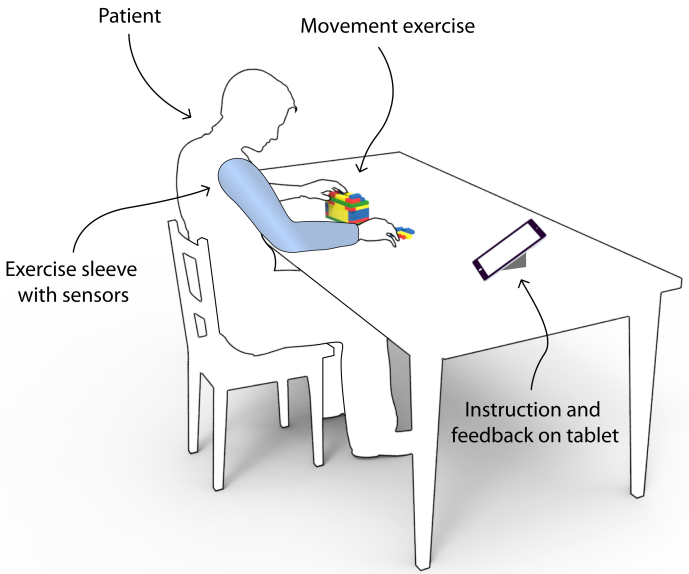


Unaffected limb reaching
Top Graph: Upper arm IMU output
Middle Graph: Trunk IMU output
Bottom Graph: Upper deltoid MMG output



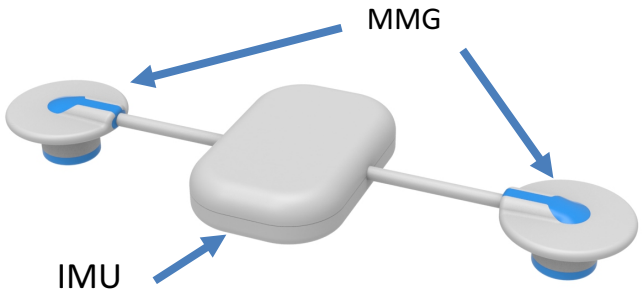
Hemiplegic limb reaching
Top Graph: Upper arm IMU output
Middle Graph: Trunk IMU output
Bottom Graph: Upper deltoid MMG output

M-MARK



Using movement and MMG sensors to:

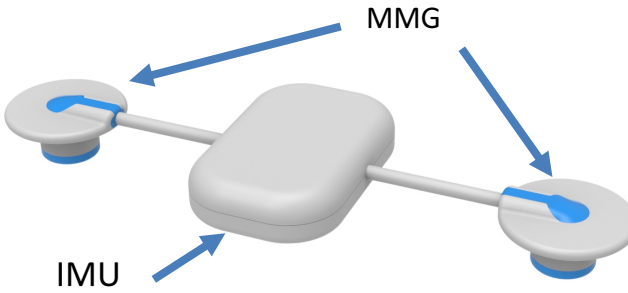
- Measure performance
- Guide activities
- Provide motivating feedback
- For patients and therapy assessment
- Potential for tele-rehab



While most technologies are using Virtual Reality we chose to use real, everyday objects

Garment and sensors

- Co-designed with patients and carers
- Stretchy fabric – easy to don and doff, but firm enough to prevent sensors moving
- Removable sensors (variable positioning) snap to garment
- Incorporates the wrist
- Trunk IMU
- Single Bluetooth transmitter to tablet and rechargeable battery that powers all devices
- Wiring integrated into the garment (washable)



Progress so-far

- MMGs and IMU have been demonstrated to be valid and reliable in lab tests
- We have identified a small set of tasks
  - Working with patients, carers and therapists
  - Review of the motor learning literature
- We are writing algorithms to classify performance of each task based on healthy and patient (and contra-lesional) data
- To provide useful valid and reliable feedback for therapists and patients

Graphical User Interface

- For therapist and patient
- Therapist interface used for assessment
- Provide instructions for use
- Personalized for the patient
- Guide the patient through performance of tasks
- Provide motivating feedback based on performance
- Include audio, real-time feedback
- Suggest how to improve performance

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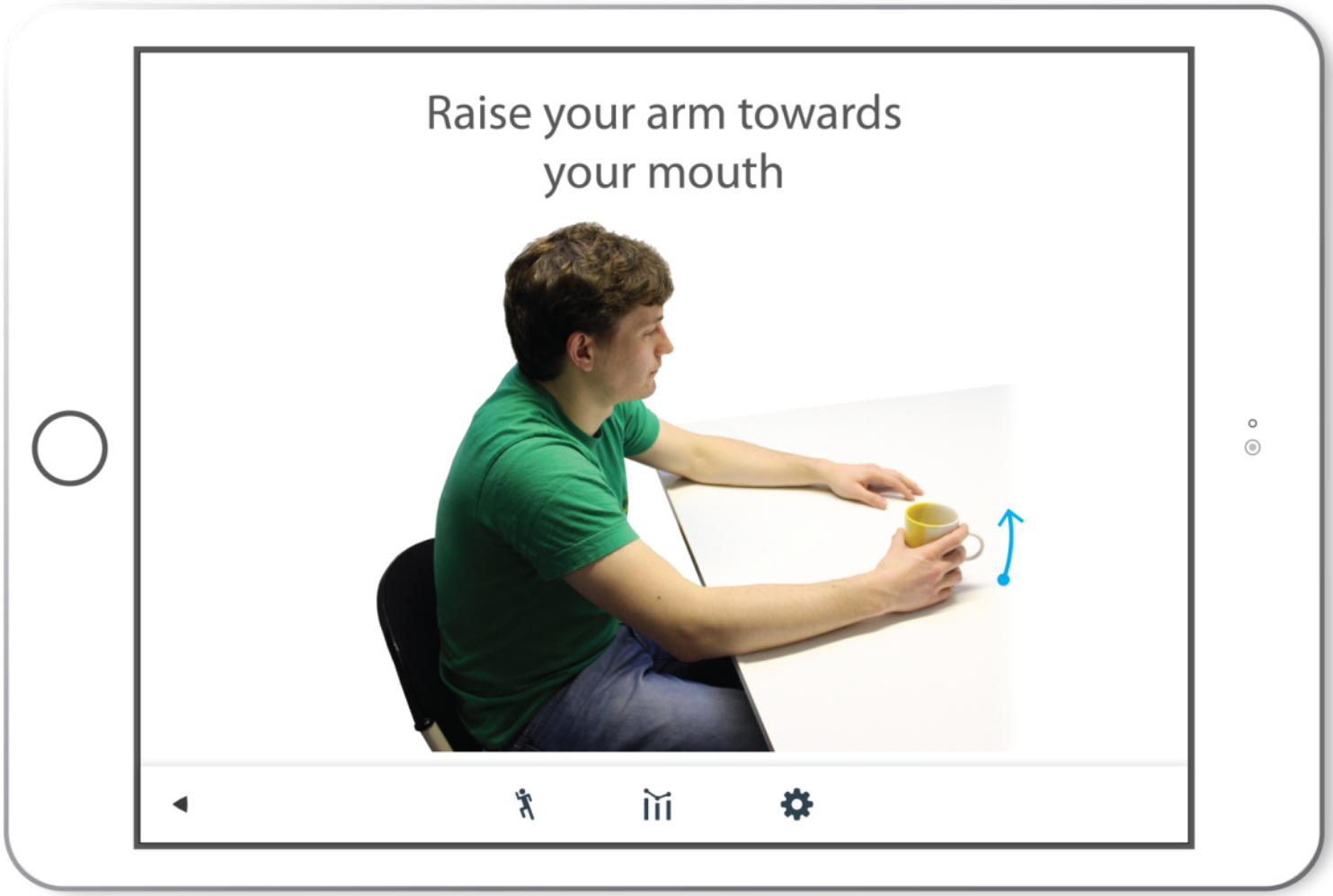

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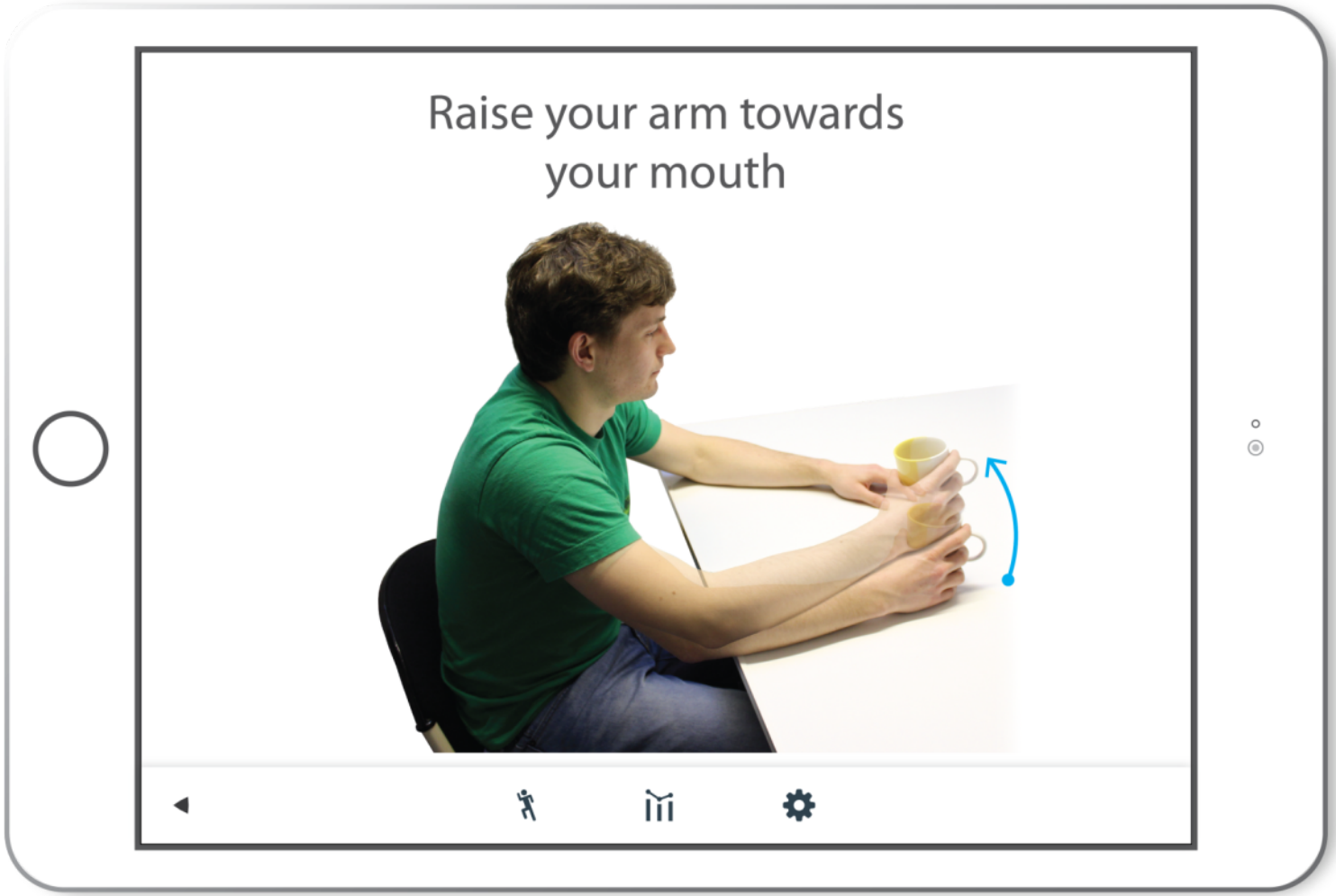

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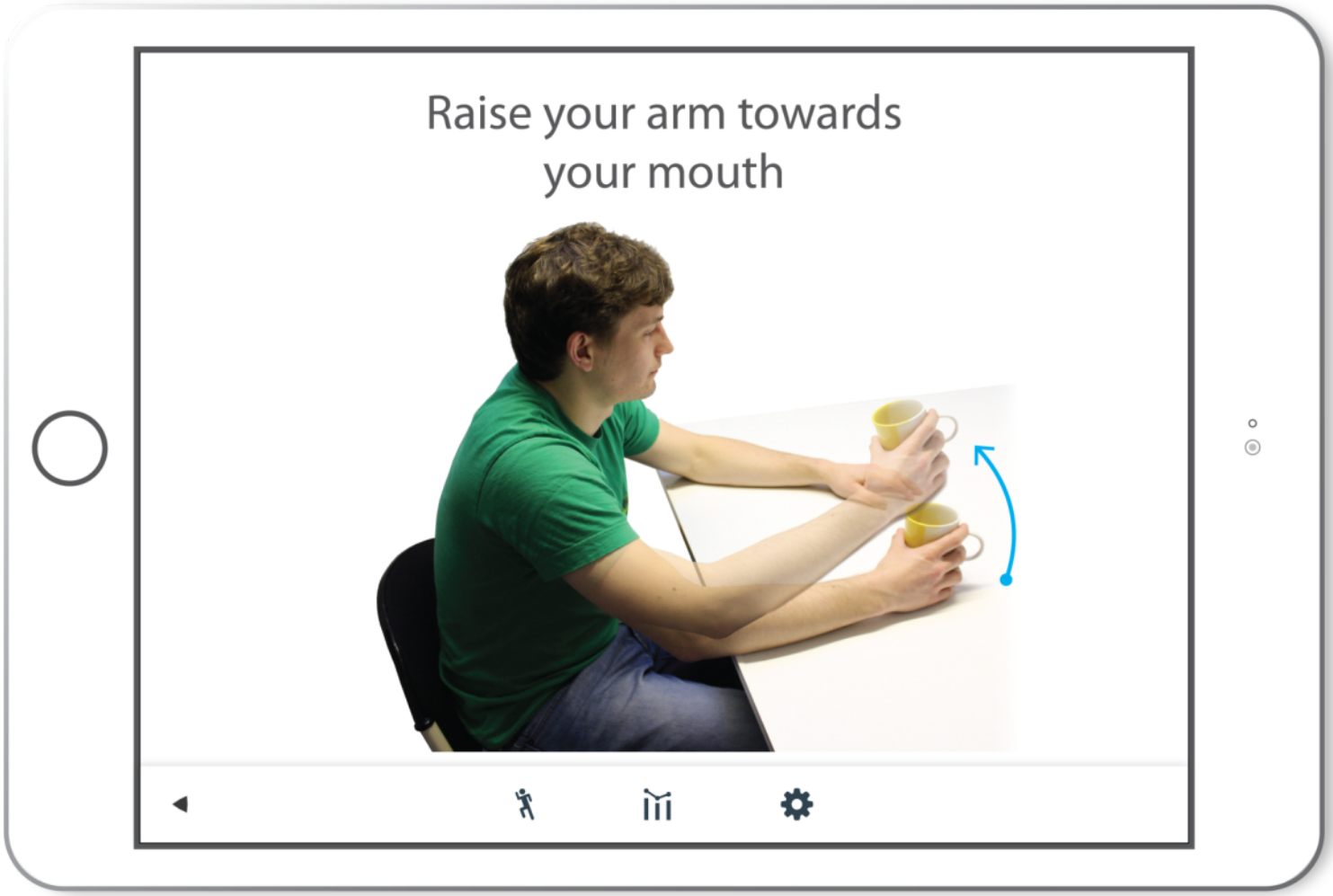

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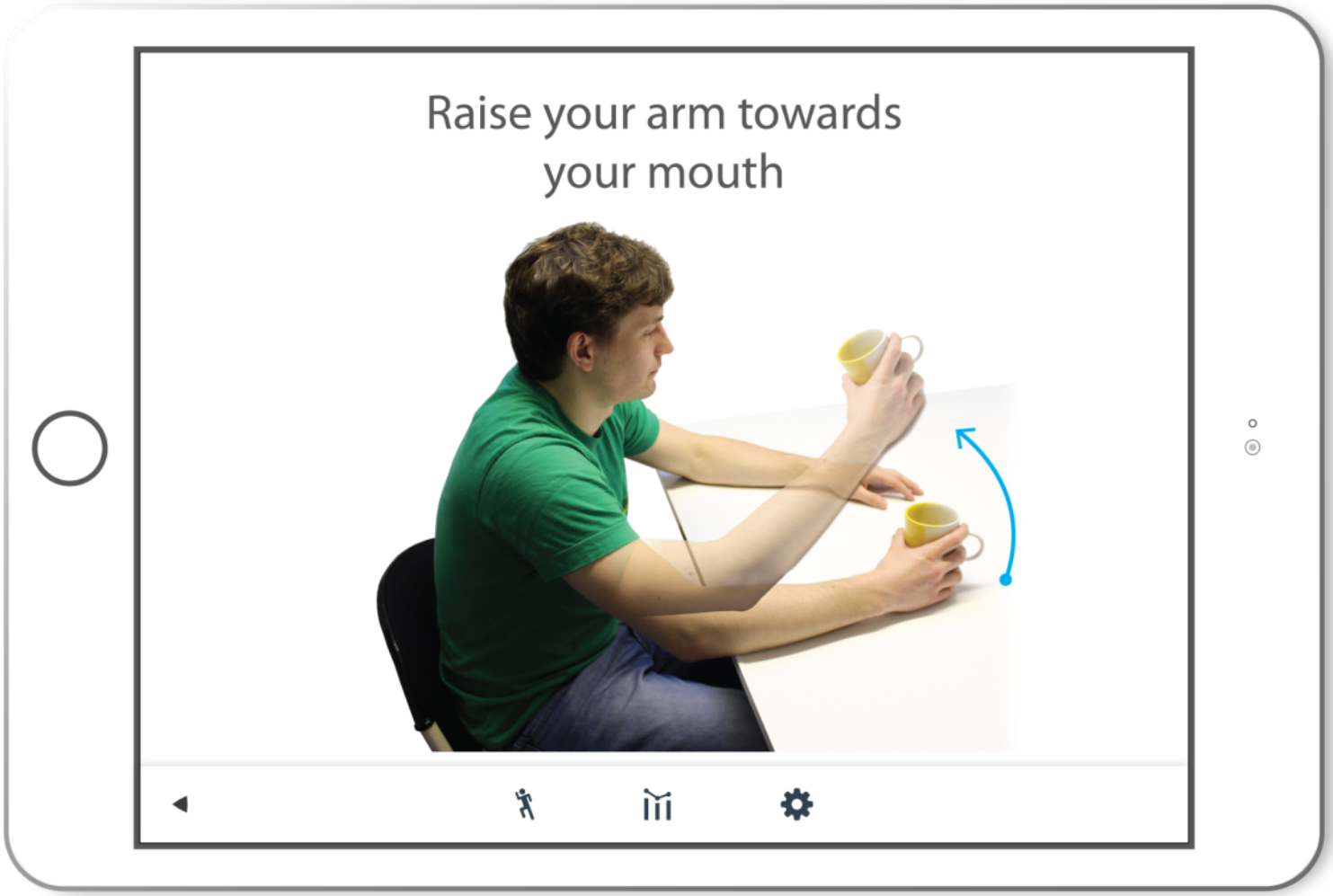

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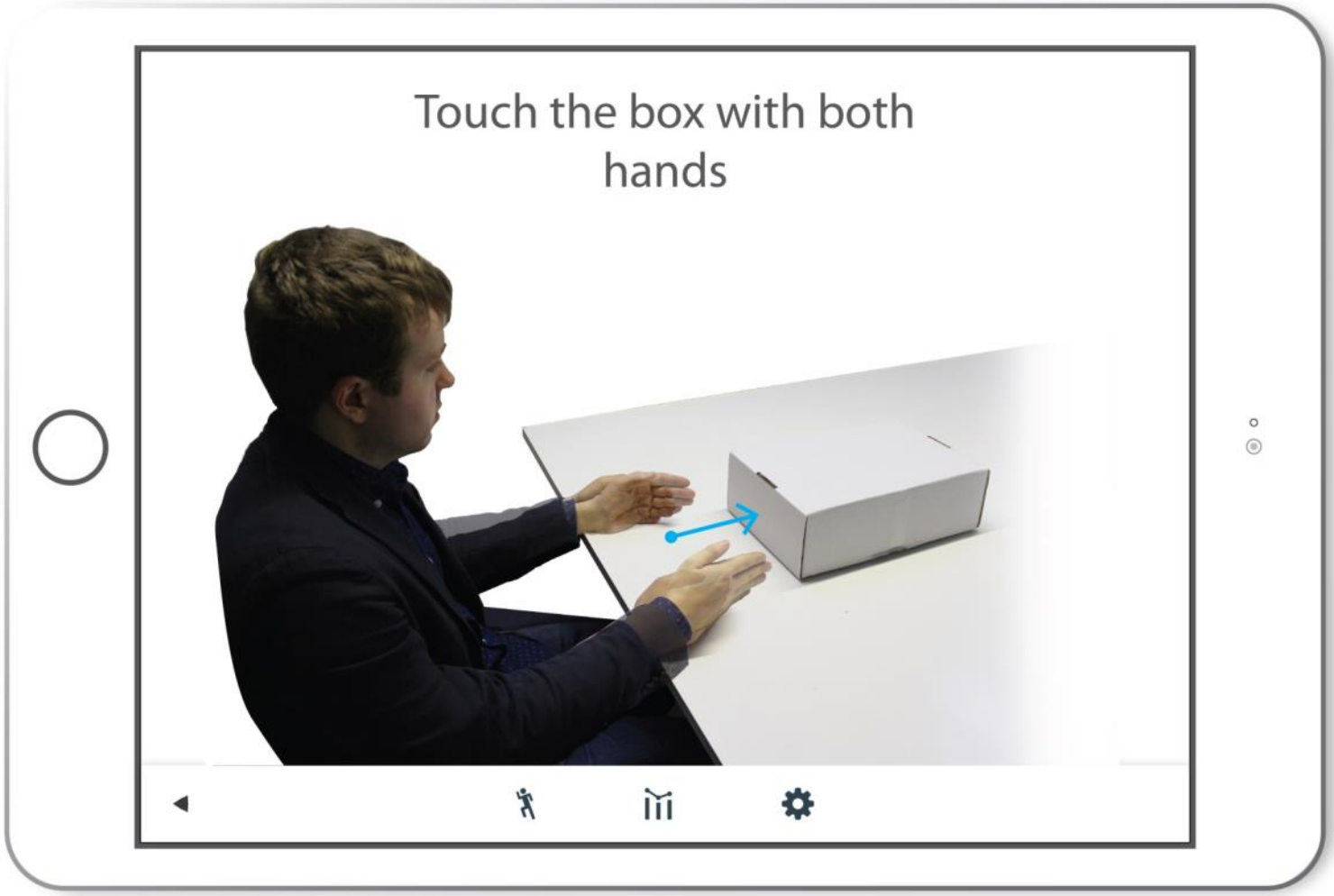

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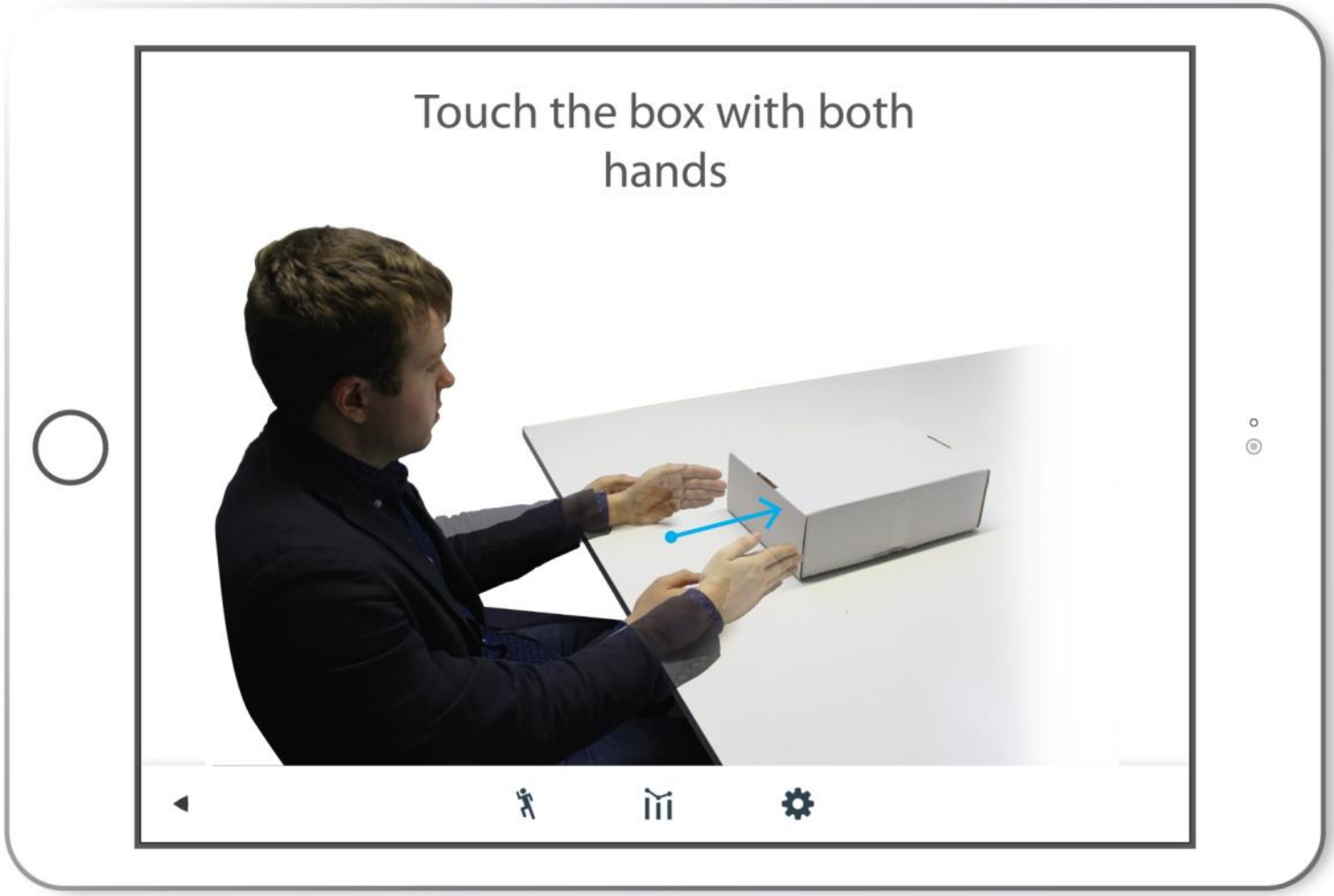

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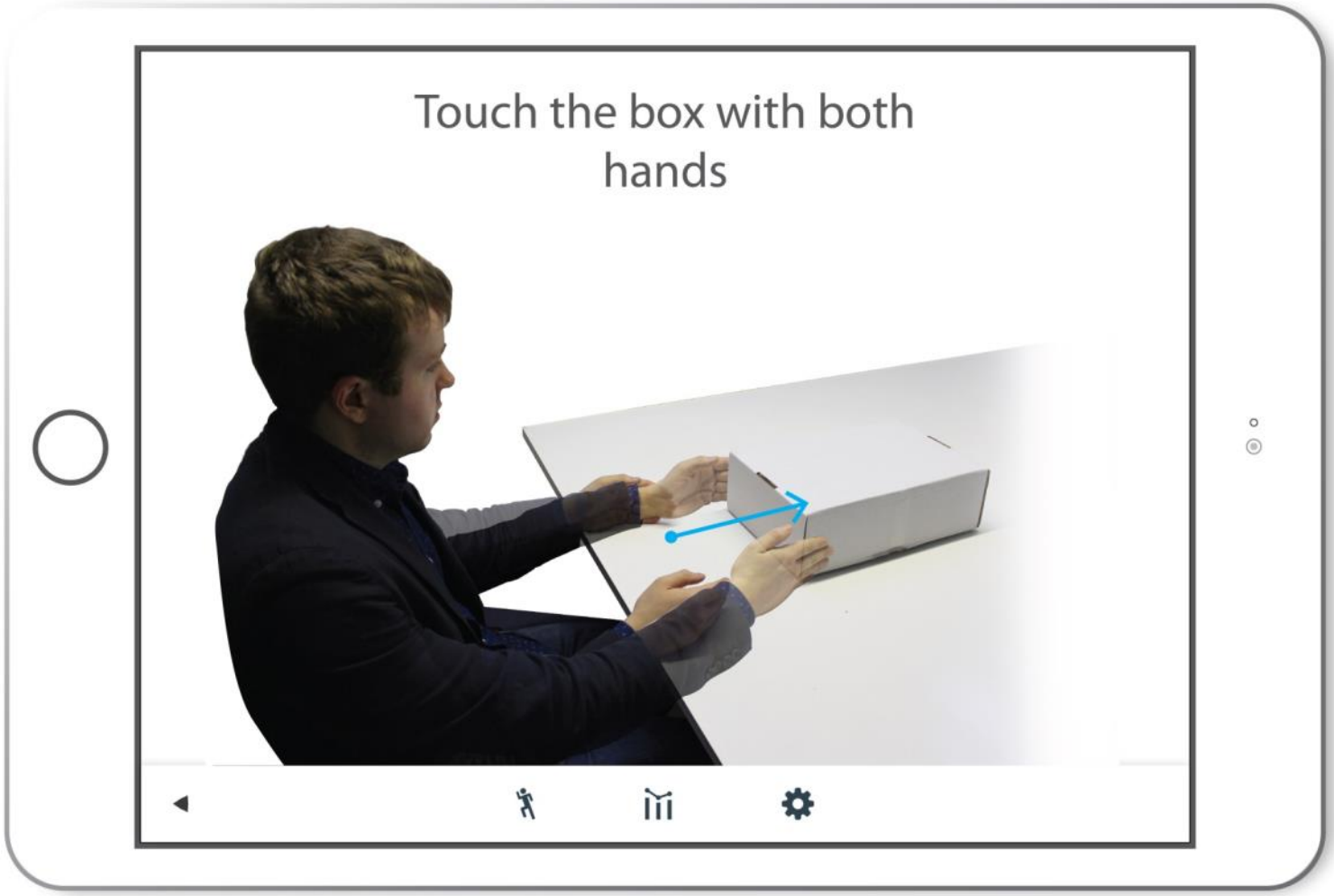
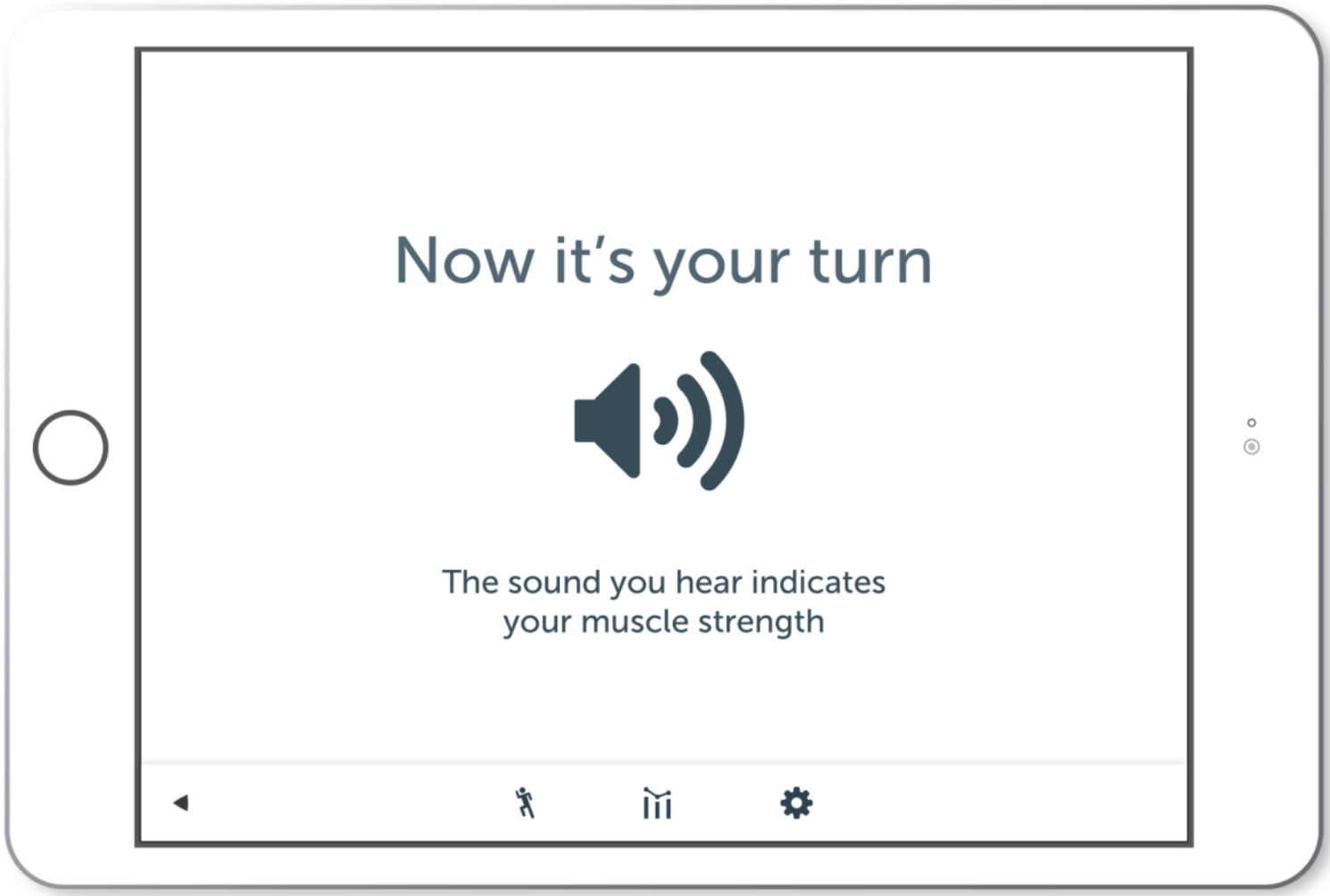


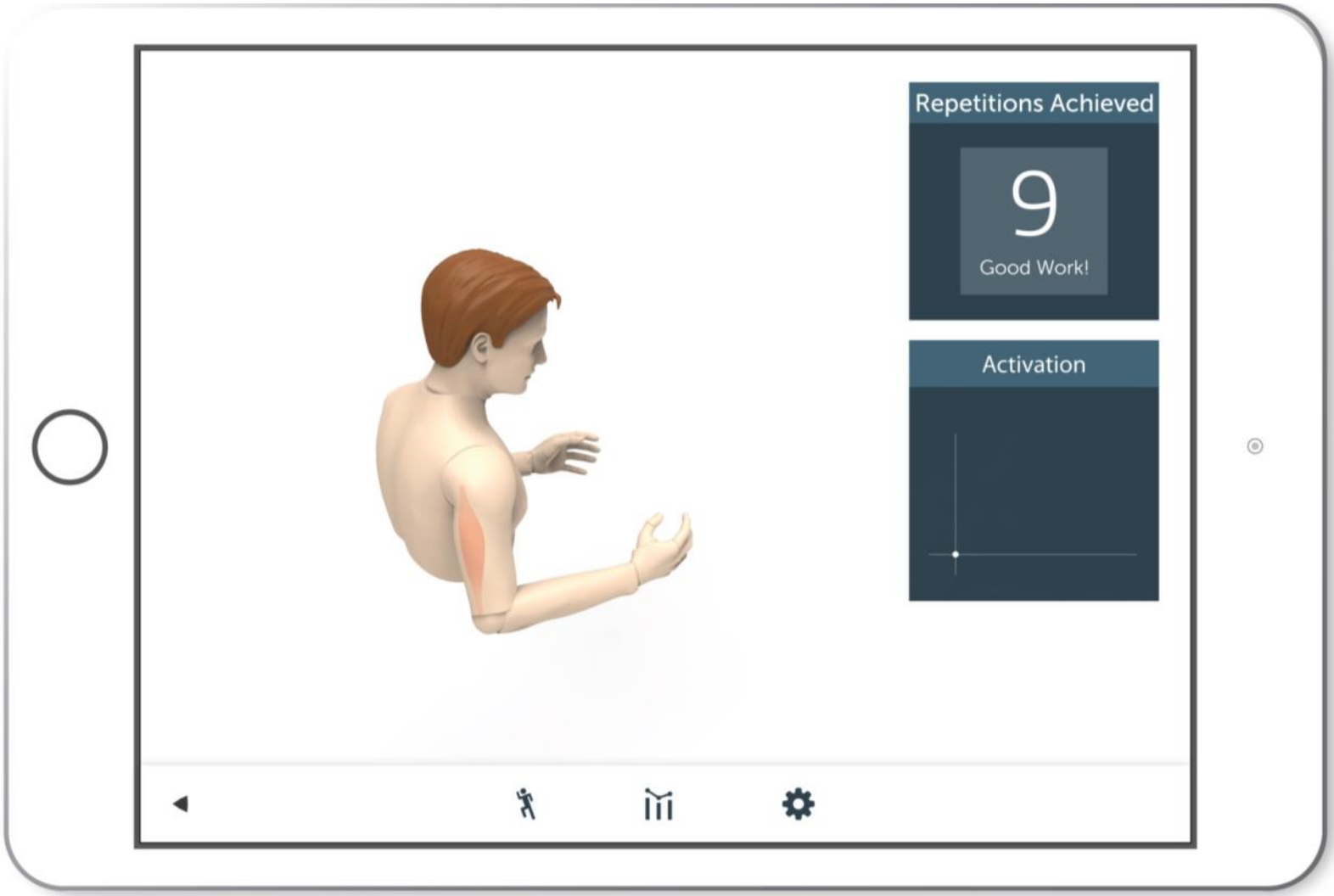
Direction to begin exercising – Real time



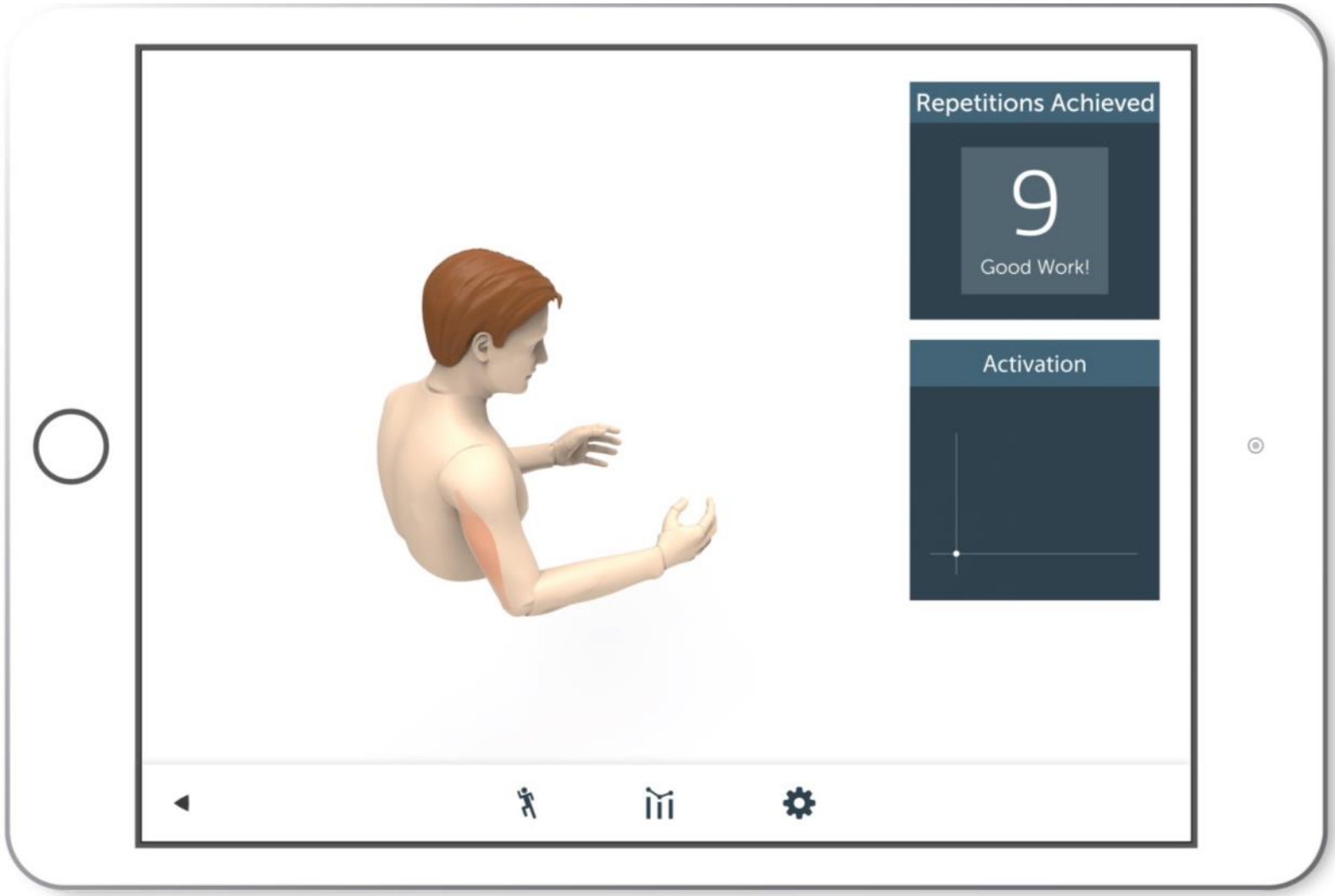
The patient can review feedback after each exercise and at the end of the session

Example of patient feedback: Range of movement, repetitions, exercise accuracy and smoothness

Muscle timing



Muscle timing



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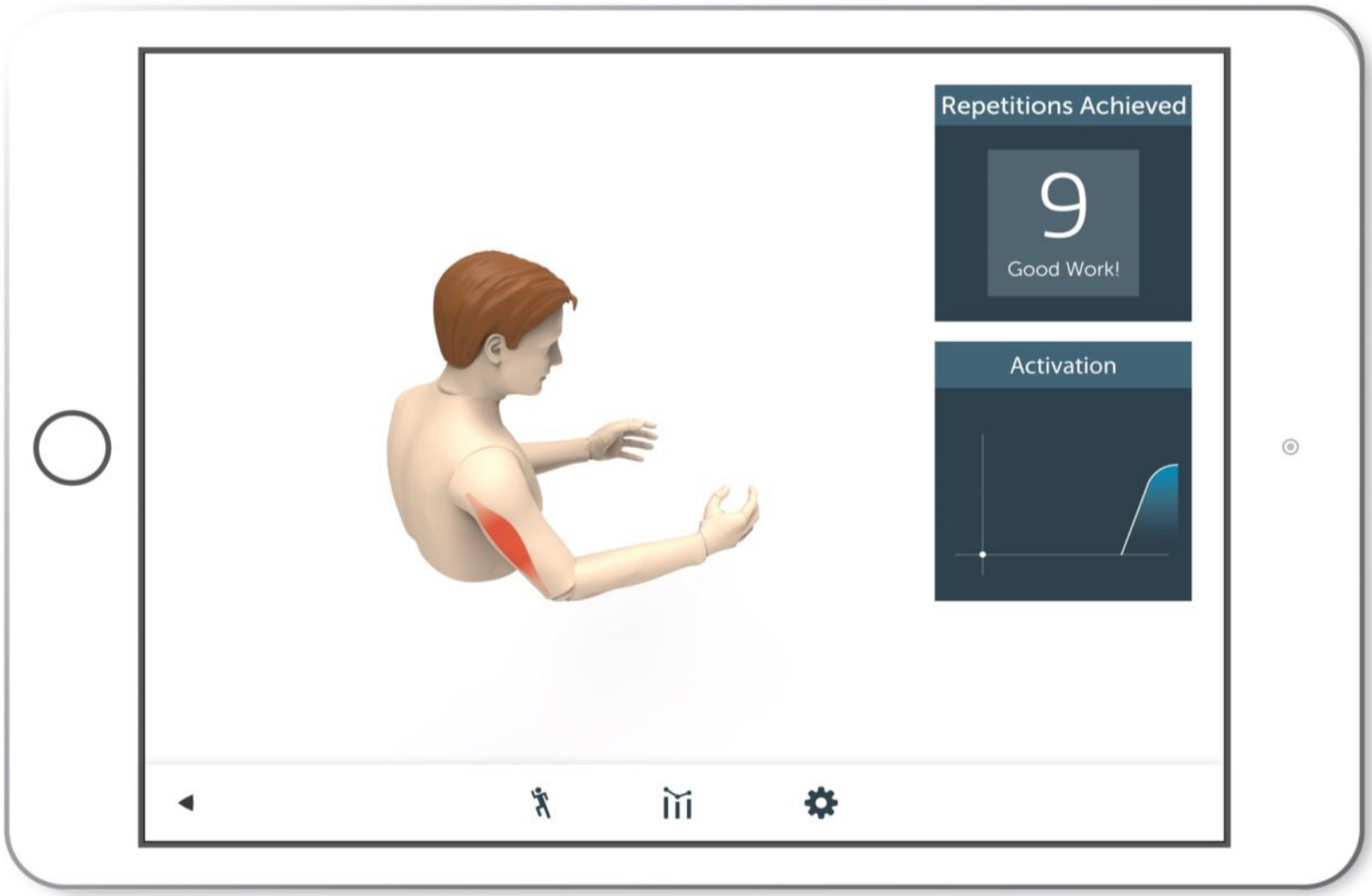

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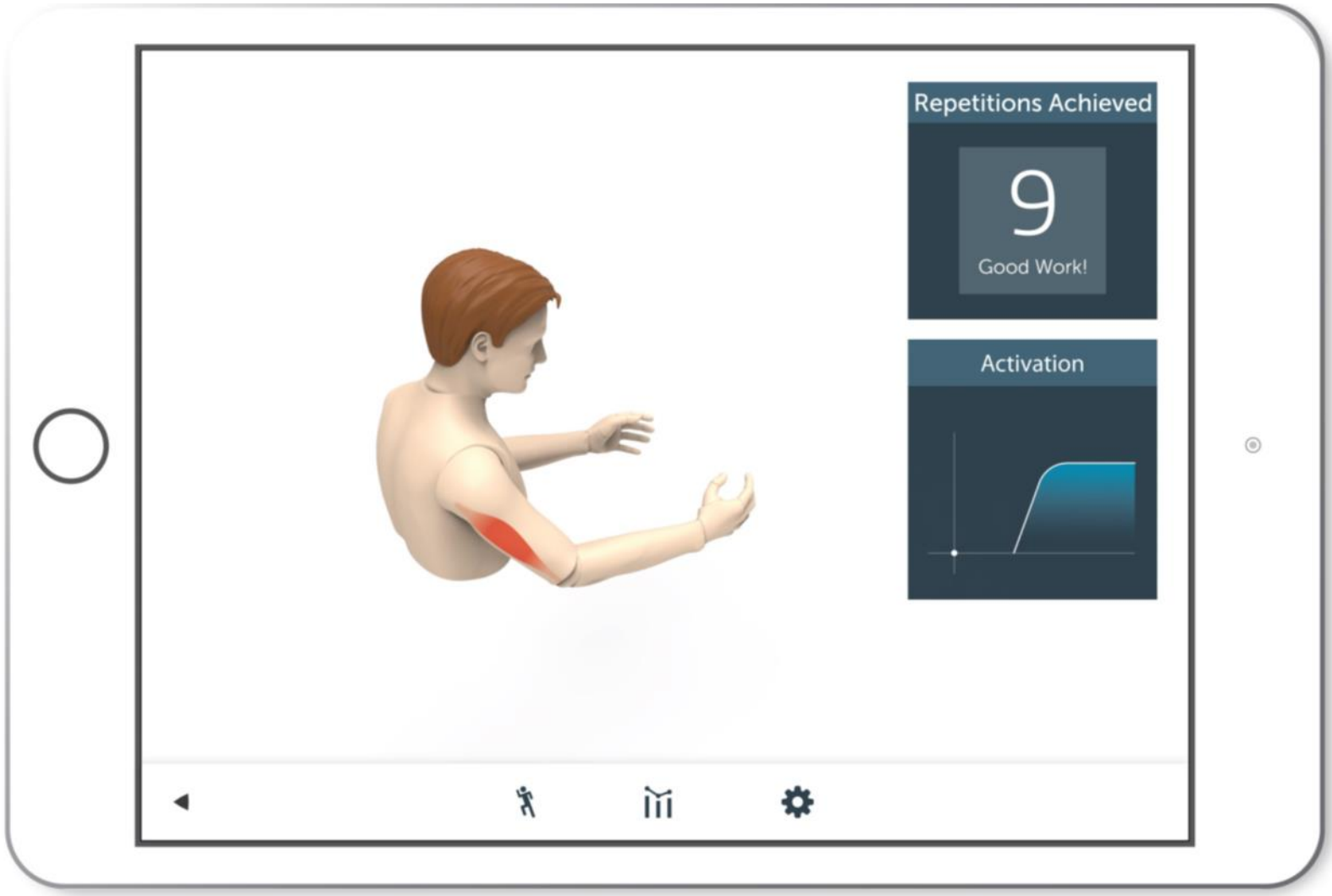

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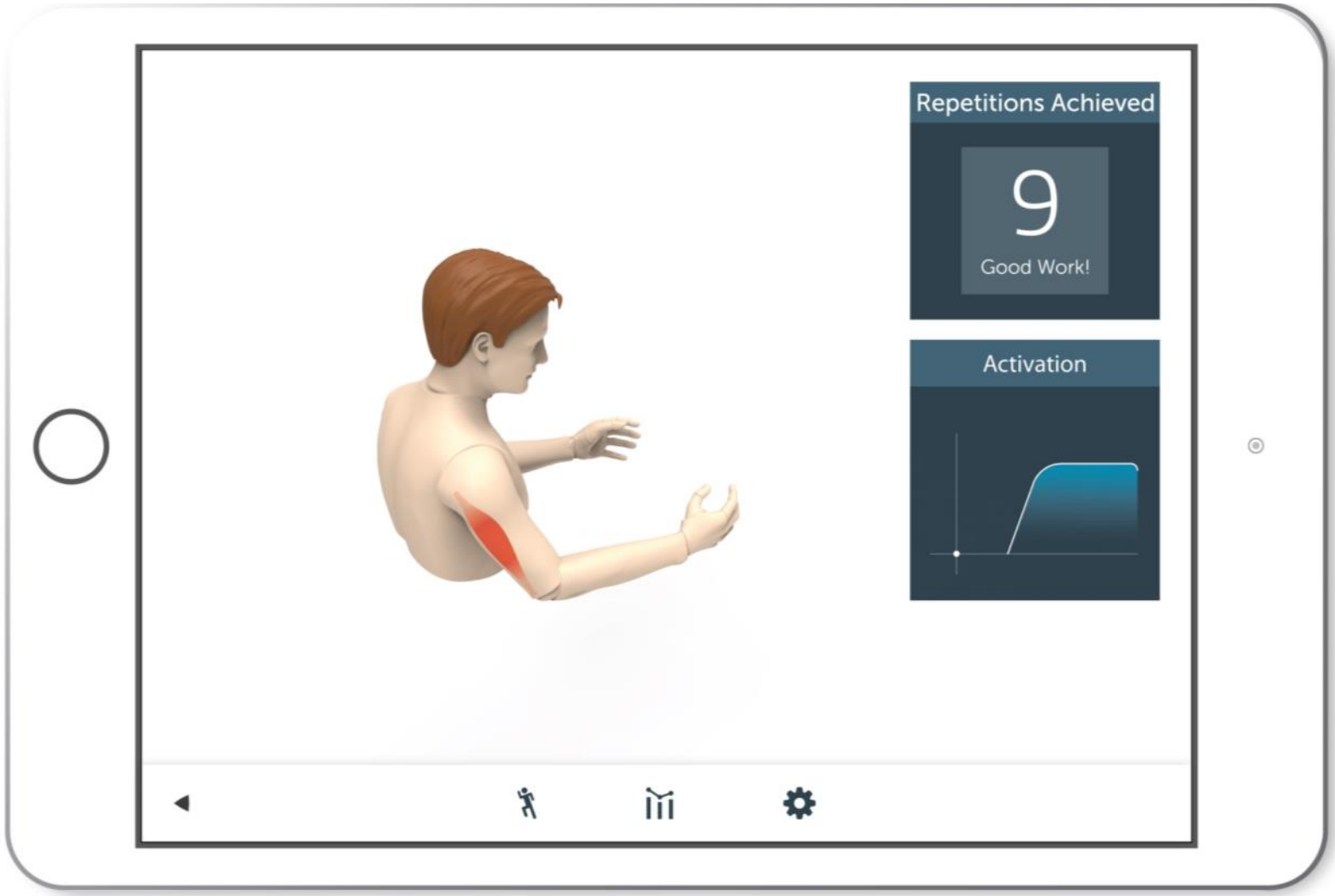

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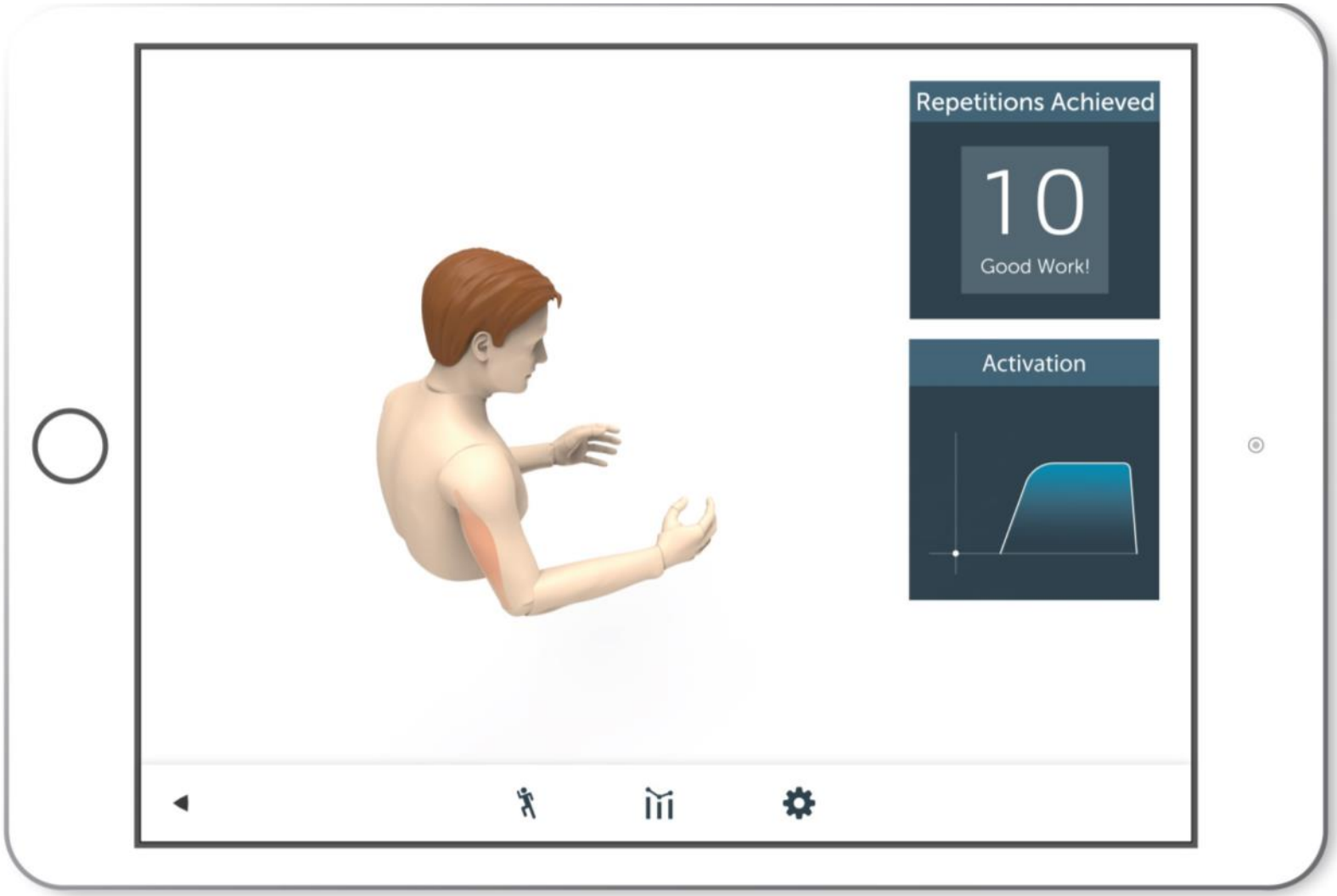

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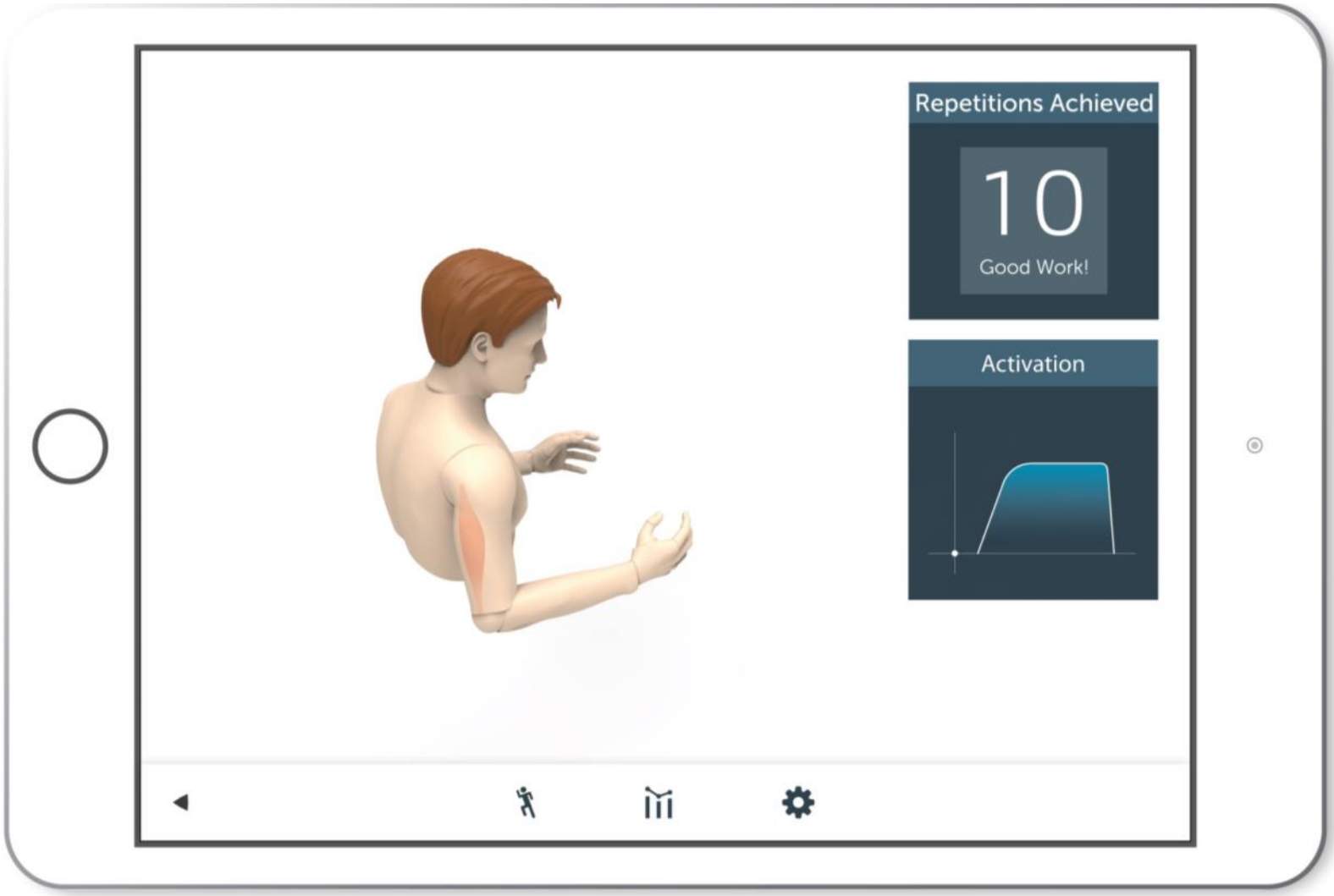
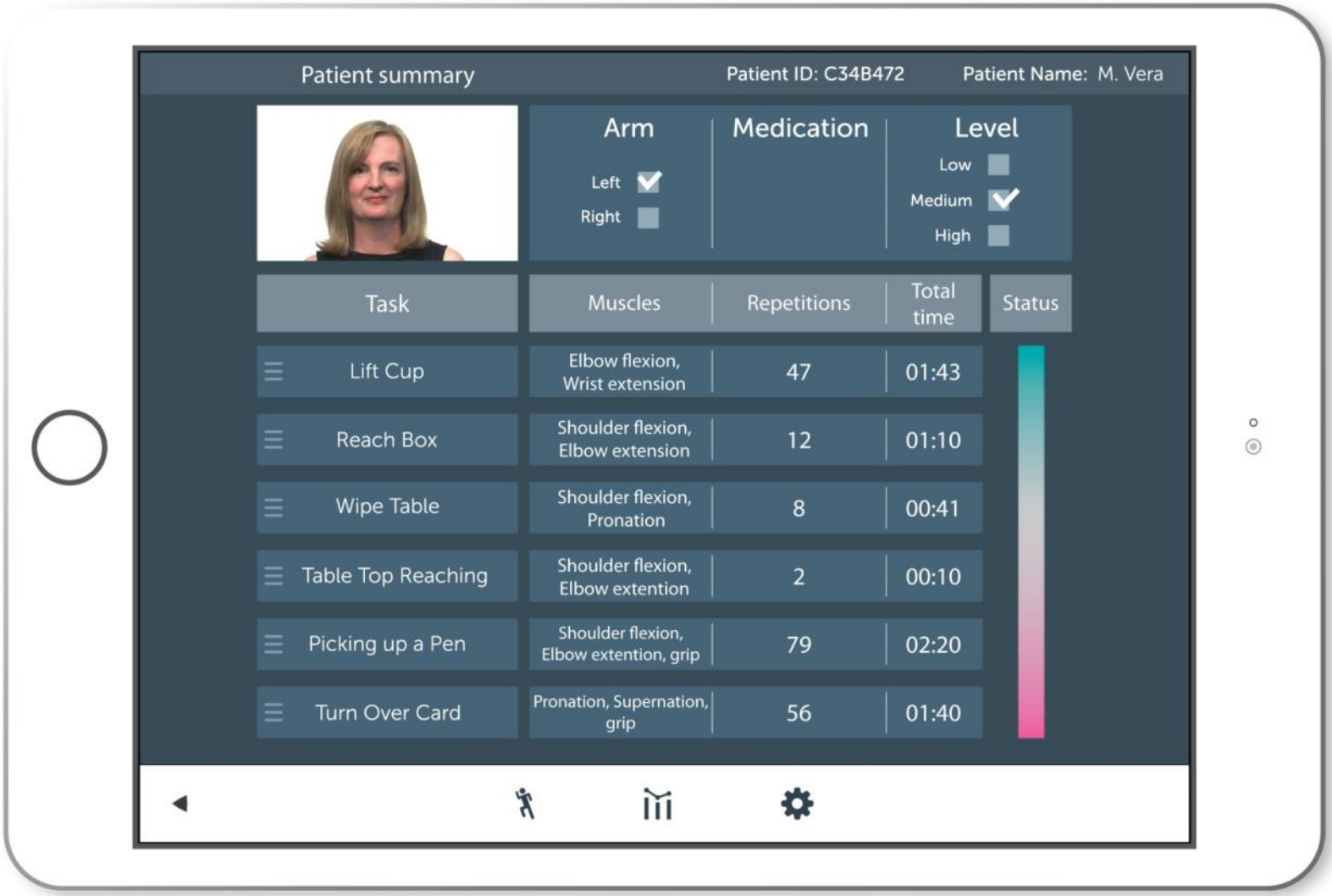


Therapist’s feedback

View a patients profile, routine and summary



Summary of Aims

- Develop (CE Mark) home-use low-cost wearable wireless device to be used while practising standardized everyday activities
- Measures quality and quantity of movement - feedback to patients and therapists
- Combines movement - Inertial Measurement Units (IMU) and muscle activity mechanomyography (MMG)
- Signal-processing algorithms to manage artifacts and generate indices to describe quality and quantity of movement
- Software to translate data into visualizations
- User Interfaces (UI) to present data/images to clinicians & patients
- Conduct a feasibility study with 10 patients in their own home

Acknowledgements

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Thank you

Questions?