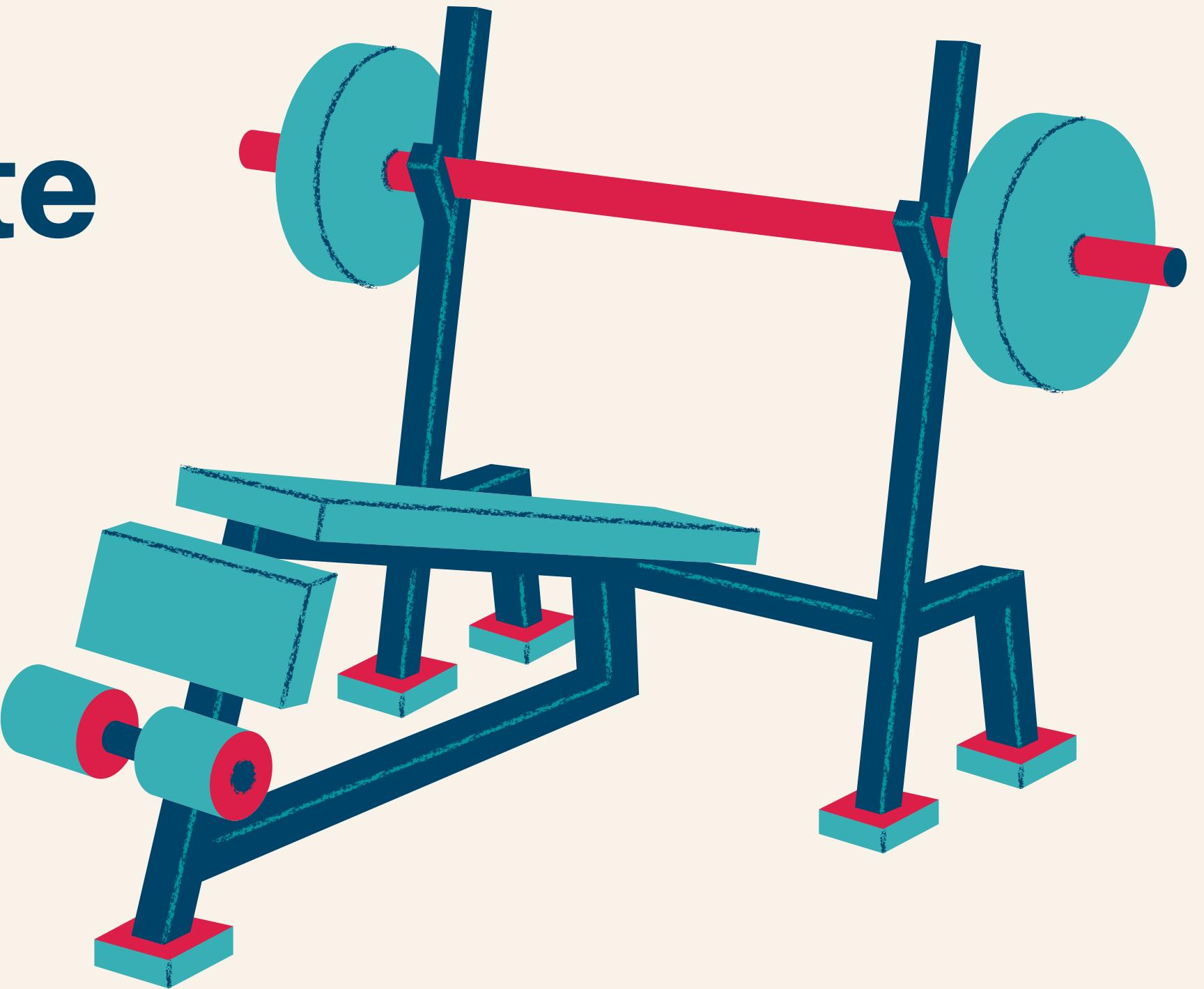
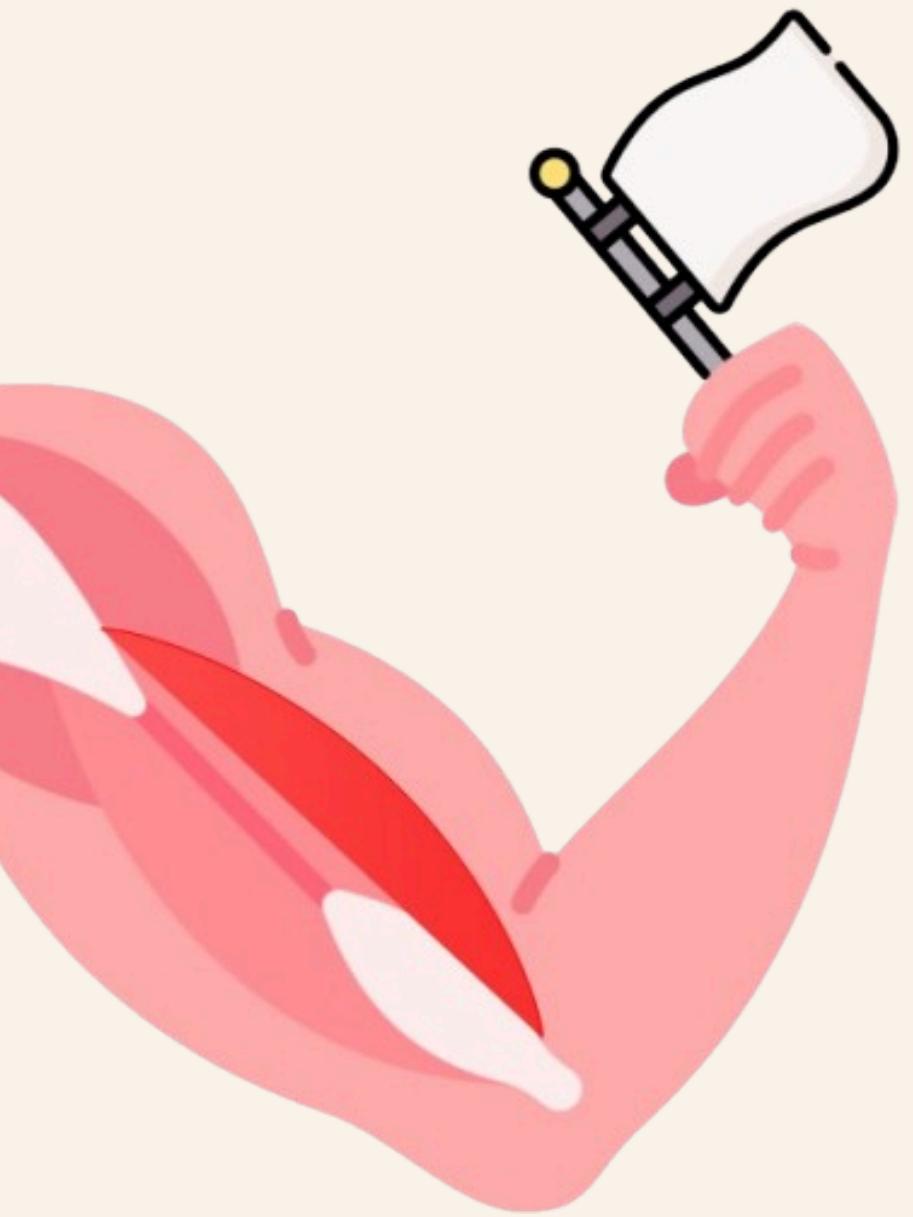
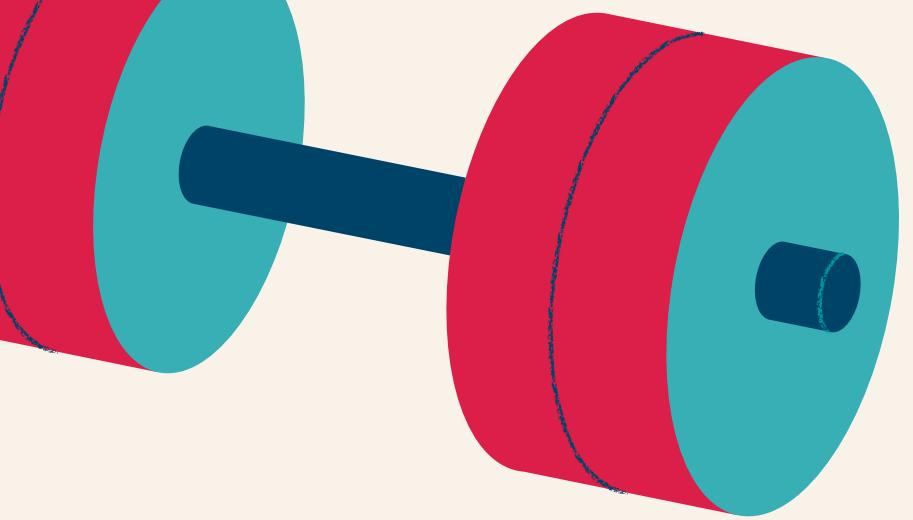


BIOMECHANICS PROJECT

Muscle's White Flag

Team 8





**When do you think the
muscle waves the white
flag?**

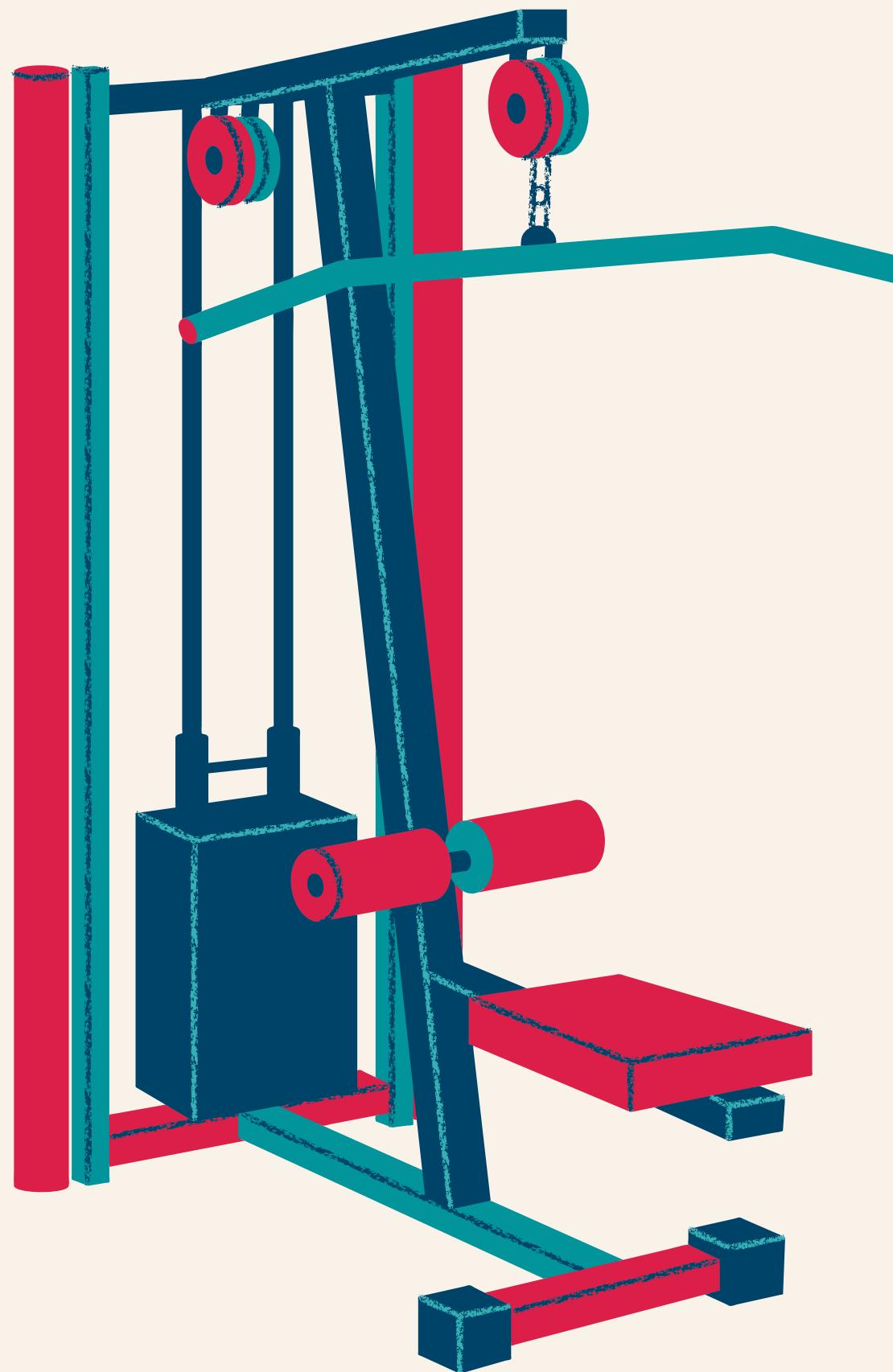


Table of contents

1. Introduction

.....

2. Our Approach

.....

3. Results & Findings

.....

4. APP development

.....

5. Conclusion

Introduction

Right now, there's no good way to know exactly when your muscles are too tired to keep lifting weights safely. People just guess based on:

1. How tired they feel (but feelings can lie)
2. Counting how many times they lift (but everyone's different)
3. Expensive machines (that normal gyms don't have)

Out of 317 participants, 85(27%) experienced gym-related injuries, with the shoulder being the most affected area in 35% of cases (according to the research of African journal).

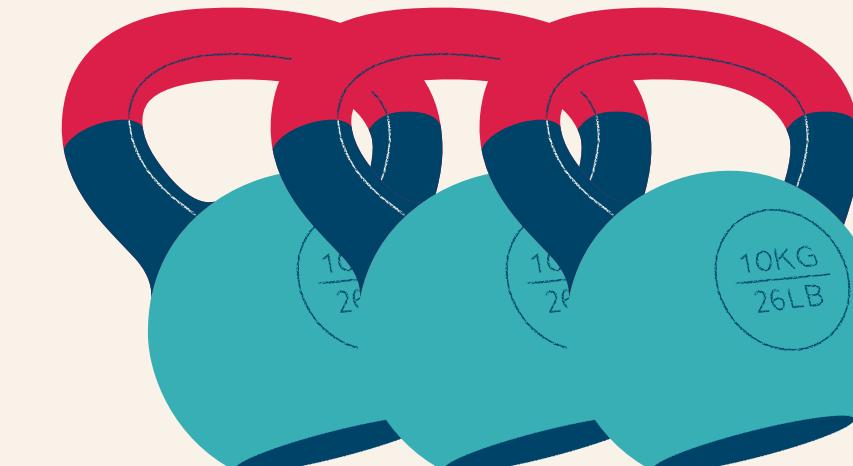
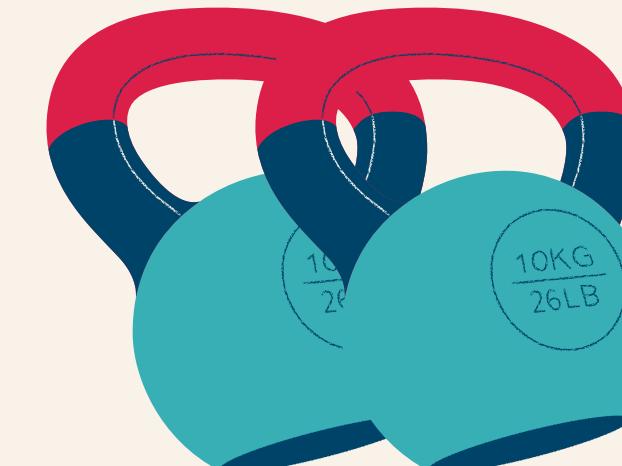


Why It's Bad:

- Stop too early → don't get stronger
- Push too far → get hurt
- Most gym injuries happen when people push past their limit

What's Missing:

A simple, accurate way to know when muscles are truly done - like a "**smart rep counter**" for your muscles that anyone can use.



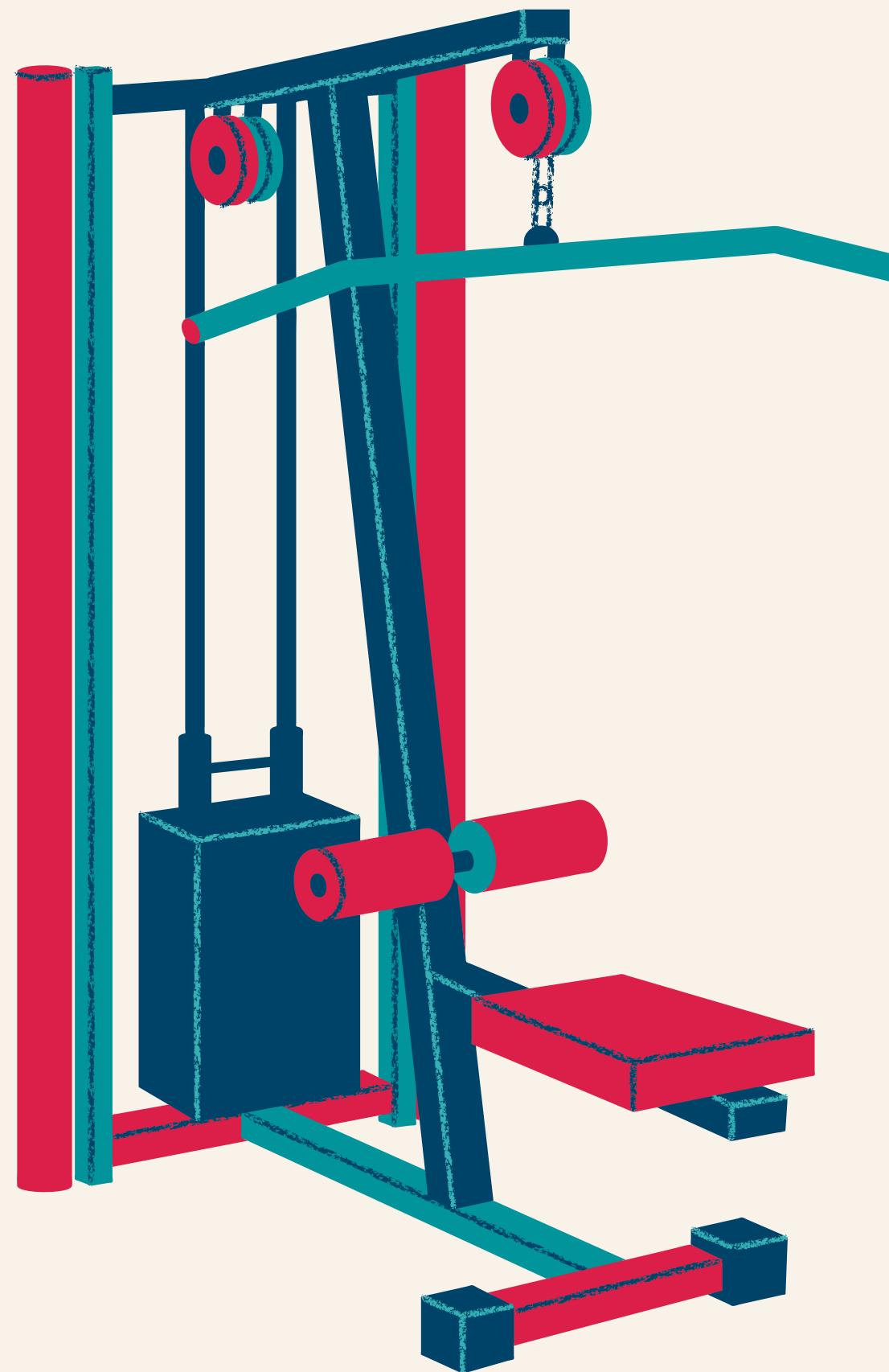


Table of contents

1. Introduction

2. Our Approach

3. Results & Findings

4. App development

5. Conclusion



OUR APPROACH

01

Brainstorming
phase

02

Data collection
phase

03

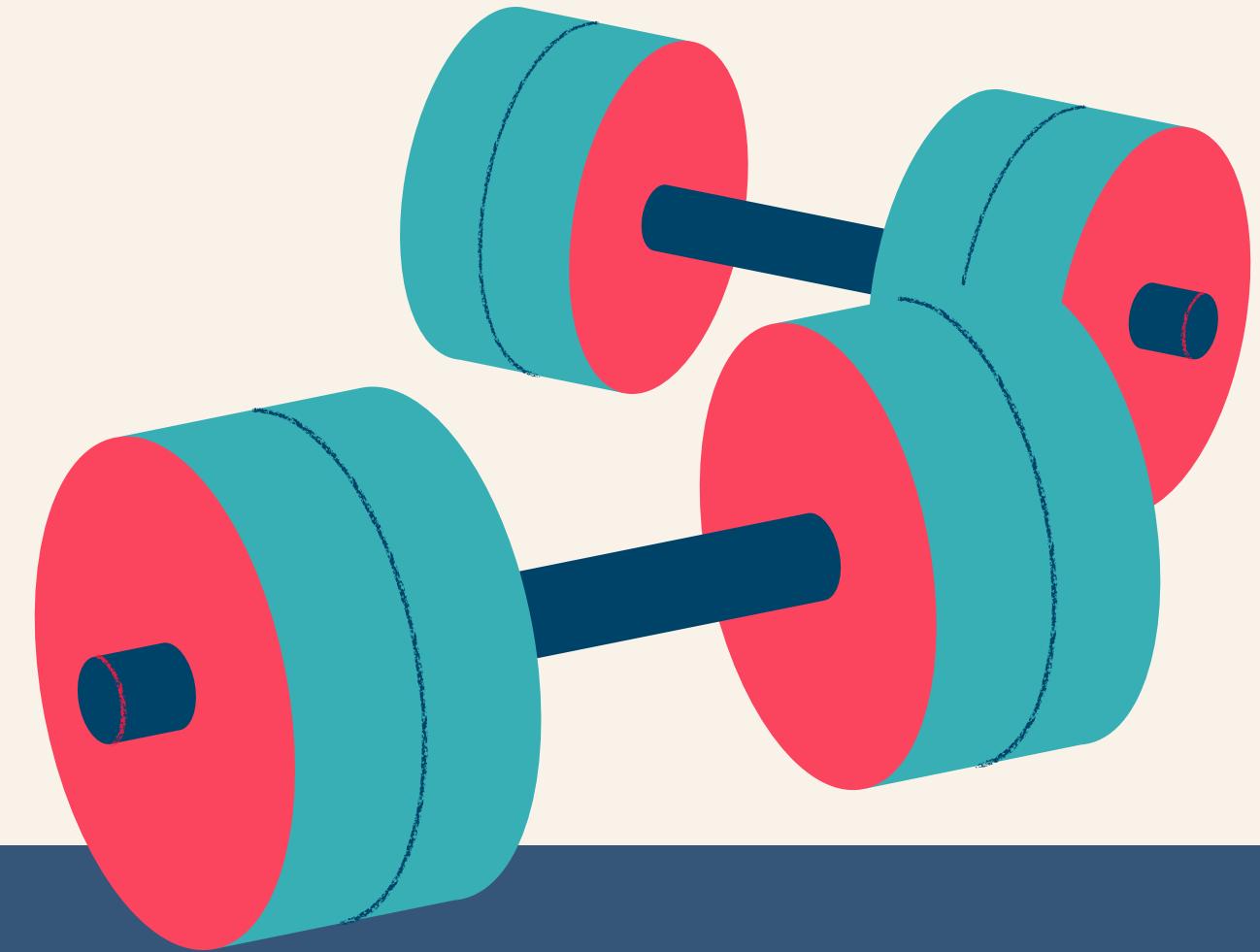
Data processing
phase

04

Motion Analysis
phase

1. Brainstorming phase

- After reviewing biomechanics studies, we learned that movement speed drops predictably when muscles fatigue.
- This led us to test if we could detect failure by tracking acceleration changes in basic exercises.



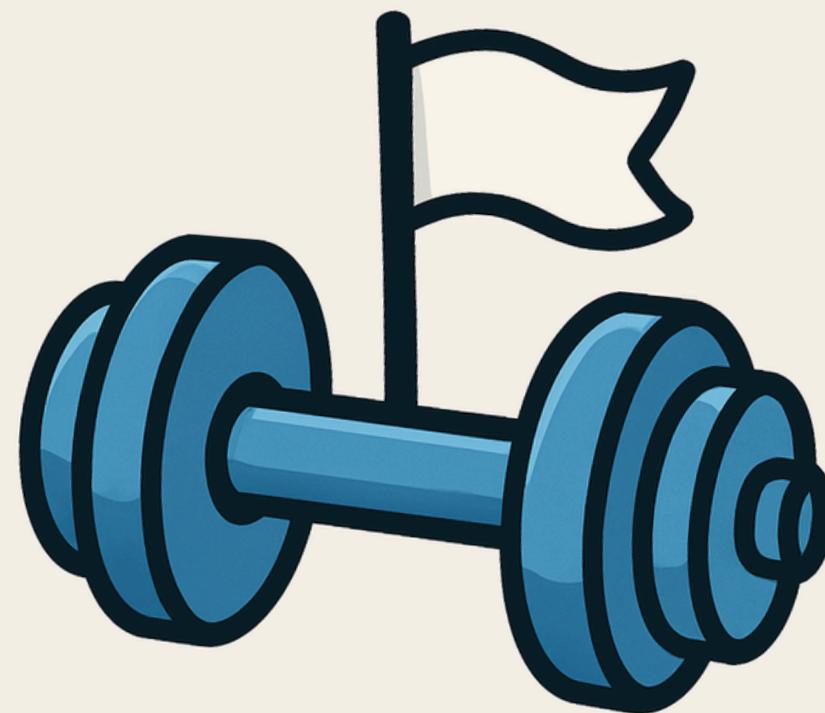
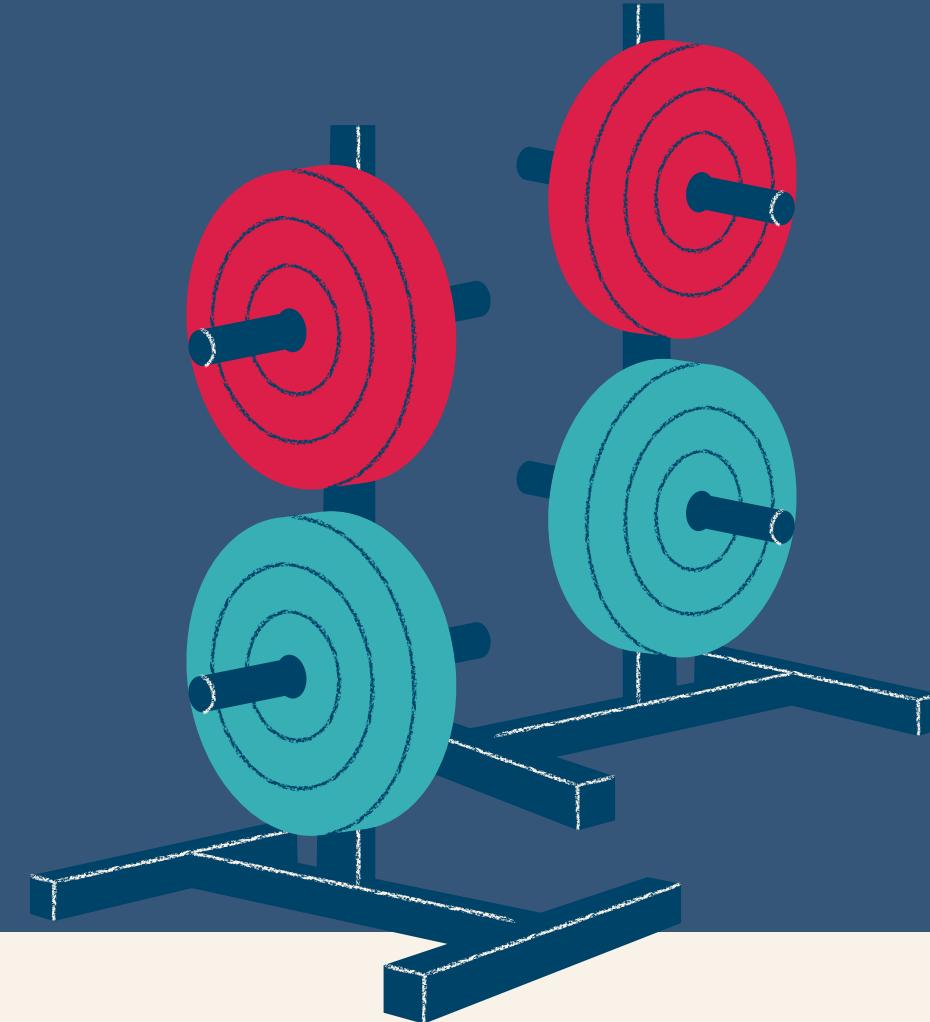
A screenshot from one of the filmed videos, showing the angle and the sticker

2. Data collection phase

- We filmed 13 participants performing bodyweight exercises (bicep curls, leg pushups, back pulls) until failure under controlled conditions.
- Using stickers placed on the joints & Multiple angles captured every speed change clearly, **as shown in the photo.**

3. Data Processing phase

- We organized all footage into a structured database, removing unwanted clips of talking with the participants, pre-workout and others.
- The filtered videos were added to Kinovea by calibrating scales and stabilizing frames for accurate tracking.



4. Motion Analysis phase

- We analyzed all footage in Kinovea, measuring speed, acceleration & timespans changes during each exercise.
- Identified consistent patterns in motion decay across all participants as fatigue set in.

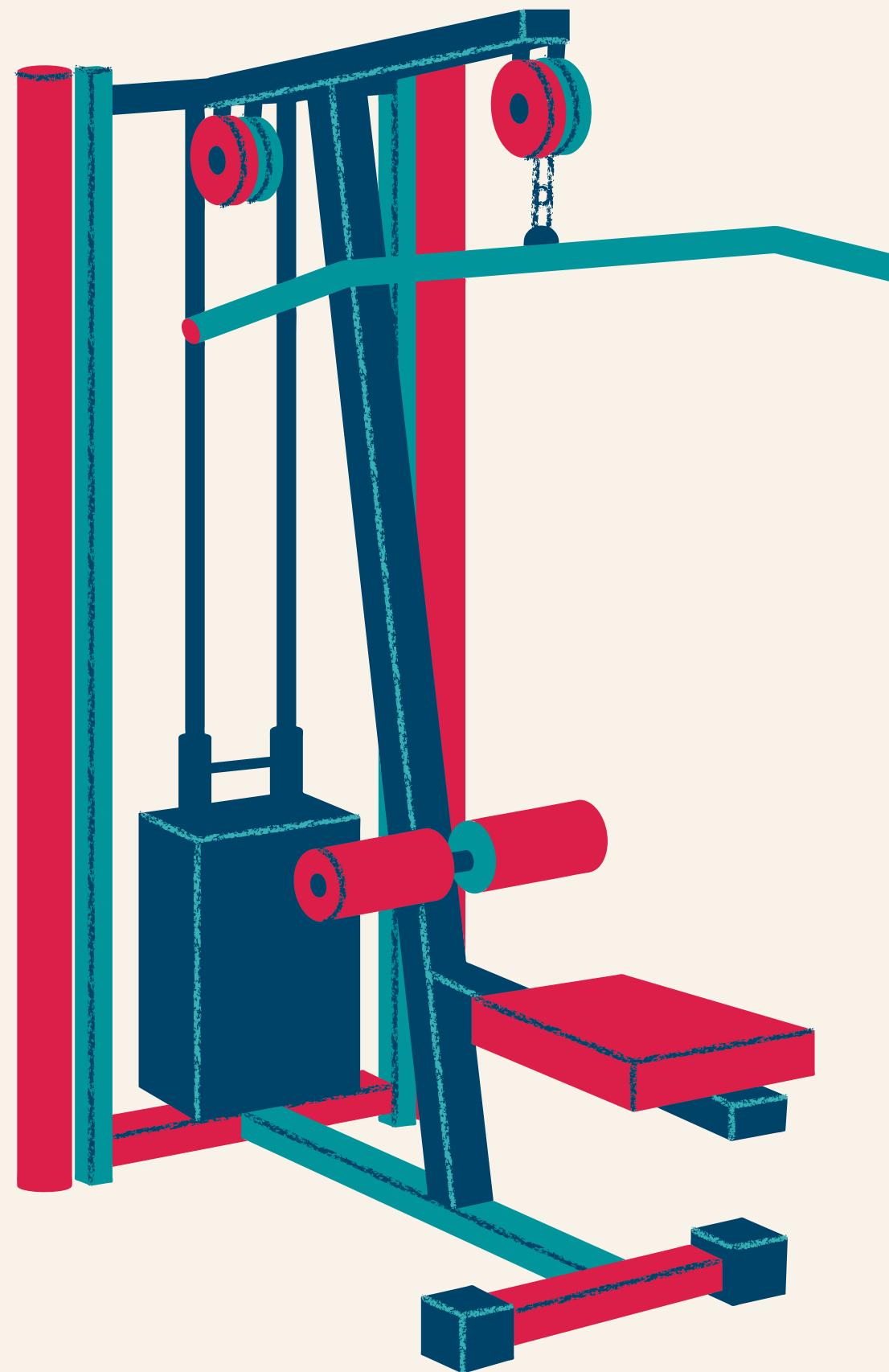


Table of contents

1. Introduction

2. Our Approach

3. Results & Findings

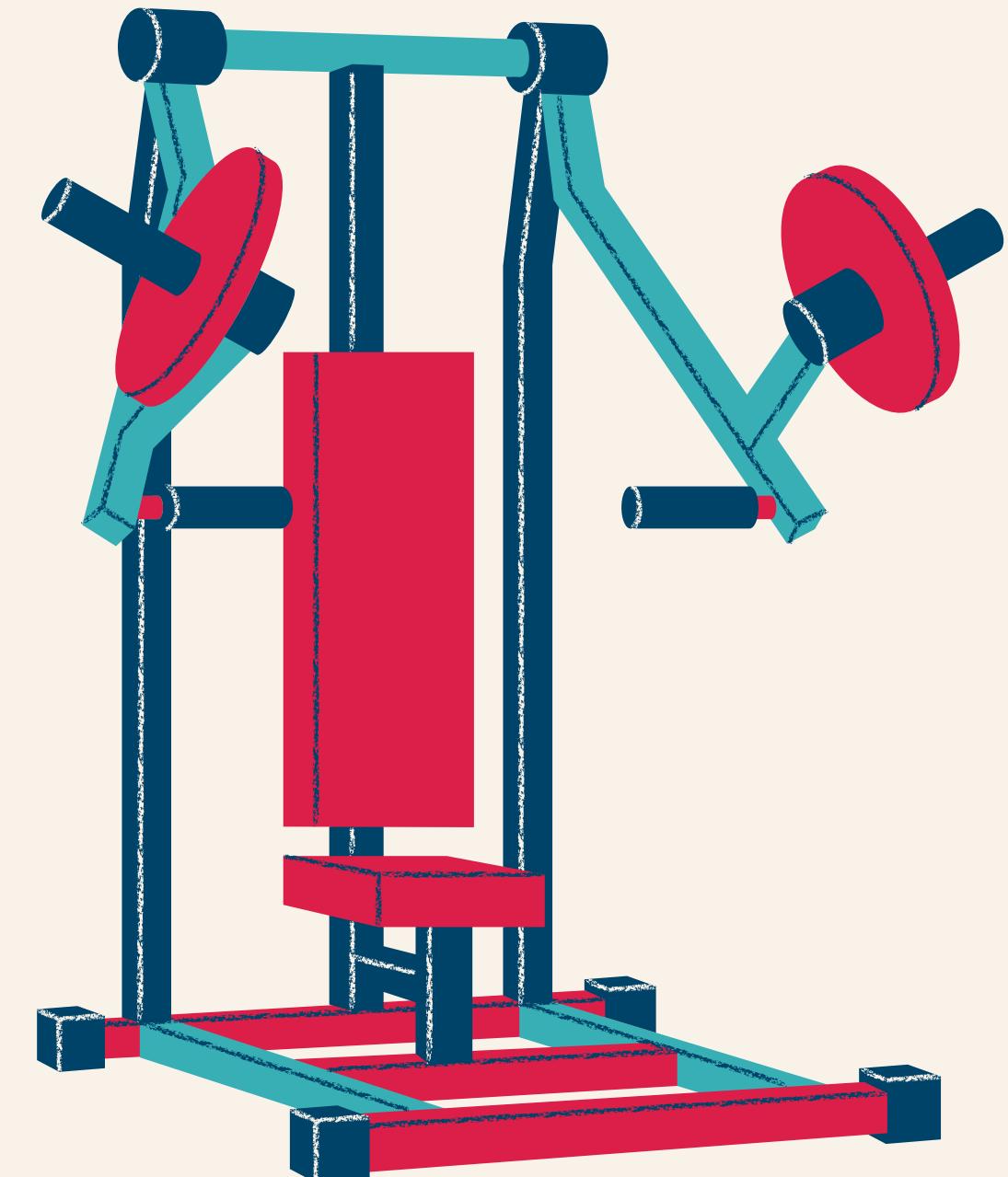
4. APP development

5. Conclusion

Results & findings

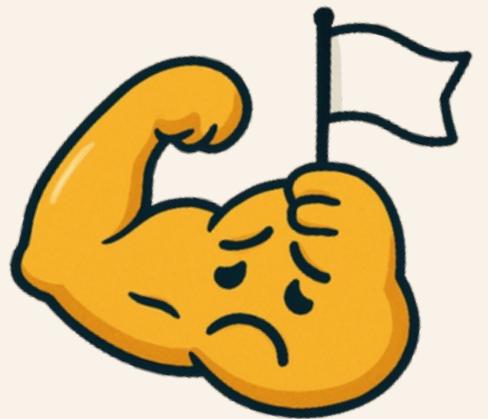
1. Expected Results

- **A clear slowing pattern (deceleration) as the muscle fatigues:** Participants truly training to failure should show a progressive decrease in acceleration in the direction opposite to gravity.
- **Consistency in normalized performance decline across individuals:** By using normalized velocity and acceleration, you expected to see a relative drop (percentage-wise) in performance, regardless of each person's actual strength.
- **Only genuinely fatigued participants would fail to continue, even when incentivized.**
- **Visual and measurable signs of fatigue:** Slower movement, visible struggle, and declining output over time were expected in participants giving maximal effort.

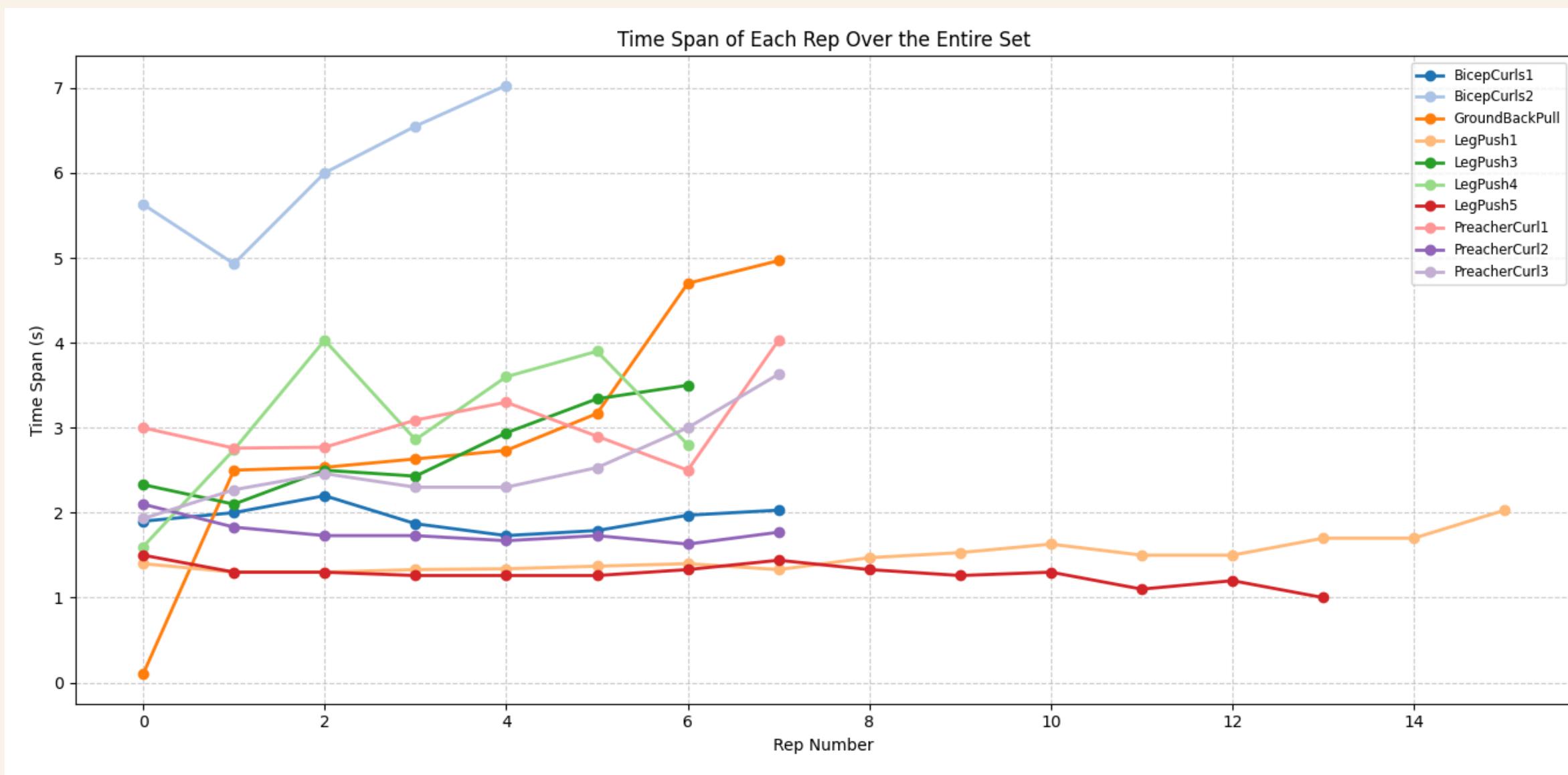


2. Actual Results

While filming the videos, we discovered that:



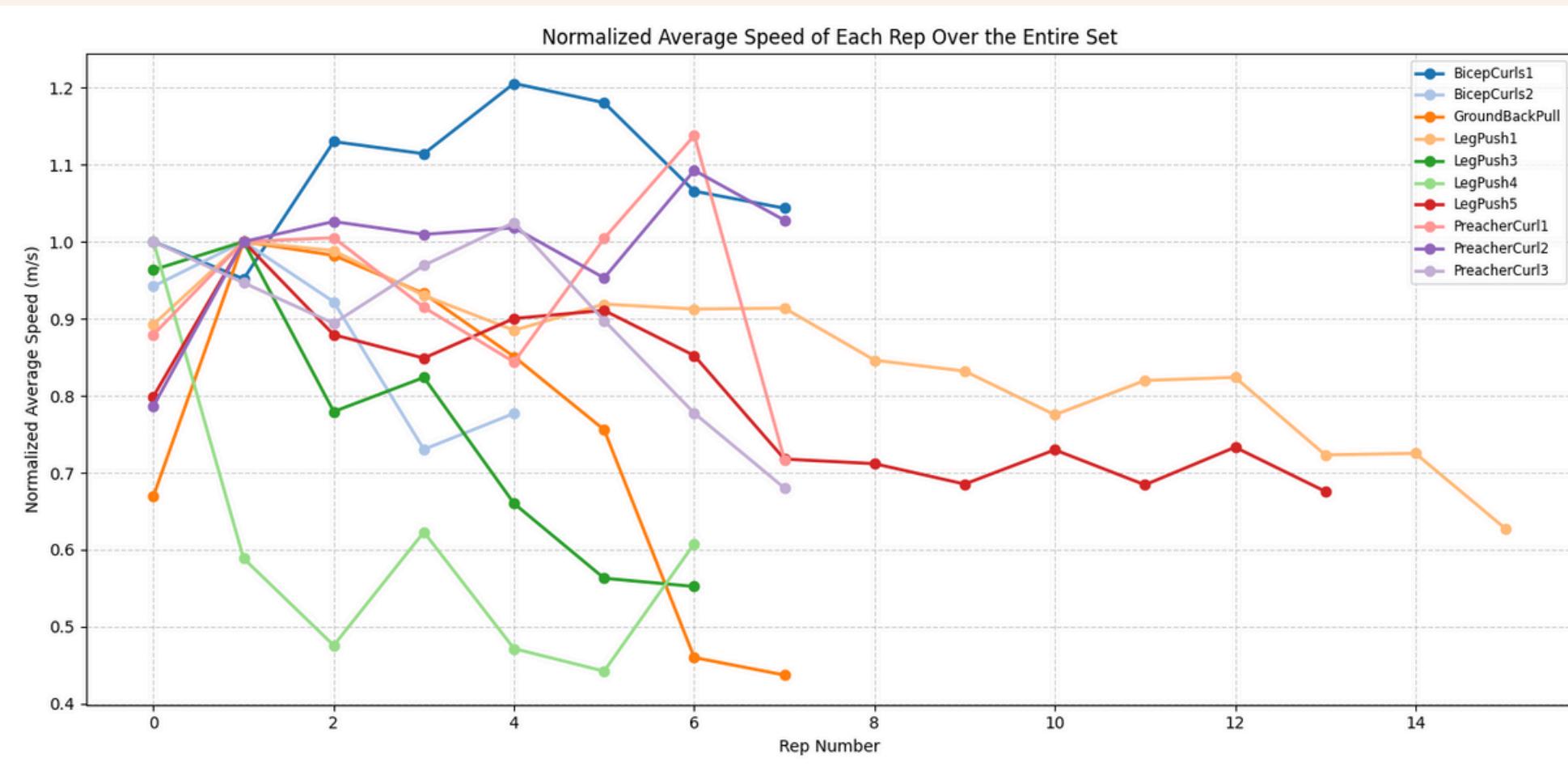
- 80% of participants who claimed they had reached failure were able to continue and perform more reps after being offered money.
- Only 20% truly reached failure and could not continue, even after accepting the £20 incentive.



A graph showing the time span of each rep over the entire set for each exercise

About the graph

- Participants who truly reached failure show a clear **increase in rep time**, reflecting muscle fatigue and reduced movement speed.
- In contrast, those who stopped early or weren't genuinely fatigued maintained a nearly **constant rep duration**, indicating they hadn't pushed to failure.

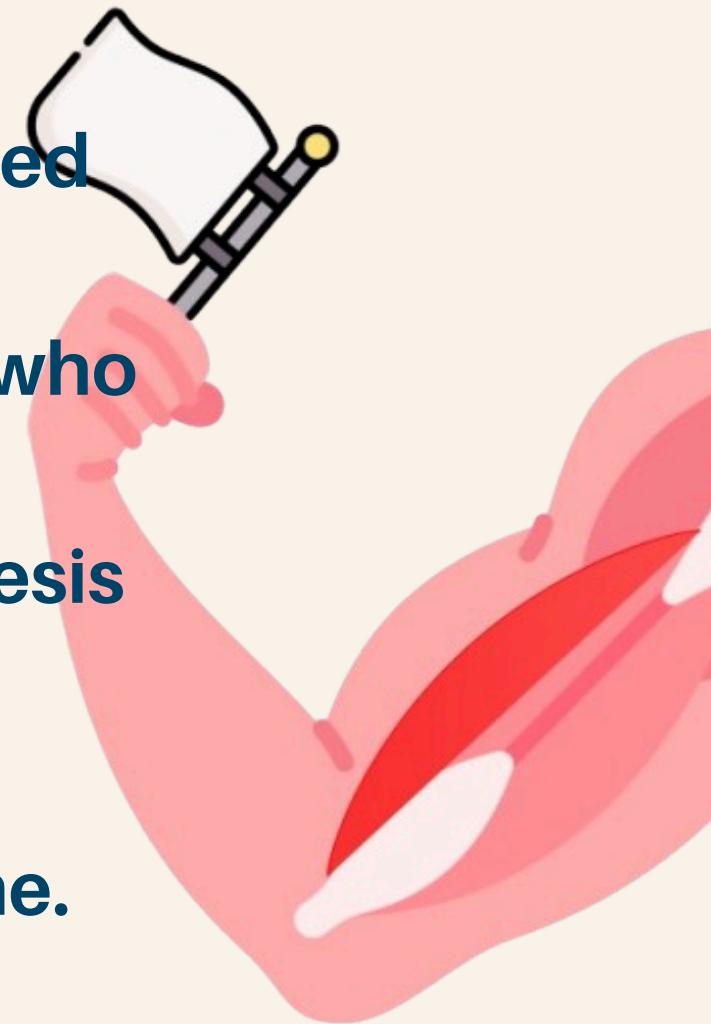


A graph showing the normalized speed of each rep over the entire set for each exercise

This graph (Normalized Acceleration vs. Rep Number) also supports our expected results:

- As the muscle approaches true failure, there is a clear and significant decrease in acceleration.
- This pattern confirms that participants were actively resisting the weight, and their muscles were fatiguing over time

- As the set progresses and fatigue builds, the rep speed generally decreases — especially in participants who reached true failure.
- This supports our hypothesis that muscular fatigue is reflected by a drop in movement speed over time.



A graph showing the normalized acceleration of each rep over the entire set for each exercise

Workout Summary Table



Exersice	Maximum Rep Time	Minimum Normalized Speed	Minimum Normalized Acceleration
BicepCurls1	2.03	1.043359128323114	0.7407523275844252
BicepCurls2	7.07	0.7302513485225773	0.647244
GroundBackPull	4.967	0.4373829179772746	0.4163520187005617
LegPush1	2.03	0.6273200224804483	0.4627422991475683
LegPush3	4.06	0.4355624220877656	0.3622399439949318
LegPush4	3.9	0.4423758785348463	0.4373426985565534
LegPush5	1.2	0.5700460094268367	0.6051124405544452
PreacherCurl1	4.03	0.7170443290410022	0.6414704658718048
PreacherCurl2	1.77	0.9627153378871908	0.9900630229549756
PreacherCurl3	3.63	0.6801930478556174	0.4529797877947175



After studying and analyzing the previous table and graphs, We reached the following equations:

Failure speed threshold = 0.664 ± 0.162 % from original speed

Failure acceleration threshold = 0.5756 ± 0.149 % from original acceleration

Interesting findings

- Participants who were already using training machines showed the expected slow-down pattern and reached real failure.
- Recruited participants brought in for filming often used lighter-than-normal weights, treating it like a flex video.
- These participants showed no real signs of fatigue and could continue easily after their supposed "failure."

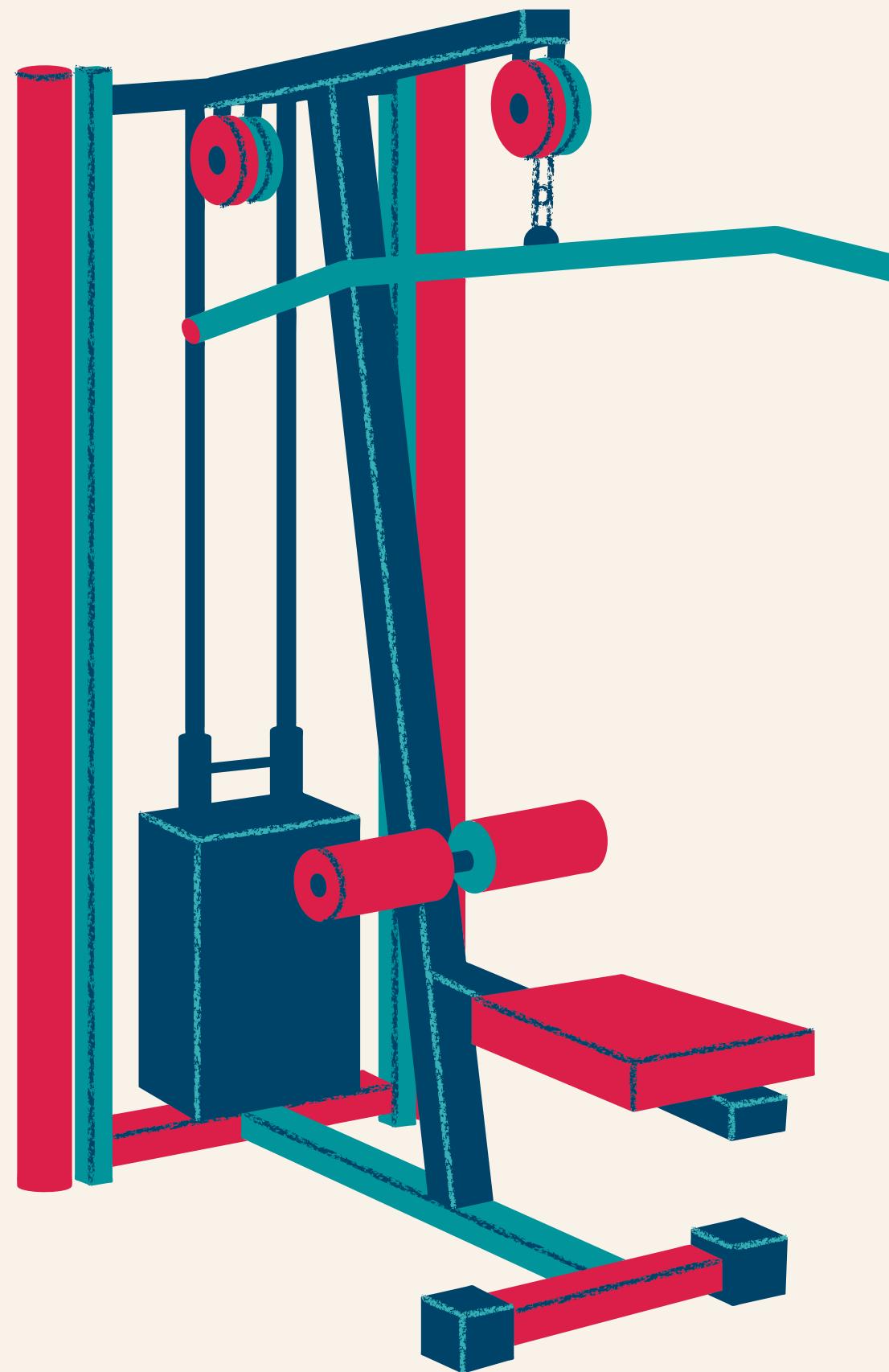


Table of contents

1. Introduction

.....

2. Our Approach

.....

3. Results & Findings

.....

4. APP development

.....

5. Conclusion



APP DEVELOPMENT (IN PROGRESS)

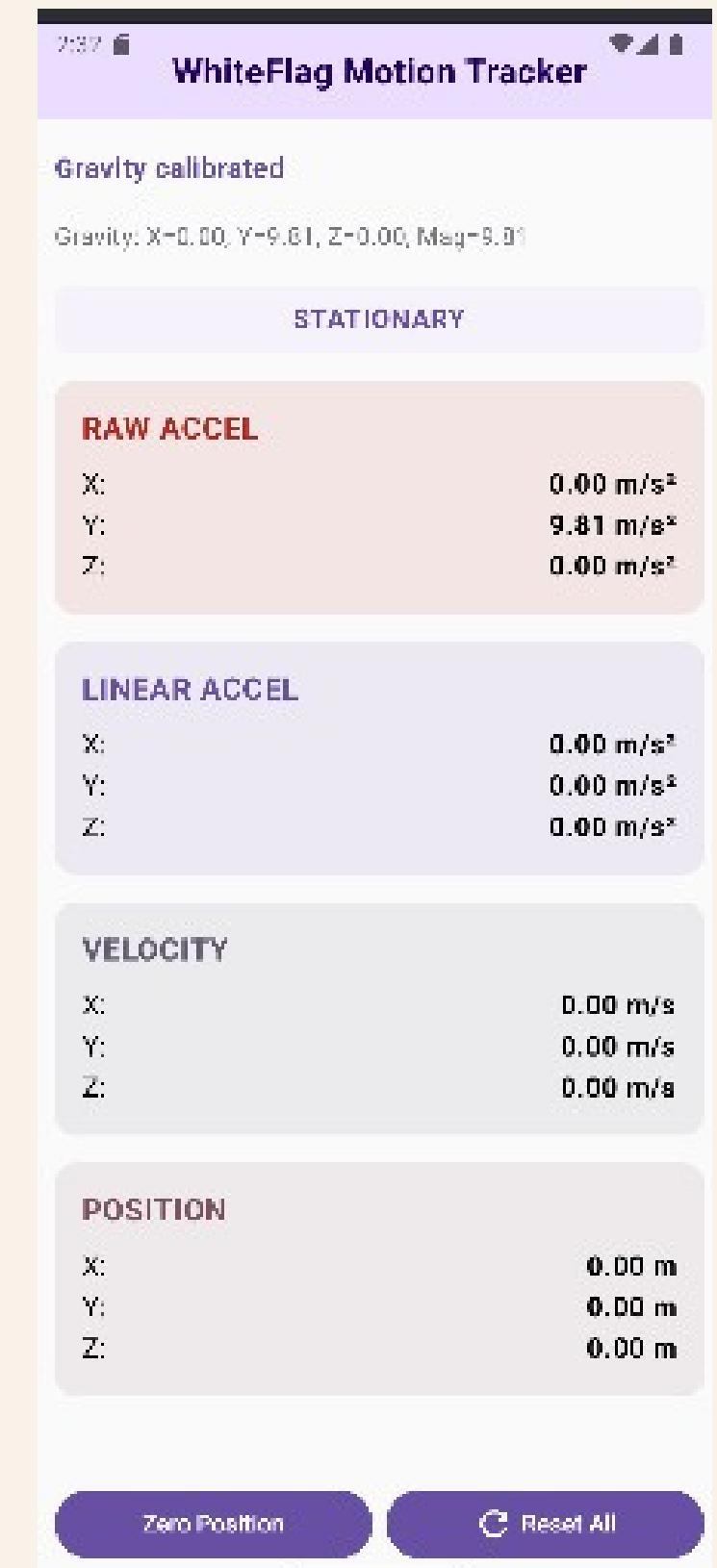
Using the Kinovea results, we designED a mobile app; **using ANDRIOD STUDIO**; that:

- Detects real-time speed declines during workouts.
- Alerts users with a vibration/sound at the failure threshold.

The app will replicate our lab analysis using just smartphone sensors—making failure detection accessible anywhere.

How would the app work?

- 1. Positioning the Device:** Place the device on your hand.
- 2. Start the Process:** Press the "Start" button.
- 3. Countdown:** The device will countdown from 3 to 1.
- 4. Hold the Device Steady:** Ensure your hand remains still while the countdown occurs.
- 5. Begin Movement:** Once the countdown finishes, begin to move. The device will track your movement.
- 6. Speed Monitoring:** The device will monitor your speed and acceleration.
- 7. Completion:** Once your speed or acceleration reaches the set target values, the device will signal that the task is complete.



A screenshot from our mobile application

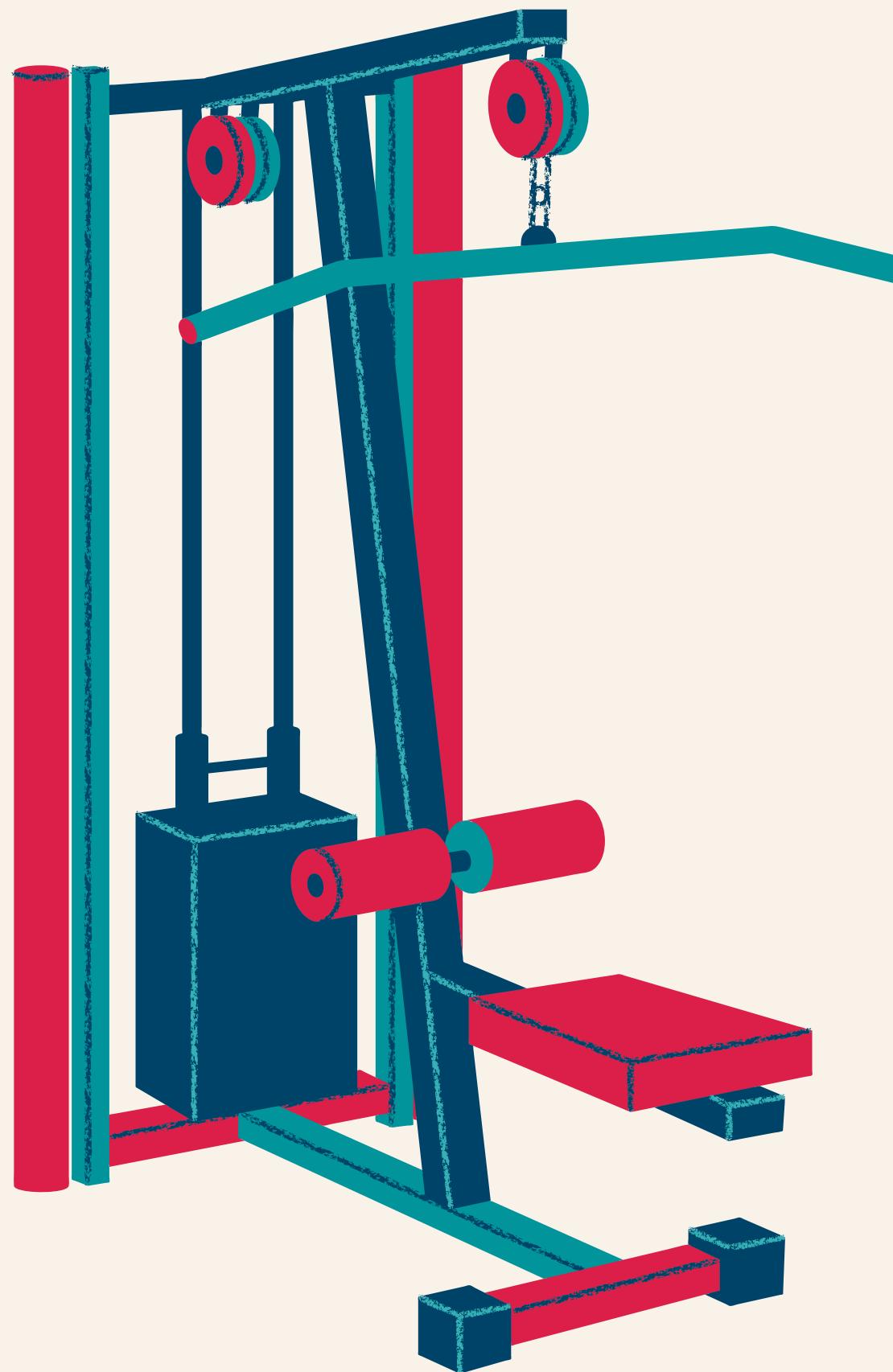


Table of contents

1. Introduction

.....

2. Our Approach

.....

3. Results & Findings

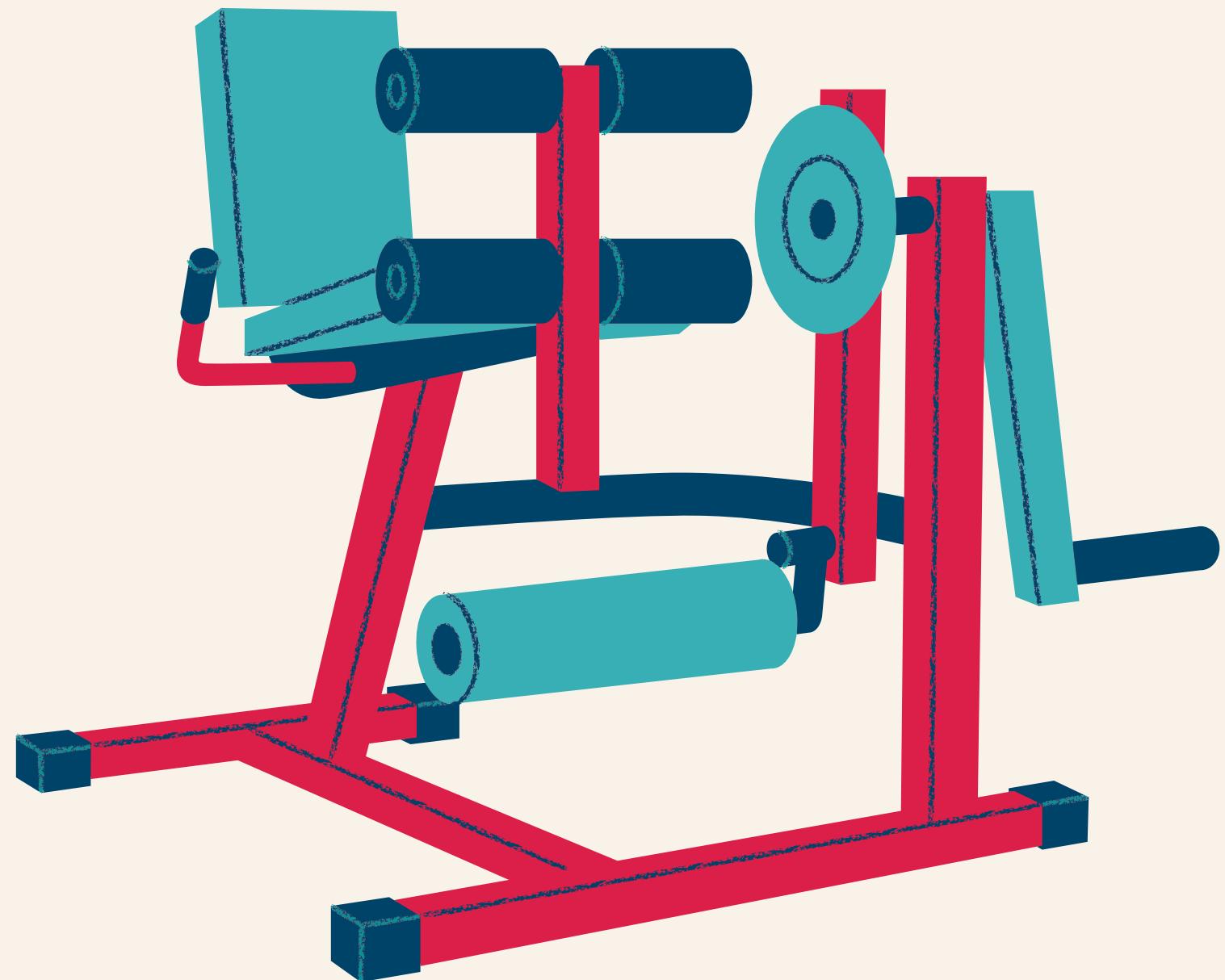
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4. APP development

.....

5. Conclusion

Let's Wrap It!



- Throughout this journey, we chased one question:
When does your muscle wave the white flag?
- From brainstorming to app development, we tracked the subtle surrender—not when you feel tired, but when your body shows it.

Our findings prove:

- Fatigue has a fingerprint.
- Speed and acceleration tell the truth.
- And now, your phone can catch it in real time.
- Whether you're pushing for progress or avoiding injury, knowing when your muscles surrender helps you train smarter—not just harder.

So next time you work out...

Listen for the white flag. Your muscles are trying to tell you something.

**Thank you for
listening!**

