TENDON LOADER PROJECT

Data Flow Diagram & System Architecture

KOHLE MERRY, PHD STUDENT IN REHABILITATION SCIENCES
FEB 24, 2021

DOCUMENT GOAL

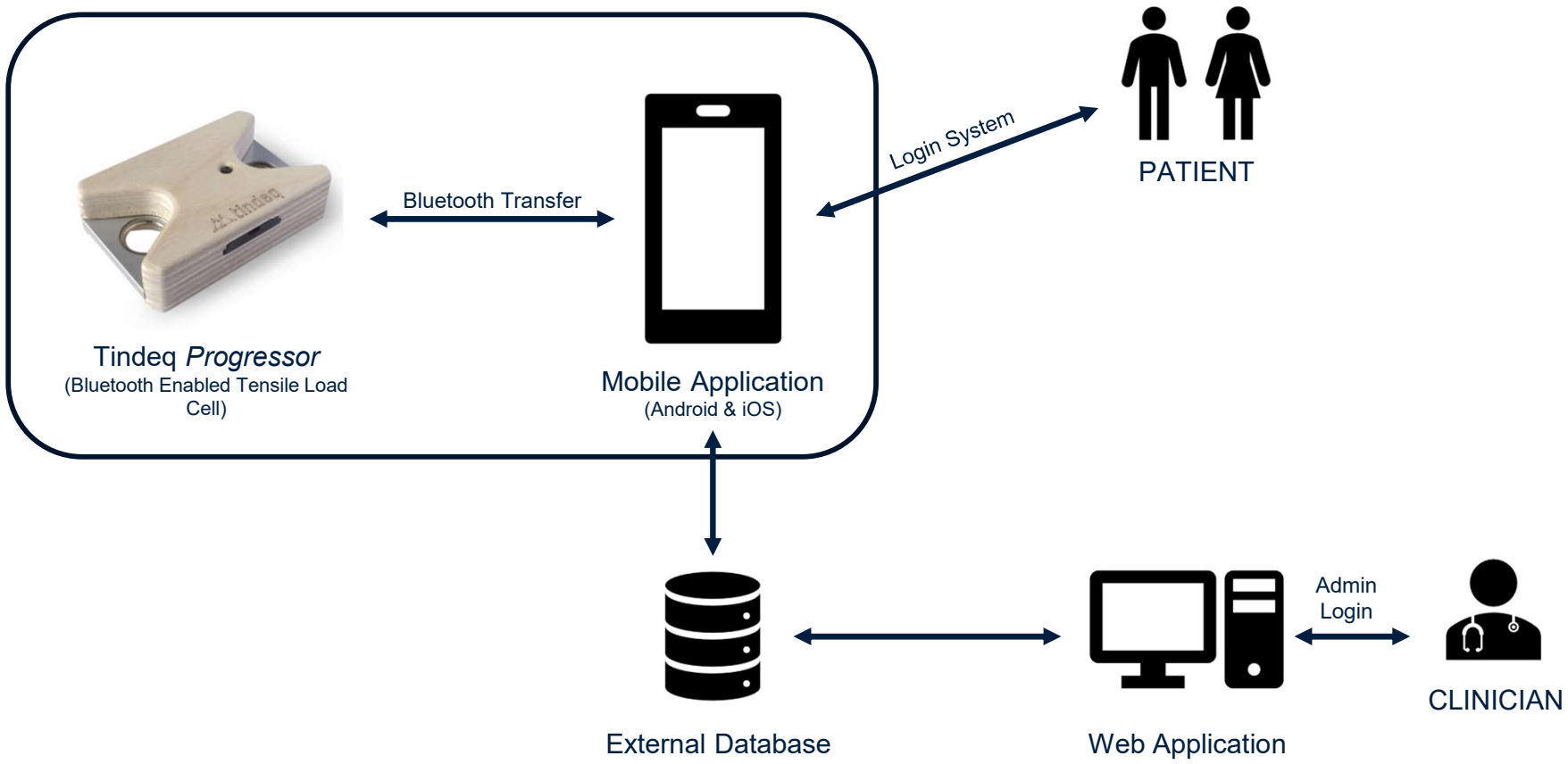
- This document aims to describe the flow of information (inputs, outputs, and data manipulation steps) for the *Tendon Loader* mobile application and anticipated web portal.

- The anticipated use of this document is to help developers to visualize the flow of information between the clinician/research staff, the mobile application, the web portal, and the end-user.

- Note that this is a working document subject to change. Further, multiple iterations of the workflow have been included in anticipation that complexity will be built into the software over time.

ANTICIPATED SYSTEM ARCHITECTURE

Anticipated System Architecture



DATA FLOW SCHEME FOR V1 DESIGN

DATA VISUALIZATION DIAGRAM (V1 BUILD)

Tensile Load [kg]

Patient hand-inputs all 5 fields (Target load, hold/rest time, sets/reps) into app before doing exercise

PATIENT

Web Portal acts as a secure point of access for downloading exported files

CLINICIAN

- For V1 Build, assume clinician talks to patient every 2-3 days via. phone or email to evaluate progress and adjust program
- Clinician reviews MVC test results & exercise progress (through web portal)
- Clinician calls/emails patient to discuss pain levels during exercise (does not assess pain through app in V1 build)
- Clinician tells patient (via. phone/email NOT app) what information to put into exercise mode regarding exercise program
  - Target load [kg]
    - Target load is based off of 70% of the MVC Test
    - e.g. Patient hits 50kg, clinician would recommend target load to be 70% * 50kg = 35kg
  - Hold time [s]
  - Sets [#]
  - Reps [#]
  - Rest time [s]

- MVC Test Export
  - Load [kg] vs. time [s] for duration of MVC test
  - Export format could be .txt, .csv, or .xlsx
- Exercise Mode Export
  - Load [kg] vs. time [s] for every exercise mode instance (e.g., user presses start on exercise mode, loads the tindeq for 5s, then presses stop). By pressing stop, the device would save 5s x 10Hz = 50 data points. Export would be 50 instances of load [kg] and 50 instances of corresponding time. Export format could be .txt, .csv, or .xlsx
  - Should also record user-inputted features for the exercise session: Target load [kg], Hold time [s], sets [#], reps [#], rest time [s]
  - **See sample export on next slide & attached**

SAMPLE DATA EXPORT

MVC Mode Export

	A	B	C	D
1	DATE:	2/24/2021		
2	TIME:	18:58		
3	USER ID:	Account ID # OR login credential		
4				
5	TINDEQ PROGRESSOR #:	Tindeq Unit ID		
6				
7				
8	TIME [s]	LOAD [kg]		
9	0	XX.X		
10	0.1	XX.X		
11	0.2	XX.X		
12	0.3	XX.X		
13	0.4	XX.X		
14	0.5	XX.X		
15	0.6	XX.X		
16	0.7	XX.X		
17	0.8	XX.X		
18	0.9	XX.X		
19	1	XX.X		
20	1.1	XX.X		
21	1.2	XX.X		
22	1.3	XX.X		
23	1.4	XX.X		
24	1.5	XX.X		
25	1.6	XX.X		
26	1.7	XX.X		
27	1.8	XX.X		
28	1.9	XX.X		
29	2	XX.X		

Exercise Mode Export

	A	B	C	D
1	DATE:	2/24/2021		
2	TIME:	18:58		
3	USER ID:	Account ID # OR login credential		
4				
5	TINDEQ PROGRESSOR #:	Tindeq Unit ID		
6				
7	EXERCISE INFO			
8	LAST MVC TEST RECORDED [kg]	XX.X		
9	TARGET LOAD [kg]	XX.X		
10	HOLD TIME [s]	X		
11	REST TIME [s]	X		
12	SETS [#]	X		
13	REPS [#]	X		
14				
15	TIME [s]	LOAD [kg]		
16	0	XX.X		
17	0.1	XX.X		
18	0.2	XX.X		
19	0.3	XX.X		
20	0.4	XX.X		
21	0.5	XX.X		
22	0.6	XX.X		
23	0.7	XX.X		
24	0.8	XX.X		
25	0.9	XX.X		
26	1	XX.X		
27	1.1	XX.X		
28	1.2	XX.X		
29	1.3	XX.X		
30	1.4	XX.X		
31	1.5	XX.X		
32	1.6	XX.X		

NOTE

- Expecting that each MVC Test and Exercise Mode ‘instance’ will export an additional file e.g:
  - 2-24-2021_ExerciseMode_ParticipantID_File1
  - 2-25-2021_ExerciseMode_ParticipantID_File1
  - 2-25-2021_ExerciseMode_ParticipantID_File2
  - 2-25-2021_MVCMode_ParticipantID_File1

APP 'MODES' & DETAILS FOR V1 DESIGN

- ***'Connect My Device' Mode***
  - *Purpose:* Allows user to establish connection between Tindeq progressor load cell and user's mobile device
  - *Functionality:* Prompts user to turn mobile bluetooth on if not already; informs user if tindeq progressor is not available (if it's asleep); informs user of successful bluetooth connection
  - *Data:* N/A

APP 'MODES' & DETAILS FOR V1 DESIGN

- ***'Live Data' Mode***
  - *Purpose:* Allows for system debugging (are the devices connected and meaningful data is being received); May be removed in future builds to reduce changes of participants hurting themselves by trying to max out the load cell
  - *Functionality:* Real-time display of the load [kg] both visualized as a bar graph as well as numeric readout; timer visible on screen; ability to stop the timer and reset the timer to zero
  - *Data Used:* Load [kg] captured at 10Hz; time [s]
  - *Data Stored:* None

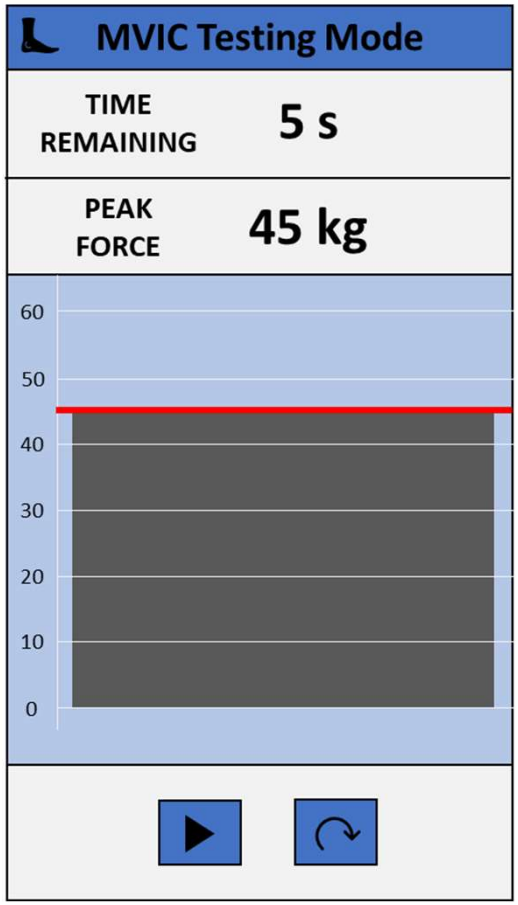
APP 'MODES' & DETAILS FOR V1 DESIGN

- ***'Exercise' Mode***
  - *Purpose:* Guides patient through an exercise session based on the user-inputted details which are advised by the clinician
  - *Functionality:*
    - Real-time display of the load [kg] both visualized as a bar graph as well as numeric readout
    - Session timer and rep timer visible on screen
    - Set/Rep counter
    - Target load visualization (horizontal bar at target load [kg]?)
    - Colour change/feedback for user during a rep/when to rest
    - Start/Stop/Reset buttons
    - Countdown feature (e.g. user hits start, app counts them in before the first rep...5,4,3,2,1, GO!)
  - *Input Data (User-entered):* Target Load [kg], Rest time [s], Hold time [s], Sets [#], Reps [#]
  - *Data Stored:* See 'sample data export' slide
    - Anticipating that hitting 'start' will begin storing data on device, and hitting 'stop' will automatically save the data, export it to the cloud, and make it available for download (not necessarily immediately) by the clinician

APP 'MODES' & DETAILS FOR V1 DESIGN

- ***'MVC' Mode***
  - *Purpose:* Tests the maximal force output [kg] of the patient so that the target load can be adjusted accordingly (typically *Target Load = 70-90% of MVC*); One way of assessing progress—higher MVC = Muscle-tendon unit getting stronger
  - *Functionality:*
    - Real-time display of the load [kg] both visualized as a bar graph as well as numeric readout of peak force achieved
    - Test timer (e.g., test may be 5 seconds long and mode will count backwards until expiry)
    - Peak load visualization (horizontal bar at peak [kg]?)
    - Colour change/feedback for user during a rep/when to rest
    - Start/Reset buttons
    - Countdown feature (e.g. user hits start, app counts them in before the test begins...5,4,3,2,1, GO!)
  - *Input Data (User-entered):* None
  - *Data Stored:* See 'sample data export' slide
    - Anticipating that hitting the start button will begin data recording, and the mode will 'timeout' after the test is complete which will automatically save the data, export it to the cloud, and make it available for download (not necessarily immediately) by the clinician
  - ***NOTE:*** Assume user has been instructed on how to complete the MVC test and no

REVISED MVC MODE WIREFRAME



EXERCISE DETAILS FOR EXERCISE MODE

PLANTARFLEXION TRAINING

- Exercise used to strengthen the muscle-tendon unit and promote symptom relief for Achilles Tendinopathy
- Example exercise (for reference): https://www.youtube.com/watch?v=jkn1Doy6YAI
- Our design:

Photo © c/o collaborator Adamantios Arampatzis, used by permission.

EXERCISE PROGRAM WORKFLOW

- User comes in for baseline session, introduced to device, app, exercise positioning/how to do exercise/etc.
- User goes home with app (on their mobile), tindeq progressor, and device pictured on previous slide
- Sample Week:
  - **Monday**: user does MVC test (in app); data exported to web portal; Clinician accesses web portal on to check MVC results (peak load); Clinician calls patient to tell them Target load/rest time/hold time/sets/reps for the week
  - **Tuesday**: Patient enters information in exercise mode, does a 'session', data is saved to cloud/web portal
  - **Wednesday**: Rest day
  - **Thursday**: Patient enters information in exercise mode, does a 'session', data is saved to cloud/web portal
  - **Friday:** Clinician calls patient to ask about pain, see how they're doing with the program, adjust as needed
  - **Saturday:** Patient enters information in exercise mode, does a 'session', data is saved to cloud/web portal
  - **Sunday:** Clinician calls patient to ask about pain, see how the week went, etc.
  - **Monday:** User does MVC test...etc.
- From the sample week, the clinician should be able to access 1 MVC data export and 3 Exercise mode exports
- Program likely continues for 12-weeks

EXERCISE MODE SAMPLE WORKFLOW

EXERCISE MODE WORKFLOW FOR V1

- User selects ‘exercise mode’ from homepage, taken to ‘exercise prescription’ page
- User manually enters exercise prescription [5 fields] based on discussion with clinician
- User taken to ‘exercise mode’ main screen
- User gets into position (long-sitting, pictured on previous slide)
- User hits ‘go’; device starts recording data
- Countdown begins on device 5,4,3,2,1...GO!
- Global timer begins, rep counter begins (currently at rep 1, set 1), rep timer begins
- User plantarflexes (pushes out) with their foot on the stirrup, generating force in the progressor
- User holds the flexed position for amount specified as ‘hold time’ which they previously input
- Rep timer counts backwards from the ‘rep time’ they previously input until it expires (e.g. 8 s rep time results in backwards count from 8, 7, 6,...0); upon expiry, rep counter increases by 1
- User instructed to ‘REST’ for ‘rest time’ input previously, ‘Rep timer’ changes to ‘rest timer’ and it counts backwards for the amount of rest time until it expires
- Rep 2 begins, user plantarflexes, counter starts counting backwards, etc.
- ...User completes all reps for a set (e.g. 10 reps); set counter increments by 1
- With exercise mode still active & recording, user rests for 90 seconds [between-set rest time]—timer to display this?
- After 85 seconds, Countdown begins on device 5,4,3,2,1...GO! To instruct a new set beginning; rep counter reset to 1
- SEE NEXT PAGE

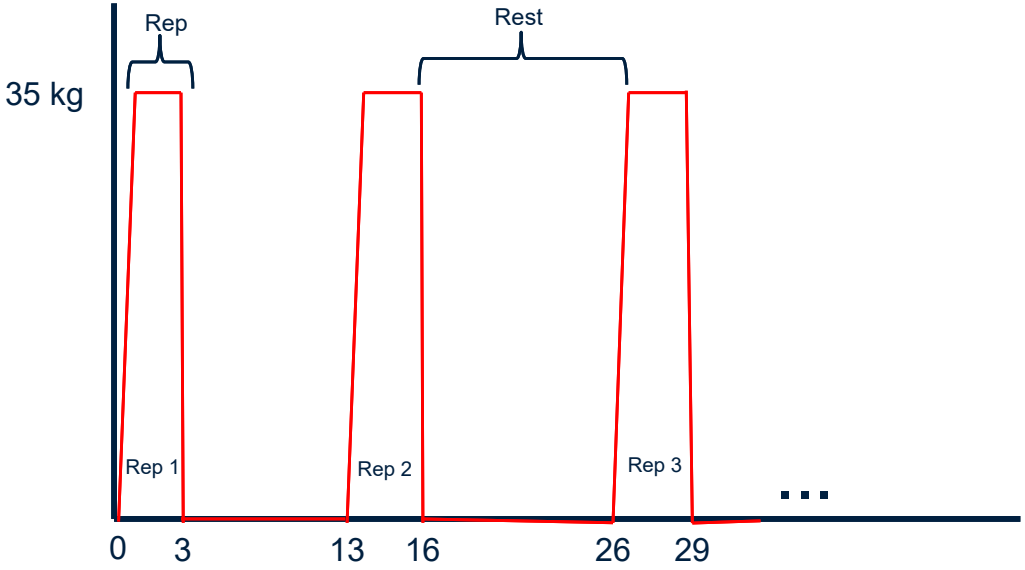
EXERCISE MODE WORKFLOW FOR V1

- ...CONT
- After 85 seconds, Countdown begins on device 5,4,3,2,1...GO! To instruct a new set beginning; rep counter reset to 1
- User completes all sets, presses ‘Stop’ which then saves/uploads/exports data
- ‘Exercise Session’ complete for the day; 1 exported data file now available via the web portal

SAMPLE EXERCISE MODE SESSION

- Exercise Prescription
  - Target load = 35kg (Based on a 50kg MVC)
  - Hold time = 3s
  - Sets = 5
  - Reps = 10
  - Rest time = 10s

Sample: Load vs. Time Plot (NOT TO SCALE)



	A	B	C	D	E
1	State	Global Timer	Rep/Rest Timer	Set	Rep
2	Countdown				
3	PUSH	1	3	1	1
4	PUSH	2	2	1	1
5	PUSH	3	1	1	1
6	REST	4	10	1	1
7	REST	5	9	1	1
8	REST	6	8	1	1
9	REST	7	7	1	1
10	REST	8	6	1	1
11	REST	9	5	1	1
12	REST	10	4	1	1
13	REST	11	3	1	1
14	REST	12	2	1	1
15	REST	13	1	1	1
16	PUSH	14	3	1	2
17	PUSH	15	2	1	2
18	PUSH	16	1	1	2
19	REST	17	10	1	2
20	REST	18	9	1	2
21	REST	19	8	1	2
22	REST	20	7	1	2
23	REST	21	6	1	2
24	REST	22	5	1	2
25	REST	23	4	1	2
26	REST	24	3	1	2
27	REST	25	2	1	2
28	REST	26	1	1	2
29	PUSH	27	3	1	3
30	PUSH	28	2	1	3
31	PUSH	29	1	1	3
32	REST	30	10	1	3
33	...	...	...	...	...