RollTime

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Table of Contents

List of Figures iii
Executive Summary 1
Introduction 2
Users and Requirements 3
1. Users and Stakeholders 3
2. Main Requirements 3
Design Concept and Rationale 7
Screw Clamp 9
Connection Joint 11
Phone Mount 11
Directions for Future Development 16
Conclusion 17
References 18
APPENDIX A: USER OBSERVATION SUMMARY 19
APPENDIX B: CLIENT INTERVIEW SUMMARY 25
APPENDIX C: SECONDARY RESEARCH SUMMARY 28
APPENDIX D: PROXY TESTING SUMMARY 35
APPENDIX E: USER TESTING SUMMARY 42
APPENDIX F: SAFETY EVALUATION 52
APPENDIX G: INSTRUCTIONS FOR USE 53
APPENDIX H: DESIGN REVIEW SUMMARY 56
APPENDIX I: PROJECT DEFINITION 62
APPENDIX J: INSTRUCTIONS FOR CONSTRUCTION 65

List of Figures

Figure 1: Diagram showing eye angles to *RollTime*........ 4
Figure 2: Diagram showing various hip angles when using *RollTime*........ 5
Figure 3: *RollTime* in use with a proxy user........ 7
Figure 4: Isometric and front view of *RollTime*........ 8
Figure 5: Illustrations of showing the two tightening steps of *RollTime*........ 8
Figure 6: Sketch of screw clamp with dimensions 9
Figure 7: Image of screw clamp with labelled features........ 10
Figure 8: Image of connection joint between the screw clamp and phone mount........ 11
Figure 9: Sketch of phone mount with features........ 12
Figure 10: Image of phone mount holding phone timer........ 13
Figure 11: *RollTime* oriented on the shaft of the measuring wheel........ 14

Executive Summary

Dr. Gina Clark, a physical therapist (PT) at the Shirley Ryan AbilityLab (SRAL), regularly administers the 6 Minute Walk Test (6MWT) to measure how far patients can walk in six minutes as an indicator of rehabilitation progress. During the test, she holds a rolling measuring wheel in one hand and supports the patient with the other, leaving no free hand to check a timer and making it difficult to monitor elapsed time without compromising patient safety.

To address this, the goal of the project was to design an attachment for the measuring wheel that keeps a phone timer visible and accessible throughout the 6MWT, allowing the physical therapist to monitor time without releasing either the patient or the measuring wheel.

We began by holding a client interview with Dr. Clark to establish requirements and a user observation session at SRAL to watch Dr. Clark conduct the 6MWT in-person and understand the test environment. Following this, we conducted physical mockup testing with Dr. Clark to evaluate different concepts and proxy testing with users of varying heights to refine specifications such as mount angle and placement on the shaft. Through this process, we developed our final design.

RollTime is a three-component attachment that clamps onto the shaft of the measuring wheel and holds the PT's phone in a fixed position, freeing a hand for the PT to guard the patient. The screw clamp fastens to the shaft using a screw-to-tighten mechanism with rubber padding for grip, accommodating measuring wheels of varying diameters and holding securely throughout the test. It attaches and removes quickly and is made with materials compatible with SRAL's sanitization protocols. A standard quarter-inch screw serves as the connection joint, linking the clamp to the phone mount. The phone mount holds phones of varying sizes using expandable side grips and positions the screen at a fixed angle selected to fall within the natural downward sightline of PTs of varying heights, keeping the display readable without significantly redirecting the PT's attention away from the patient. The mount sits within arm's reach along the shaft, allowing the PT to interact with the timer when needed, such as during patient rest breaks when the PT takes a screenshot to record elapsed time. All components are commercially available and low in cost to replace if damaged.

Future development should focus on refining the fixed mount angle to better match each PT's unique natural line of sight across users of varying heights, and on exploring a faster one-motion clamping mechanism to further reduce setup time.

Introduction

Our design challenge involves the 6 Minute Walk Test (6MWT) that physical therapists (PTs) at the Shirley Ryan AbilityLab (SRAL) regularly administer to evaluate and track patient rehabilitation progress. Our project partner and user, Dr. Gina Clark, is a PT at SRAL. The test supports patients with different conditions such as brain injury, stroke, and pulmonary diseases. During the test, patients walk as far as possible over six minutes, taking breaks if needed, while the PT measures distance using a rolling measuring wheel. Because many patients require physical support while walking, the PT holds the measuring wheel in their non-dominant hand, while their dominant hand guards the patient. This leaves no free hand to hold a separate timekeeping device, making it difficult for PTs to consistently monitor elapsed time throughout the test without compromising patient safety.

Our user has adopted three current solutions to manage timekeeping during the 6MWT, though none are fully effective. The first is wearing a stopwatch around the neck, but the display is difficult to see from that position. This requires the PT to periodically grab and reorient the stopwatch, removing a hand that would otherwise be guarding the patient. In the second, the PT holds a stopwatch or phone in the same hand as the measuring wheel, keeping the other hand free to guard the patient. However, this makes the measuring wheel harder to operate and difficult to maintain stability throughout the 6MWT. Lastly, when guarding is not required, the user holds the timer in the opposite hand of the measuring wheel, but this is unreliable since many patients require physical support.

To address these limitations, our solution is *RollTime*: a clamp attachment for the measuring wheel that includes a phone mount, holding the PT's phone at an angle that allows them to glance at the display throughout the 6MWT without needing to reposition it. The attachment fastens and detaches quickly, holds securely during use, and keeps the phone visibly accessible and within reach throughout the test.

The sections that follow outline the users and requirements that shaped our design process, describe the final design and rationale behind each component, and discuss recommendations for future developments.

Users and Requirements

1. Users and Stakeholders

Dr. Gina Clark: Our main user and project partner is a physical therapist (PT) at SRAL who administers the 6MWT to track patient rehabilitation progress. During the test, she holds the measuring wheel with her non-dominant hand and guards the patient with the other (Appendix A, User Observation), leaving no free hand to check a timer. She works in a busy lab environment where patient safety and test accuracy are the top priorities, and must respond to unpredictable situations such as rest breaks, assistive devices, and delayed starts without losing focus on the patient (Appendix A, User Observation). She strongly prefers using her phone as a timer and needs any solution to be quick to set up, secure during use, and easy to glance at throughout the test (Appendix B, Client Interview Summary).

Patients at SRAL: Patients complete the 6MWT under the user's supervision and are likely physically and/or cognitively impaired (Appendix C, Secondary Research Summary). While they do not interact with the attachment directly, their safety is the central constraint on the design.

PTs at SRAL: Other PTs at SRAL administer the 6MWT and face the same challenges as our user (Appendix A, User Observation Summary). As secondary users, they may adopt the solution. Because PTs vary in height, the attachment must accommodate different heights and sightlines to remain accessible across users.

2. Main Requirements

Throughout the quarter, we have identified that the design must satisfy the following requirements:

Free up a hand to hold the patient
The design must allow the PT to keep one hand free to guard the patient at all times. During the 6MWT, Dr. Clark holds the measuring wheel in her non-dominant hand while her dominant hand grips the patient's gait belt (Appendix B, Client Interview Summary), allowing her to properly support the patient as they walk. Current solutions, such as holding a phone in the same hand as the measuring wheel, compromise the PT's ability to prioritize the safety of the patient (Appendix B, Client Interview Summary).

Allow for timer to be accessibly viewed for PTs of various heights
The attachment must position the phone display within the PT's natural downward sightline so that time can be monitored without significantly redirecting attention away from the patient (Figure 1). Because multiple PTs of varying heights use the measuring wheels at SRAL, the

attachment must be oriented at a universal angle to accommodate different users (Appendix A, User Observation Summary; Appendix D, Proxy Testing Analysis).

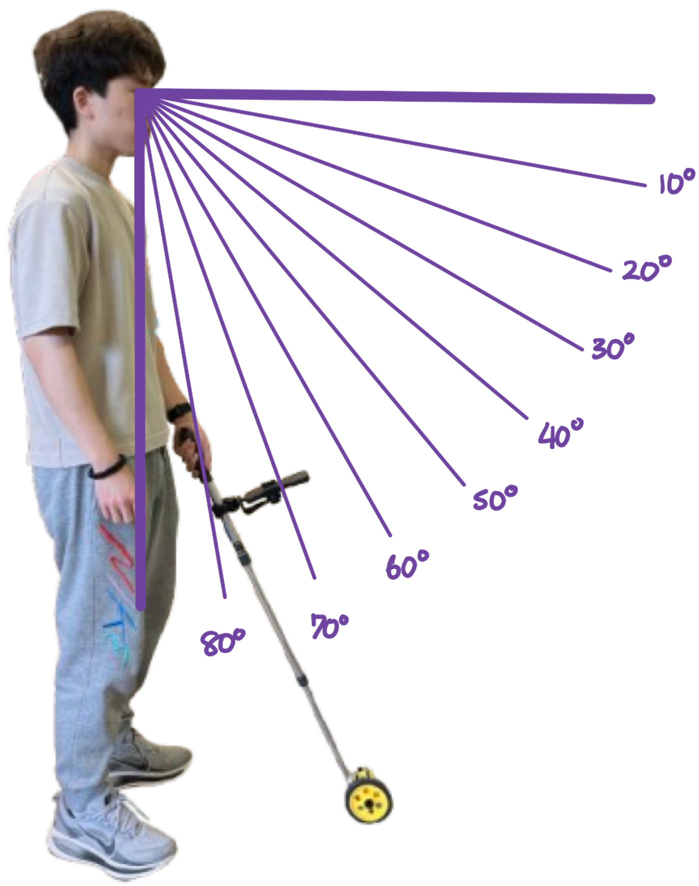

Figure 1. Diagram showing eye angles to RollTime

Allow for user to interact with timer display

The attachment must position the phone within arm's reach so that the PT can interact with it during the test when needed (Figure 2). During user observation, Dr. Clark demonstrated taking screenshots of the timer to record when patients took rest breaks rather than relying on memory (Appendix A, User Observation Summary).

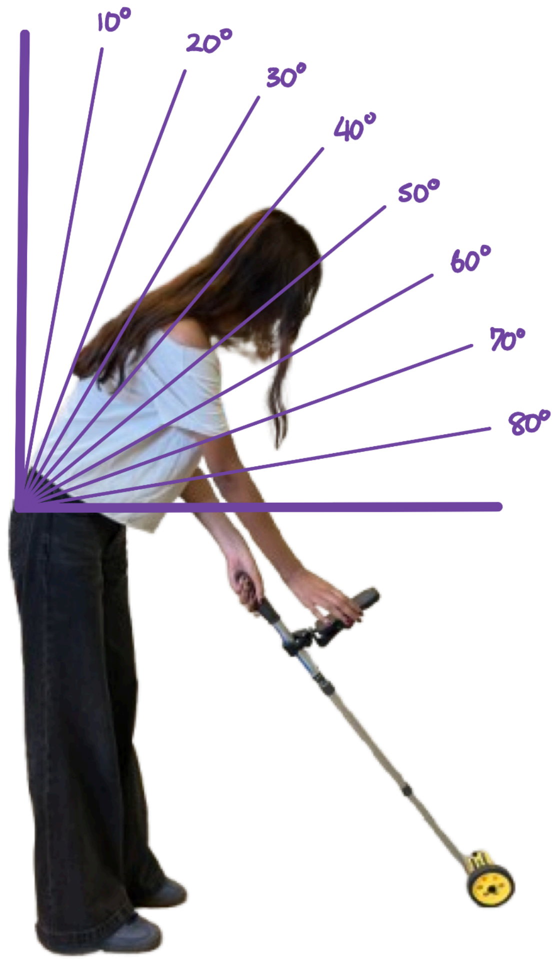

Figure 2. Diagram showing various hip angles when using RollTime

Ensure accurate results
The 6MWT is a low-cost, standardized, accessible method to quantify patient progress (Appendix C, Secondary Research Summary). The solution must not interfere with the functionality of the measuring wheel or obstruct the distance display (Appendix C, Secondary Research Summary). Additionally, the design should allow the PT to interact with the phone when needed such as taking a screenshot, or adjusting the timer to account for small delays that can occur at the start of the test (Appendix A, User Observation Summary).

Hold fast/secure well
The attachment must remain in place during the 6MWT. A falling phone or attachment is a critical safety hazard, as it could create a tripping risk for the patient or others in the room (Appendix E, User Testing Summary; Appendix F, Safety Evaluation). Any attachment mechanism must be stable and reliable during use.

Allow for proper sanitization
All equipment at SRAL is sanitized regularly to prevent the transmission of pathogens (Appendix B, Client Interview Summary). The materials used in the design solution must be compatible with standard sanitization protocols at SRAL, ensuring the design is safe for repeated use across patients and PTs.

Cost a low price to create
The design must be cost-effective to produce and replace if damaged. Dr. Clark mentioned during the client interview that items costing around $100 or more are too expensive (Appendix B, Client Interview Summary).

Allow for easy setup and removal
The attachment must be quick and easy to put on and take off independently, as Dr. Clark's schedule requires her to set up between appointments (Appendix E, User Testing Summary). Since any time utilized for setup is time taken away from the patient, we aim for setup and removal to each take no more than 20 seconds.

Design Concept and Rationale

RollTime (Figures 3 and 4) is a hands-free timer device designed to assist physical therapists during the 6MWT. The device allows therapists to maintain visual and physical attention on their patient while keeping a timer visible and accessible throughout the test. The attachment secures a phone timer display mounted onto the shaft of a measuring wheel. This enables therapists to use the measuring wheel while keeping one hand free to support the patient.

Figure 3. RollTime in use with a proxy user

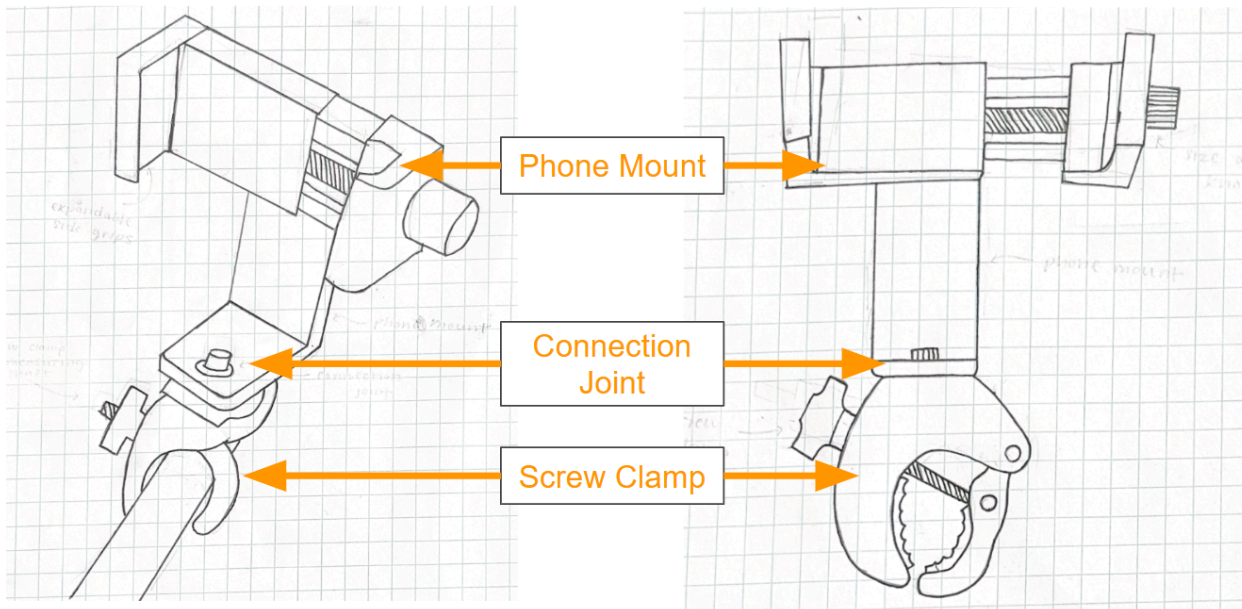

Figure 4. Isometric and front view of RollTime

To operate and use *RollTime*, the user should pick up the measuring wheel and align it to the natural operating position with the distance reader facing towards the user. Once aligned, the user grabs *RollTime* and positions the clamp around the measuring wheel, making sure to align the marked spot with the top of the pole. Then, they turn the screw knob clockwise until the clamp is locked into place (Figure 5). Once *RollTime* is attached, place the phone into the phone holder, making sure it does not tip or fall. When the phone is positioned correctly, tighten the screw on the right side of the mount and clamp the phone into place. For step-by-step instructions, follow Appendix G, Instructions for Use.

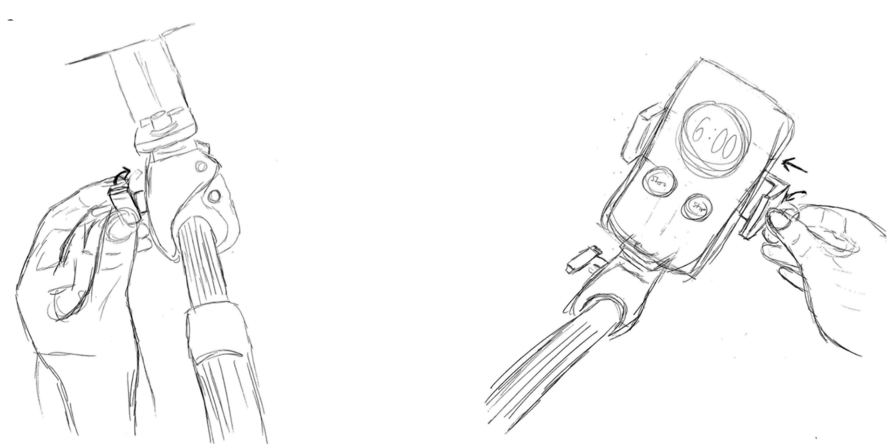

Figure 5. Illustrations of showing the two tightening steps of RollTime

RollTime consists of a screw-clamp mechanism, a connection joint, and a phone mount (Figure 4). The screw clamp secures the attachment to the shaft of the measuring wheel and can be adjusted to account for measuring wheels of varying shaft diameters. A fixed connection joint links the clamp onto the phone mount which positions the timer display into the therapist's line of sight. The phone mount has expandable side grips that extend and retract to secure phones of varying sizes.

The following sections describe the components of the device–the screw clamp, connection joint, and phone mount–as well as the rationale for each component.

Screw Clamp

Specifications and Use

The screw-clamp mechanism is a claw-style clamp design that is tightened with a screw on the side as shown in Figures 6 and 7. The clamp has a weight of 0.06 kg and measures 64 mm by 76 mm. The clamp is adjustable in size, accommodating pole sizes ranging from 19 mm to 50 mm in diameter. It is made out of Acrylonitrile Butadiene Styrene (ABS) plastic with heat set inserts applied to allow for ¼"-20 screws to be attached. Within the circular insides of the claw, there are rubber pads attached to increase friction and grip with the pole.

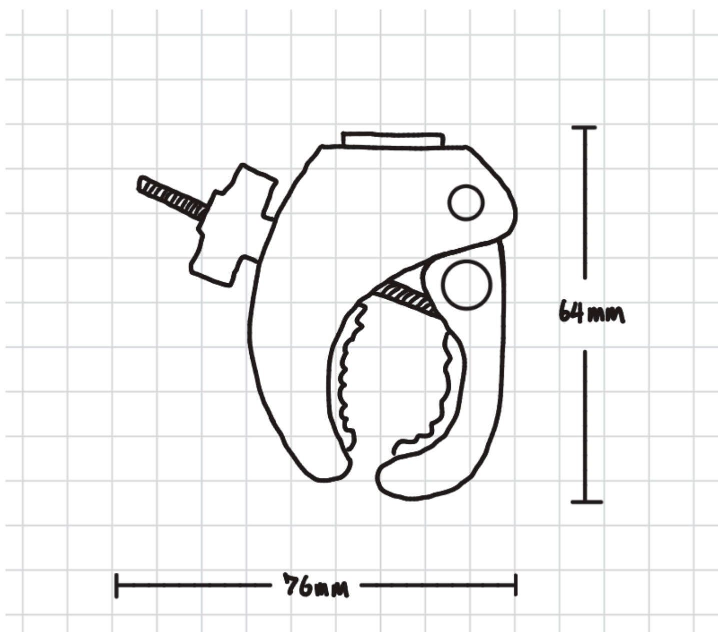

Figure 6. Sketch of screw clamp with dimensions

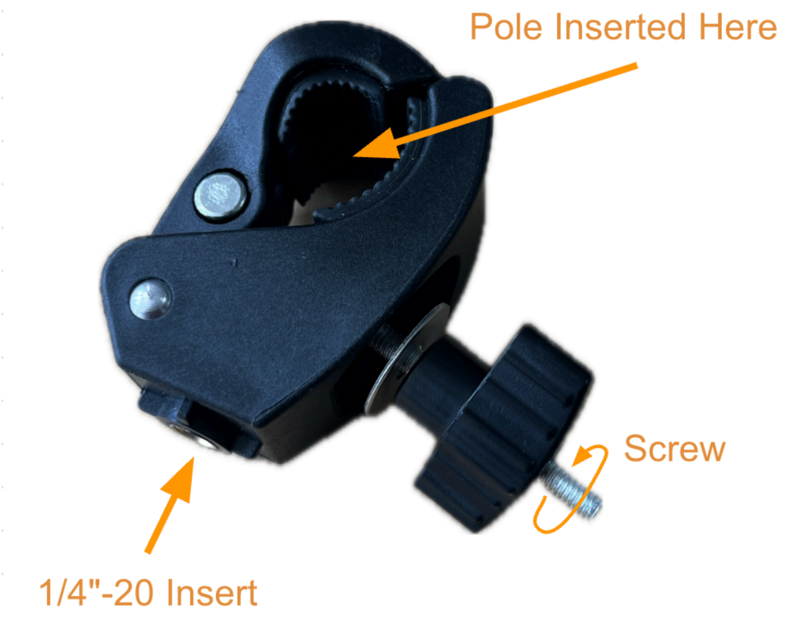

Figure 7. Image of screw clamp with labelled features

Rationale

We considered numerous designs using feedback from design review and proxy user testing before settling on our final design (Appendix H, Design Review Summary). This specific design was chosen because it excelled in our tests in regards to our defined requirements (Appendix I, Project Definition). By attaching onto the measuring wheel, it allows the user to view the timer without utilizing their alternate hand. Additionally, its location on the measuring wheel gives access to the timer within the sight of the user. In terms of degrees, the phone is within 10 degrees of vision between the distance indicator and it is within the lower peripheral vision of the user when looking straight forward. The user of the device is also able to bend down and take a screenshot of the timer with relative ease (Appendix D, Proxy Testing Summary).

Our testing has shown that it aligns with our primary requirements for the device to be secure, quick to attach, and sanitizable, and adjustable. In user testing with alternate designs (a cam lever and a metal screw design), the screw-clamp performed the best in speed of attachment. On average, the screw clamp had a time of 15.30 seconds, compared to 24.20 and 15.60 seconds to the other designs respectively (Appendix D, Proxy Testing Summary). Users also rated it the simplest to understand and use consistently compared to the other designs. Additionally, we conducted tests for proxy users to violently shake the device while it was attached to the measuring wheel. It was shown that the clamp is highly unlikely to fall off even with excessive force, due to the extra friction granted by the rubber padding. It is adaptable for measuring wheels of various pole diameters and can be attached from the side of the measuring wheel, allowing for unrestricted placement. Additionally, its material (ABS plastic) allows for simple sanitation with 70% isopropyl alcohol or diluted bleach, following facility sanitation guidelines. The clamp can be bought on Amazon for $9.99, avoiding high replacement costs.

Connection Joint

Specifications and Use

The connection joint is a simple ¼”-20 screw, the most common U.S. fastener size. The design itself uses a ¼”-20 hex socket cap screw of ½ inch length as well as two ¼” washers to hold the phone mount in place. The screw attaches the phone mount and the screw clamp in place by threading through the heat set inserts in both designs as shown in Figure 8. For more detail, refer to the assembly guide (Appendix J, Instructions for Construction).

Figure 8. Image of connection joint between the screw clamp and phone mount

Rationale

The ¼”-20 screw was chosen for its availability in hardware stores as well as online and is the typical industry standard for attachments. Throughout testing, the screw held the attachments very tightly and never disassembled (Appendix D, Proxy Testing Summary), which fits our requirement for a secure device. The hex socket cap screw was chosen as it allowed the attachments to be finger-tightened, preventing the need for tools.

Phone Mount

Specifications and Use

The screw clamp mount (Figures 9 and 10) has expandable side grips that retract and expand to securely hold phones of different sizes. The mount expands to a maximum of 7’’ and retracts to a minimum of 4’’. A size adjustment knob located on the left side of the mount loosens the side grips allowing them to expand or retract. Tightening the knob secures the side grips in place around the width of the phone. The inner surfaces of the side grips have rubber padding to prevent the phone from slipping.

An angle adjustment knob on the back of the mount allows the phone display to rotate up to 360 degrees. In the final design, the phone is at a fixed vertical position relative to the shaft of the measuring wheel, and the 360 degree turning feature is disabled. At the base of the mount, there is a ¼" screw connection hole for the connection joint to connect the mount to the clamp. During use, the user places the phone into the mount and secures the side grips using the size adjustment knob before conducting the 6MWT.

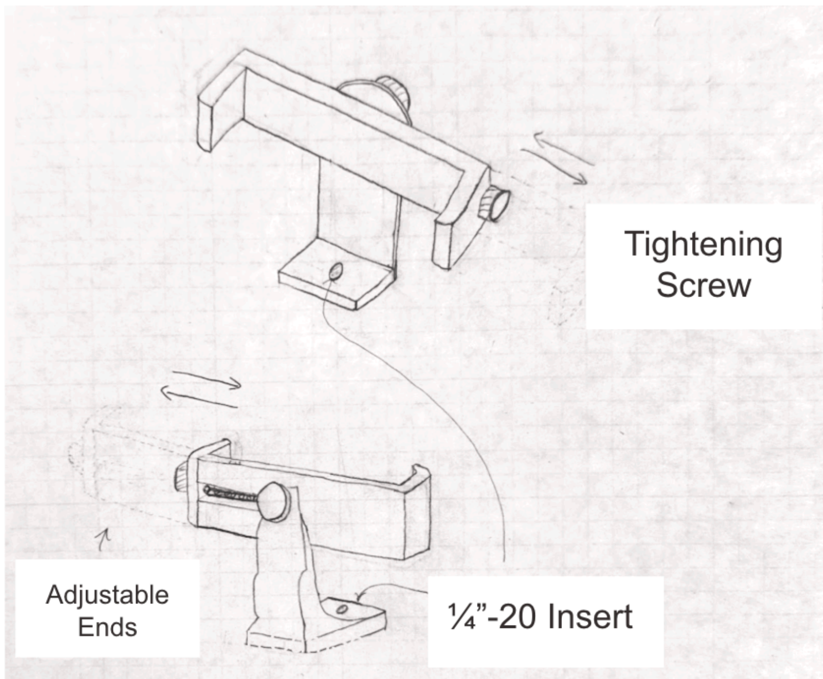

Figure 9. Sketch of phone mount with features

Figure 10. Image of phone mount holding phone timer

Rationale
A phone mount was selected as opposed to a holder for a different timing device, such as a stop watch, based on user preferences and observations collected during client interviews, user testing, and user observation (Appendix A, User Observation Summary; Appendix B, Client Interview Summary; Appendix E, User Testing Summary). Dr. Clark currently uses a phone timer when administering the 6MWT and expressed greater familiarity and comfort with the visual display of the phone timer compared to a stopwatch display. Additionally, the phone is readily available in the testing environment, making it practical for repeated use during testing (Appendix A, User Observation). By securely mounting the phone to the measuring wheel, the design eliminates the need for the PT to hold the phone while administering the 6MWT. This allows the PT to keep one hand free to guard the patient using a gait belt and maintain safety as identified in the client interview (Appendix B, Client Interview Summary).

The phone mount is positioned at a fixed angle 90 degrees above the shaft of the measuring wheel. This angle was selected following testing with proxy users of different heights, where users found the 90 degree angle easier to view compared to 75 degree and 105 degree angles. At the alternative angles, users experienced increased screen distortion, making the timer more difficult to read. The vertical orientation of the phone in the mount was chosen based on comfort observed with this orientation in user testing (Appendix E, User Testing Summary; Appendix D, Proxy Testing Analysis). This orientation positions the timer within the user's natural line of sight supporting the need for the PT to continuously monitor the patient while having accessibility to the timer display.

The expandable sides grips allow the mount to accommodate a variety of phone and phone case sizes. A screw-adjustment mechanism was chosen over spring-loaded clamp mounts after user testing demonstrated that screw-adjustment mounts were easier to operate (Appendix D, Proxy Testing Analysis). Although spring-loaded mounts allowed users to place phones into the holder more quickly, users reported difficulty pulling the sides apart because the mounts require two hands and greater force to pull. In comparison, the adjustment knob requires less force to twist and gives the user greater control to secure the phone. Testing with proxy users showed that it took approximately 11 seconds to place and secure the phone in the mount (Appendix D, Proxy Testing Analysis). The screw adjustment mechanism provides a secure attachment method preventing potential risks of the phone falling causing safety hazards in the testing environment. In addition to securely holding the phone, the mount is also positioned to support usability during the 6MWT. During observation, the user demonstrated taking screenshots of the timer to record the patient's breaks rather than relying on memory (Appendix A, User Observation Summary). The mount position allows this action without interrupting the administration of the 6MWT.

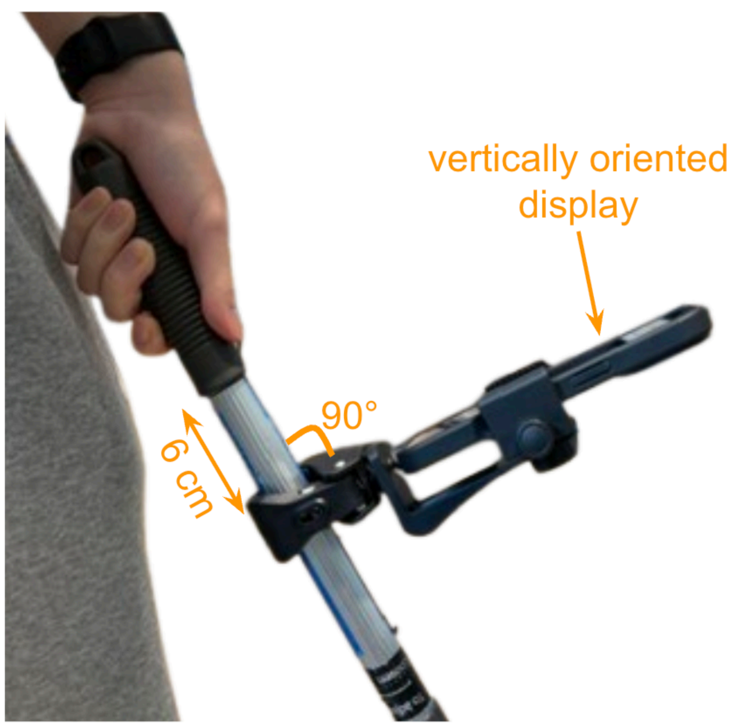

Figure 11. RollTime oriented on the shaft of the measuring wheel

The phone mount is positioned vertically and angled 90 degrees relative to the shaft (Figure 11). This provides a clear view of the timer display while minimizing screen distortion. The screw clamp is attached approximately 6 centimeters below the handle of the measuring wheel, a location selected through testing to balance screen visualization and usability. This distance was chosen so it was high enough to easily view the phone display but far enough from the handle that it did not interfere with holding the measuring wheel (Appendix D, Proxy Testing Analysis). Additionally, the phone mount can be bought for $5.89 on Amazon, matching our low cost criteria. Together the clamp placement, viewing angle, and phone orientation allow the user to monitor time effectively when administering the 6MWT.

Directions for Future Development

While *RollTime* addresses the core challenges of the 6MWT timekeeping problem, several areas remain open for refinement in future iterations.

Line of Sight Angles

The current design positions the phone mount at 90 degrees relative to the shaft of the measuring wheel. However, the more relevant reference point for viewing comfort is the PT's natural line of sight when holding the measuring wheel during the test; this is not necessarily perpendicular to the shaft. Because PTs hold the measuring wheel at varying angles depending on their height and gait, the optimal viewing angle of the phone mount likely differs across users. Future development should measure the average line-of-sight angle across PTs of varying heights while holding the measuring wheel in a realistic testing posture, and use that data to inform a specification for the revised fixed mount angle.

Attachment Adjustments

The screw-clamp mechanism performs well in terms of security and ease of use relative to alternatives tested, but attachment speed could remain a meaningful constraint depending on the necessity of speed in busier contexts. A one-motion fastening mechanism (e.g. a squeeze-activated clamp that locks onto the shaft with a single grip) could reduce setup time significantly without necessarily sacrificing hold strength. Future iterations should evaluate quick-release clamp options with this priority in mind.

The current design also places the full mechanical load of any impact or fall directly on the phone and the attachment joint. A collar-based design that allows the attachment to rotate around the shaft upon impact would distribute that energy across the attachment and the shaft rather than concentrating it at a single point, reducing the risk of damage to either the phone or the device. This modification would also address Dr. Clark's concern about the phone falling as a patient safety hazard (Appendix F, Safety Evaluation), since a rotating collar is less likely to detach entirely under sudden force than a rigidly fixed clamp.

Clamping Force Specifications

Finally, the optimal clamping force for this application warrants a more precise definition. The attachment must be tight enough to remain stable throughout the 6MWT, including during turns, starts, and stops, but not so tight that it damages the measuring wheel shaft over repeated use. Future work should establish a torque specification or tactile indicator (e.g. a defined number of turns past initial contact) that would communicate to the user when the clamp is sufficiently tightened. This would improve consistency across different PTs using the device and reduce the risk of under or over tightening.

Conclusion

RollTime addresses a recurring challenge in physical therapy: the inability of PTs to monitor elapsed time during the 6MWT without releasing the patient or the measuring wheel. Through a process of secondary research, client interviews, user observation, proxy testing, and direct user testing with Dr. Clark at SRAL, our team developed a three-component attachment (screw clamp, connection joint, adjustable phone mount) that keeps the phone timer within the PT's natural sightline while leaving both hands free for patient care.

The design meets the core requirements established over the course of the quarter in that it frees a hand for patient guarding, positions the display accessibly for PTs of varying heights, supports interaction with the phone during the test, maintains the accuracy of the measuring wheel, holds securely, is compatible with standard sanitization protocols, and can be set up and removed quickly between tests. User testing with Dr. Clark confirmed that the measuring wheel mount concept was strongly preferred, and the final design reflects the feedback and safety considerations raised during that session. The directions for future development outlined above, particularly refining the mount angle relative to the PT's line of sight and improving attachment speed, represent the most impactful areas for continued work. With those refinements, *RollTime* has even further potential to be adopted more broadly across PTs at SRAL and in similar rehabilitation settings.

Ultimately, the most important reasonings behind this design extend far beyond the mechanics of a clamp or a phone mount. When PTs can administer the 6MWT with greater ease and confidence, they are better positioned to give their full attention to the people in their care. More accurate and consistent test results benefit patients directly by producing a clearer picture of their rehabilitation progress, and contribute to the broader research mission at SRAL. In that sense, *RollTime* is designed to not just support the mechanics of the 6MWT, but the confidence a PT brings into their work and the quality of care that their patients receive out of it.

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APPENDIX A: USER OBSERVATION SUMMARY

Introduction

Esha Chandra, Lois Xie, Ethan Park, and Jimmy Tsai observed a user conducting the 6 Minute Walk Test (6MWT) at the Shirley Ryan AbilityLab (SRAL) on Tuesday, April 14th. The team spoke with client and user Gina Clark, a physical therapist, to better understand the challenges she faces when tracking the time during the 6MWT. The purpose of this observation was to understand the test process, inefficiencies, and opportunities for improving time tracking and safety. The session lasted approximately 60 minutes. This appendix explains the methodology used in conducting our observation, describes the testing environment and user behavior, and summarizes key findings.

Methodology

The observation took place in the Margret and Mark Stephan Legs + Walking Lab which is one of several labs where the test is conducted by different physical therapists. Dr. Clark displayed several scenarios of conducting the 6MWT with a colleague standing in as the patient. The scenarios demonstrated patients who use different assistive devices such as a walker, cane, and wheelchair. Dr. Clark was asked about her priorities for a design and what parts of administering the test were more challenging. Finally, the team took measurements of tools and environment involved in the test.

Environment

The 6MWT is typically conducted in the Legs + Walking Lab (Figure 1B) or other similar labs across other floors in the building. Regardless of if the patients on that floor are inpatient or outpatient, the lab environment and test is very similar. Each floor varies in set up, but the test must remain standard. Dr. Clark performs on average two 6MWTs per day, and other physical therapists in the facility perform the test daily as well.

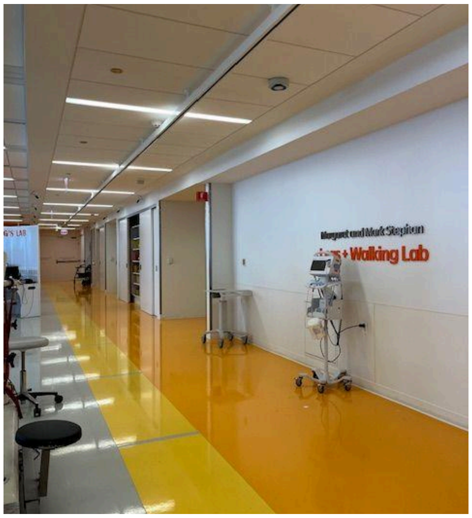

Figure 1B. SRAL Legs + Walking Lab right side wall from entrance.

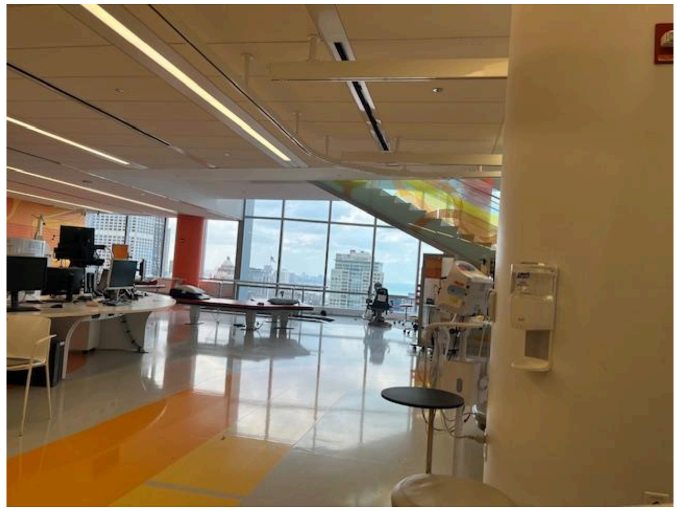

Figure 2B. SRAL Legs + Walking Lab, forward view walking through the entrance.

The environment at times was busy with many other therapists and patients in the room. Background noise is common. There was a lot of equipment around the room such as treadmills or stationary bikes for rehabilitation, and some of this equipment was actively being used. The walk test track was around the edge of the room, so Dr. Clark and the patient would pass these elements on each lap. The yellow walk track on the floor can be shown from two angles in Figures 1B and 2B. Dr. Clark mentioned that if this lab room gets too busy she may also conduct the test in the hallway.

Conducting the Walk Test

Required Equipment

- Measurement wheel
- Phone/stopwatch - phone is easier/more commonly used

Optional Equipment, varies according to patient needs

- Gaitbelt (for patients that need guarding)
- Wheelchair and wheelchair follow
- Cane
- Walker
- Rolling cart with vitals monitors
- Rate of Perceived Exertion (RPE) chart

Process

The following list describes the general process that Dr. Clark follows when administering the 6MWT.

1. Set a 6-minute timer on the phone

2. Position the right hand under the patient's gait belt and the left hand holding the measuring wheel.
3. Start the timer and prompt the patient to begin walking.
4. Follow a half step behind the patient. Roll the measuring wheel along the patient and maintain a secure hold on the patient's gait belt.
5. When the timer ends, notify the patient. Make sure the patient is safely seated.
6. Record the total distance on the measuring wheel. Make other notes about observations from the test such as amount of rests and duration of rest breaks.

User Priorities

- Patient Safety
- Accurate, reliable results of distance and time
- Maintaining attention and line of sight on the patient and surroundings
- Communication of the timing. Typically at 4 and 2 minutes.

User Observation Table

Table 1B. User scenario and observation

Scenario or Interaction	Observation	Follow Up
Starting the timer	Dr. Clark would rush to start the timer, then quickly secure it in her pocket. After, she moves her hands on to the measuring wheel and gaitbelt (outlined in the Process section above). She prompts the patient to begin walking, and sometimes the patient may not begin walking immediately.	Dr. Clark commented on how often these steps would delay the actual start time compared to the recording on the timer. She said sometimes she notes a roughly 15 second delay and mentally adds that at the end of the test.
The user wants to check time while the patient walks or the patient asks the user how much time is left.	Dr. Clark will slip her hand out of the patient's gait belt and take out the phone screen to glance at. This movement is very quick and rushed.	Dr. Clark displayed discomfort from removing her hand from the patient. She fiddled with the phone trying to place it back quickly and reassume her initial position.
Patient decides to take a rest	The patient asks to take a rest. They either choose to stand in	She wants to check the time and mentally note the duration of the

	place or take a seat which Dr. Clark walks them towards.	rest. Sometimes, she wants to take a screenshot on her phone to remember the timing.
Obstacle in the walk pathway	Dr. Clark quickly stepped out of line with the patient and kicked the stool out of the patient's pathway. She seemed frustrated and eager to quickly return back to the patient's side.	She says this can happen because the patient is free to wander anywhere in the room, even off the track, as long as she follows. She dislikes not being by the patient's side and having to move her body away temporarily.
Patient uses a wheelchair follow	The phone timer was placed on the wheel chair. Then the patient asked for a rest. Dr. Clark quickly had to grab the phone from the seat, put it in her pocket, and then help the patient take a seat.	She was frustrated to have to move the phone instead of helping the patient sit as soon as they ask. In the case of wheelchair users, the patient may be especially at a high fall risk.
Patient uses a cane or walker	The most typical case; Dr. Clark used the position outlined in the Process section above. She keeps one hand on the patient's gait belt and the other on the measurement wheel. She carries her phone in the same hand as the gaitbelt, in a fanny pack worn across her body, or in her pants or jacket pocket.	Dr. Clark noted that even in the standard general process, she may come across the other scenarios described in this table. This includes difficulty starting the timer, checking the time, patient taking rest breaks, and navigating obstacles in her path.

Measurement Data

Measuring Wheel Dimensions

- Light green measurement wheel
  - Thin shaft diameter: 0.8 inches/22mm
  - Thick shaft diameter: 0.9 inches/26.4mm
- Orange measurement wheel
  - Thin shaft diameter: 22mm
  - Thick shaft diameter: 26.4mm

Environment Measurements

- Storage shelf dimensions (Figure 3B)
    - 4 ft length
    - 10.5 inches height
- Track length
    - About 200 feet

Phone Timer Measurements

- Non-bulky phone case
- iPhone 13 Pro
    - Length: 150mm
    - Width: 76.2mm
- Other PTs have iPhones or Androids most commonly

Figure 3B. Storage for 6MWT and other physical therapy equipment

Discussion

The observation provided insight into the environment and workflow of the 6MWT at Shirley Ryan AbilityLab. A key finding was that the test is conducted in an active and often busy environment, where therapists must navigate other patients, therapists, and rehabilitation equipment while focusing on patient safety. Observing Dr. Clark conducting the 6MWT allowed our team to better understand the general testing procedure, including her typical hand positioning, use of the measuring wheel, and timing process. The observation revealed that the standard process is frequently interrupted by real-world scenarios such as delayed patient starts, requests for time updates, rest breaks, obstacles in the walking path, and use of assistive devices such as canes and wheelchairs. In many of these situations, Dr. Clark displayed difficulty in viewing her phone timer without maneuvering her body or hands. This created frustration because it could compromise her attention or patient safety. Additionally, measurements of the environment and testing equipment were recorded.

There were some limitations in our observation findings due to protecting Dr. Clark's patient's privacy. The observation took place in an active lab environment where patients were present. This meant our team was limited in taking pictures as we moved through the lab to prevent any patients from being in our visuals. We were able to capture some images of the environment if there were no patients in the frame, however, we were unable to do so when Dr. Clark was modelling the test because we were walking around the room. Another limitation was that the team did not observe Dr. Clark conduct the test with actual patients, and instead she demonstrated the test with a colleague who acted as a patient. Although the colleague was a physical therapist who regularly administers the 6MWT, the demonstrations may not fully capture the unpredictability or safety considerations of working with actual patients.

Conclusion

We will move forward by ideating potential solutions and creating mockups to address Dr. Clark's challenges in timing the 6MWT. Then, we plan to return to Shirley Ryan AbilityLab to test our mockups with Dr. Clark and get feedback on their effectiveness. During our follow up, we plan to capture more photos and video of the test equipment, the 6MWT being conducted, and our mockups in use for visual documentation.

APPENDIX B: CLIENT INTERVIEW SUMMARY

Introduction

The client interview was conducted with Dr. Gina Clark, a physical therapist at Shirley Ryan AbilityLab on April 7th, 2026 at 3:00pm. The meeting was conducted in cooperation with two other groups on Zoom and was recorded. The purpose of the meeting was to establish a mutual understanding of the 6 Minute Walk Test (6MWT) and how Dr. Clark manages to measure time and distance. This appendix summarizes the interview into 4 separate categories: design context, design problem, users, current solutions, and requirements.

Design Context

The Use of a 6 Minute Walk Test

To evaluate a patient's progress in walking, Dr. Gina Clark conducts a 6 Minute Walk Test (6MWT) to measure the distance the patient walks in the time span of 6 minutes.The test is a standardized reliable validated outcome measure and commonly used across many labs in the country. As a patient's foot speed increases, the walk distance increases, so the test is a relevant method to measure patient progress.

The Way to Conduct a 6 Minute Walk Test

A 6 minute timer is set at the start of the test, and never stops during the test. The final distance walked is measured at the end of 6 minutes and noted down. The physical therapist may assist the patient from behind while conducting the test. Patients may wear gait belts during testing, so if someone loses balance or trips, the physical therapist prevents them from falling. Some patients may use a walker to assist in walking, and other patients may need to use a wheelchair follow

The Location of the 6 Minute Walk Test

They conduct the test at the Shirley Ryan AbilityLab Main Facility. There is an indoor track in the facility that is a smooth flat level therapy gym floor. The therapy floor may become busy, in which case the test is conducted in the hallways. The indoor track is not a straight path around the floor.

Design Problems

1. When conducting the 6MWT, both of Dr. Gina Clark's hands are occupied with holding items
    a. Uses her right hand to hold the gait belt on the patient
    b. Uses her left hand to hold the measuring stick
2. Providing a timing update may motivate patients and allow them to know how long their rest breaks are

a. However, if patients want to know the distance walked or time elapsed, Dr. Clark must let go of either the patient or the measuring wheel to pull her phone out of her pockets

User Conditions

Dr. Gina Clark holds the measuring wheel to measure the distance walked during the 6MWT. Both physical therapist and patient are allowed to see the timer—the timer does not need to be hidden. The therapist may check the time to jot down notes at a specific time or to make a mental note of how long the patient has taken a break for.

Current Solutions

- Shirley Ryan AbilityLab stocked items
  - Stopwatches
  - Measuring wheels
  - Walkers

- Smartphone as a timer
  - Most physical therapists use their smartphones instead of a stopwatch
  - The phone is always available and on-hand compared to the stopwatch

- Apple Watch as a timer
  - Dr. Gina Clark has used her Apple watch to measure time before
  - However the screen turns off frequently and the angle at which the watch faces is uncomfortable to read

- Carry-on solutions (to hold phone)
  - Fanny pack
  - Sling pack

Suggestion for Potential Solution

Dr. Gina Clark suggested attaching a timer (either in the form of a phone or a stopwatch) somewhere on the measuring wheel. The location can vary, but we should investigate the top, middle and bottom of the measuring wheel.

Requirements

- *Improve 6MWT protocols*
  - Prevent physical therapist from constantly taking out phone to check time and losing a hand for use
- *See timer easily*
  - The physical therapist must be able to see the timer in an open spot with relative

ease. This could come in the form of a bigger screen or ergonomic placement.

- C*ost-effective*
    - If things were to break then we would want to be able to replace it
    - For example, an item costing $104 is a bit too much
- A*djustable/modular*
    - Many PTs will use the design
    - Adjustable to different designs of measuring wheels
- S*anitizable*
    - All items in SRA are sanitized on a regular basis
- D*urable*
    - The design will be under constant use—attaching, detaching, and moving around, so it must be durable enough to withstand use

Conclusion and Next Steps

The interview was extremely informational and offered us much insight into the scope of the problem as well as a potential solution. We were able to generate additional questions to ask and measurements we need for the next step of the process—observation. The observation will be held at Shirley Ryan AbilityLab and Dr. Gina Clark will demonstrate the 6MWT to us and field additional questions we have. With the information from secondary research, interview, and observation, we will be able to begin ideating more potential solutions and developing mockups to test.

APPENDIX C: SECONDARY RESEARCH SUMMARY

Introduction

Our problem is that during a 6-Minute Walk Test (6MWT), physical therapists must simultaneously support patients while measuring both their distance and time progression using a measuring wheel and a separate time-keeping device. Our project partner reached out to us to develop an attachment that connects the time-keeping device to the measuring wheel such that the digits can be read throughout the 6MWT, eliminating the need to hold another tool. This solution would allow the physical therapist to operate the measuring wheel in one hand while being able to see the time progression, freeing their other hand to guard or assist the patient.

Our background research is divided into several topics, including information about the project partner, the 6MWT, measuring wheels, and current solutions. We also analyze how this information informs our ideation and design process. Through understanding these topics, we build a comprehensive understanding of the design challenge in order to prepare for our initial project partner meeting.

Project Partner Background

Our project partner and end user Dr. Gina Clark works at the Shirley Ryan AbilityLab (SRAL) (Figure 1C), a physical medicine and rehabilitation research hospital [1]. SRAL is a leading institution in rehabilitation and medical discovery and has been ranked by the *U.S. News & World Report* as the top rehabilitation hospital for the past 35 years [2]. Dr. Clark is an outpatient physical therapist who primarily works in rehabilitation settings in order to improve patients' mobility and functional independence. In her role, she works with individuals with a variety of diagnoses, including but not limited to those with arthritis or other joint conditions, brain injury, spinal cord injury, and stroke [3].

Figure 1C. Shirley Ryan AbilityLab. Source: [4].

6 Minute Walk Test

During the 6MWT, the physical therapist controls the measuring wheel while walking near the patient, typically about a half step behind, in order to observe gait and ensure patient safety. Additionally, physical therapists record documentation such as the number of rests and their duration [5]. Thus, they must simultaneously monitor the patient's safety and gait, the distance traveled using the measuring wheel, and the time progression. Important features of the 6MWT are that it is low-cost, easy to administer, and requires minimal equipment, acting as a standardized and accessibility method to quantify patient mobility progress [6]. SRAL reinforces this by providing documentation in their database outlining how to administer the test and analyze the results [5].

Since the 6MWT is an easy yet informative tool, physical therapists frequently employ it in order to measure patient rehabilitation progress. It replicates day-to-day movement, allowing the patient to determine their pace and speed. Physical therapists utilize the 6MWT for a wide range of patients with different conditions including but not limited to brain injury, stroke, neurological conditions, pulmonary diseases, and spinal cord injuries [5].

Measuring Wheel and Context of Use

SRAL most commonly uses the standard size of measuring wheel shown in Figure 2C, however, other wheel and rod diameters are also used. Regardless of these variations, all measuring wheels need to be reliable and consistent, and any attachments to wheels should maintain this consistency. Measuring wheels are not only limited to the 6MWT; they are commonly used in sectors such as construction and landscaping to measure distances across terrain. To operate a measuring wheel, the user grasps the handle with one hand and rolls the wheel across the ground (Figure 3C). The wheel then measures the distance traveled and displays it on a screen located near the wheel. Wheel diameters vary depending on intended use, with smaller wheels typically being used for smaller spaces, while larger wheels are used for measuring longer distances [7].

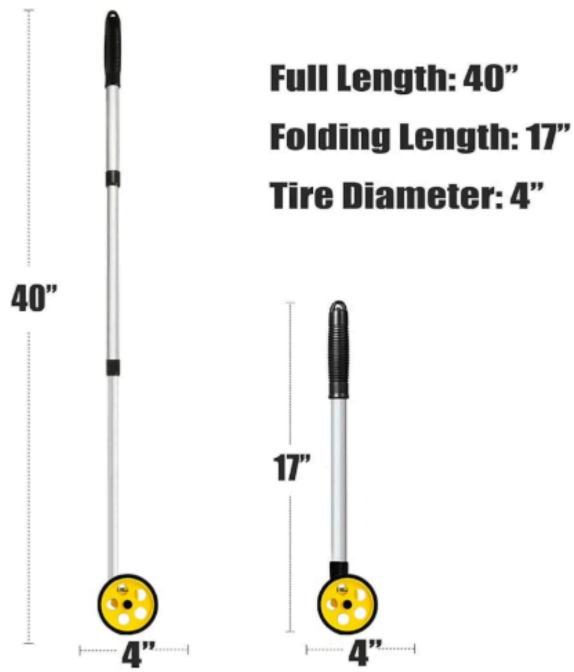

Figure 2C. Dimensions of a standard measuring wheel. Source: [8].

Figure 3C. A person using a measuring wheel. Source: [9].

Current Solutions and Model Products

The project definition illustrated three different solutions that the project partner currently uses. The first involves wearing a stopwatch around the neck; however, the user is unable to see the time progression unless they reposition the watch to a more visible angle. Thus, the user is unable to consistently view the time and must resort to periodically checking it. This removes a hand that would otherwise be guarding or assisting the patient. In the second solution, the user holds a stopwatch or phone in the same hand as the measuring wheel. By holding both in one hand, the user is able to keep the other hand free in order to guard the patient. When guarding is not required, the user holds the timer in the opposite hand, since maintaining a free hand is not necessary.

In researching model products, we explored devices that acted in place of the stopwatch. Key model products researched for the time-keeping component included clip-on stopwatches and wrist timers/watches (Figure 4C). Clip-on stopwatches are commonly used for activities such as hiking, climbing, or biking. They act as a relevant model product due to their ability to be attached to other equipment and their hands-free use, which aligns with a key priority of the user. Despite this, these clip mechanisms may not be compatible with the shaft of a measuring wheel and lack adjustability for better positioning.

Figure 4C. Clip-on stopwatches on the market. Source: [10, 11].

Wrist timers/watches are worn around the wrist and act as a model product since they allow for relatively effective time monitoring (Figure 5C). Compared to a stopwatch worn around the neck, checking the time on a watch may require less movement. Despite this advantage, it still requires arm movement, which may distract the user from their main responsibility of guarding and observing the patient.

Figure 5C. Example of a wrist watch. Source: [12].

During our research, we also identified GPS tracking as an alternative method for measuring distance in place of a measuring wheel (Figure 6C). GPS tracking offers hands-free distance measurement, which supports the user priority of maintaining at least one free hand. However, this method has several shortcomings. Utilizing GPS tracking requires the test to be conducted outdoors and may result in inaccurate measurements of short distances. Although the project partner may not be seeking an alternative method to the measuring wheel, this research was included to provide a broader understanding of potential approaches and current technologies available.

Figure 6C. GPS tracking materials for the 6MWT. Source: [13].

Implications on Design Process

Based on the research above, several implications emerged that will inform our design process. First, the physical therapist is performing multiple tasks simultaneously, such as monitoring patient safety, measuring distance, and tracking time. As a result, the design must be simple, intuitive, and easy to use without adding burden. In addition, the design will be used in a medical environment at SRAL. Thus, it is possible that the attachment must be easily cleaned or disinfected and be compact enough for storage.

The solution should allow the user to efficiently view the time progression without requiring significant hand movement. In order to achieve this, the timer must be seen at an optimal position so the user can easily view the display. If the solution is to be used for not only Dr. Clark, but other physical therapists at SRAL, would likely have to be adjustable to account for staff of different heights as well as possible different measuring wheel brands.

Accuracy is also an important priority to maintain. The 6MWT relies on precise measurements of both time and distance for reliable results. Therefore, the attachment should not interfere with the functionality of the measuring wheel or obstruct the screen that displays the distance measurements.

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APPENDIX D: PROXY TESTING SUMMARY

Introduction

Proxy testing was conducted by the team at the Ford Design Shop prior to finalizing the design configuration. The purpose of this session was to evaluate design variables (namely phone orientation, attachment placement on measuring wheel shaft, pole attachment mechanism, and phone mount mechanism) before committing to a specific combination of components. Proxy users stood in for the primary user (Dr. Clark) to generate preliminary data on visibility, comfort, and attachment speed across a range of options.

Phone Orientation

During user testing, we noticed that Dr. Clark found certain orientations on the phone on the measuring wheel more comfortable than others. The solutions where she didn't notice the weight of her phone when maneuvering the wheel and conducting the test were rated highest on comfortability by her.

We found having the phone oriented vertically and slightly off centered to the right of the wheel, when Dr. Clark used her left hand to move the wheel, was comfortable. We also found that having the phone oriented horizontally, centered, and resting on the rod of the wheel was equally comfortable as the described vertical orientation.

The free body diagram shows the torque balance between the weight of the measuring wheel rod and the weight of the phone (Figure 1D). When holding this attachment system, the handling of the measuring wheel feels more weighted than it did prior to having an attachment. Dr. Clark expressed that a moderate weighted feeling is not detrimental and actually is helpful. It makes rolling the measuring wheel feel more anchored, which helps it stay on path.

Dr. Clark held the device in her left hand with her palm facing upwards and the rod angled downwards. In this orientation, her forearm feels most comfortable if her hand is not twisting further left. When the palm is facing upwards, the left wrist has reduced comfortable range to rotate towards the left and greater range to rotate right. As a result, torque that produces a slight rightward rotation, or maintains a neutral moment balance, feels more comfortable than a torque that rotates the wrist further left towards the end of its natural range of rotation.

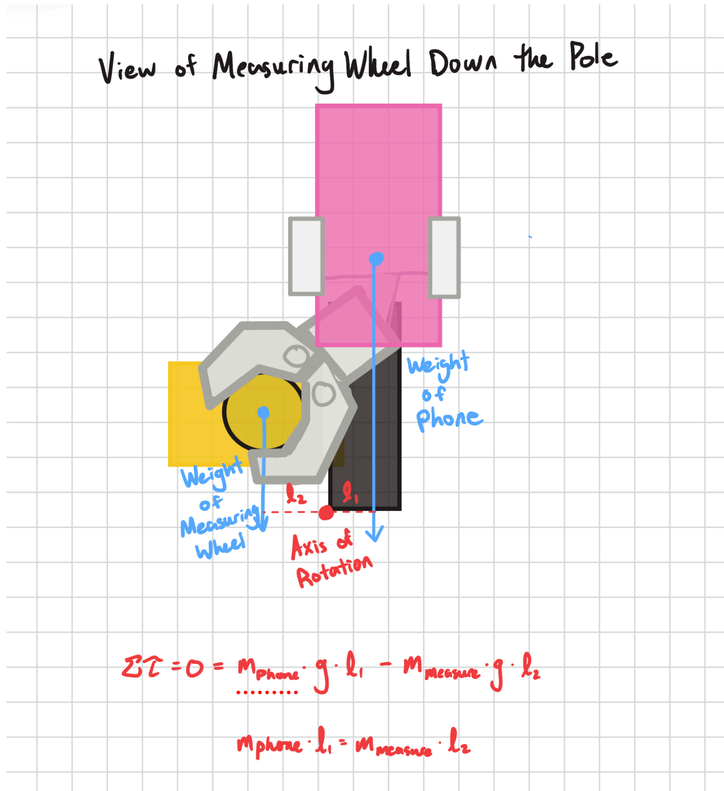

Figure 1D. Diagram of the torque around the contact point of the wheel and the ground

Table 1D. Results of phone angle proxy testing.

Users	Height	Angle away from the line of the shaft (degrees)	Visibility Rating
User #1	5'2"	75	8
		90	10
		105	10
User #2	5'4"	75	10
		90	10
		105	10
User #3	6' 2"	75	9
		90	9.5
		105	10

In our proxy user testing, set the phone at three different angles off the shaft of the measuring wheel: 75°, 90°, and 105°. Our testing revealed that users rated the 90° orientation as the easiest to view and read the screen (Table 1D). There was little difference between the 90° and 105° angles, however, some users noted that the screen felt slightly distorted towards the top at the 105°, so we ultimately chose the 90° which worked well for proxy users across different heights.

Measuring Wheel Location

Figure 2D. Diagram of the location of the attachment of the measuring wheel.

When considering where attachment should be placed on the measuring wheel, it must be high enough on the rod that the phone is at a proper angle for the therapist to view. It also must be high enough that the therapist can reach the phone with their non-measuring wheel hand and press the screenshot buttons. However, it must not be too high that it gets in the way of the hand holding the rod of the measuring wheel. These requirements were used to create the specifications for the attachment placement.

In our proxy user testing, we placed the attachment in 4 different lengths from the bottom of the handle: 0 cm, 6 cm, 12 cm, and 15.5 cm. Our testing showed that overall, users rated the 6 cm length to be the most convenient, although the other distances also showed high visibility rating (Table 2D). This shows that we should place the attachment at a distance of 6 cm, but the distance is subject to variability.

Table 2D. Results of the phone location proxy testing.

Users	**Height**	**Distance from the bottom of the handle (cm)**	**Visibility Rating**
User #1	5'2"	0	9
		6	10
		12	9

		15.5 (max)	7
User #2	5'4"	0	9.5
		6	10
		12	8
		15.5 (max)	10
User #3	6' 3"	0	8
		6	7
		12	7
		15.5 (max)	5

Ultimately, the attachment is removable and will be reattached each time the 6MWT is conducted, so there will be some variability in where it is placed each time. These specific dimensions are suggested approximates for where the attachment is ideally placed.

Design Mechanisms

The mechanisms involved in the design come in two locations: the attachment to the measuring wheel pole, and the phone holder. For the attachment to the measuring wheel, there were three main alternatives that we considered: the cam lever clamp, the claw clamp, and the red lever clamp. Each one of these has its own advantages, however, we focused on the attachment speed and ease of use for each alternative. The speed of attachment is one of our main problems as any time spent attaching the device is equal to the time not spent on the patient, and ease of use reduces overall issues with the design in daily use.

Our proxy user testing involved a) time to attach and b) difficulty of use. For the time of attachment, the cam lever clamp averaged 24.20 seconds, the plastic screw clamp averaged 15.30 seconds, and red lever screw clamp averaged 15.60 seconds (Table 3D). For the difficulty rating, the cam lever clamp was rated a 3.33, the plastic screw clamp was rated a 2.00, and the red lever screw clamp was rated a 3.33 (Table 3D). Of the three designs, the plastic screw clamp performed the best in both the time to attach and difficult rating, which is why we settled on using it in our final design.

Table 3D. Results of the pole attachment proxy testing.

Attachment 1	Users	Difficulty of Use (1-5)	Time to attach (s)
Cam Lever Clamp	User #1	3	21.55
			22.14
			23.7
	User #2	4	31.13

			25.34
			20.95
	User #3	3	24.32
			27.63
			21.08
	Average	3.33	24.20
Attachment 2	**Users**	**Difficulty of Use (1-5)**	**Time (s)**
Plastic Screw Clamp	User #1	2	21.91
			14.5
			11.73
	User #2	2	19.54
			15.97
			12.43
	User #3	2	16.72
			14.23
			10.64
	Average	2.00	15.30
Attachment 3	**Users**	**Difficulty of Use (1-5)**	**Time (s)**
Red Lever Screw Clamp	User #1	2	19.73
			14.28
			11.65
	User #2	4	18.06
			19.72
			14.83
	User #3	4	15.28
			14.29
			12.54
	Average	3.33	15.60

Similarly with the pole attachment, we considered two main alternatives for our phone holder. The main concern for these mounts is not only the compatibility for various phones and the speed of attachment, but also comfortability for daily use. The size of most phones with their phone cases range from 70 to 86mm in width as well as 6mm to 15 mm in thickness, therefore we chose designs that fit within this range of phone sizes: the screw-in mount and a clamp-in mount.

From testing, the screw-in mount provided a mean time of 11.02 seconds to attach and the clamp-in mount took a mean of 4.33 seconds to use (Table 4D). For the user-rated difficulty of use, the screw-in mount had an average of 1.33 compared to the clamp-in mount's 4.33 (Table 4D). Although the clamp-in mount was faster to attach, its difficulty of use limits it from being a safe and reliable option compared to the screw-in mount. Ultimately, the ease of use of the screw-in mount decided the matchup and we settled on using the screw-in mount.

Table 4D. Results of phone mount attachment proxy testing.

Mount 1	**Users**	**Difficulty of Use (1-5)**	**Time to clamp phone (s)**
Screw-In Mount	User #1	2	26.45
			11.12
			8.42
	User #2	1	9.52
			8.55
			8.82
	User #3	1	12.43
			6.89
			6.97
	Average	1.33	11.02
Mount 2	**Users**	**Difficulty of Use (1-5)**	**Time to clamp phone (s)**
Clamp-In Mount	User #1	4	6.31
			4.86
			4.5
	User #2	4	4.97
			6.23
			5.61
	User #3	5	7.51
			6.76
			5.34
	Average	4.33	5.79

Adjustability

The location of the attachment on the wheel is slightly variable in each use. Other factors of the design including the diameter of the measuring wheel rod and the phone timer width are also variable in different scenarios of the 6MWT.

We decided to not make the angle of the phone mount adjustable although we had previously considered a ball and socket joint. In testing, we found that the one set angle of the phone (90 degrees set vertically in relation to the shaft) is typically in the line of sight and the phone does not need to be adjusted. A phone mount with a set angle makes the design more intuitive and removes the risk of the phone orientation changing or screen being unstable during the 6MWT.

Materials

During design review, we were recommended to include a silicone or foam aspect to the measuring wheel clamp, allowing for increased friction as well as reducing the damage done to the measuring wheel over time. After evaluation, the team opted to retain the ABS plastic construction of the clamp body, as plastic provides sufficient structural rigidity for secure attachment. The inner surface of the clamp's claw already incorporates rubber pads, which provide adequate grip on the shaft while distributing pressure more evenly than bare plastic would. This reduces the risk of surface wear to the measuring wheel shaft over time without requiring a separate foam or silicone addition to the design.

Conclusion

Overall, the proxy user testing informed our design rationale and final design considerations. The testing regarding phone orientation and phone placement showed that the phone orientation of 90 degrees from the handle and a distance of 6 cm from the handle was comfortable for our proxy users. Regarding the design itself, the plastic screw clamp and the screw-in clamp proved to be both the fastest and most comfortable for users. Thus, our design should look to incorporate the plastic screw clamp and the screw-in phone clamp at a 90 degree angle on the measuring wheel.

APPENDIX E: USER TESTING SUMMARY

Introduction

User testing was conducted with Dr. Gina Clark, a physical therapist at Shirley Ryan AbilityLab (SRAL), on May 5th, 2026. The session took place at SRAL and lasted approximately 60 minutes. Team members present were Esha Chandra, Lois Xie, and Ethan Park.

The purpose of the session was to evaluate physical mockups of a phone/timer attachment designed to assist in administering the 6 Minute Walk Test (6MWT), which measures the total distance a patient walks in six minutes and is a standardized, validated outcome measure used widely across rehabilitation settings. During the test, Dr. Clark holds a measuring wheel in one hand and supports the patient via a gait belt with the other, leaving no free hand available to check a phone timer. The mockups under evaluation were designed to keep the physical therapist aware of the elapsed time without requiring release of the patient or of the measuring wheel.

Three mockups were evaluated during the session:

- Measuring Wheel Clamp (Mockup 1): A phone holder clamped directly onto the measuring wheel shaft
- Arm Band (Mockup 2): An adjustable arm band tested in two placements - on the patient's upper arm (Placement A) and on the PT's forearm (Placement B)
- Landscape Frame (Mockup 3): A horizontal phone holder also mounted on the measuring wheel

The team had also planned in advance to discuss a potential auditory supplement as a design feature. No physical mockup or sketch was produced for this concept; the team described the idea verbally and solicited Dr. Clark's feedback.

Methodology

The following describes each mockup as it was constructed and presented for testing.

Measuring Wheel Clamp (Mockup 1)

Figure 1E. Measuring Wheel Clamp

The Measuring Wheel Clamp (Figure 1E) was assembled from miscellaneous parts. At its core was a commercially available phone clamp fitted with a ball joint, which allowed the phone to be repositioned at different angles. The clamp was affixed to the measuring wheel shaft using a small metal plate and a U-bolt secured by two small nuts, which could be tightened directly onto the shaft.

Arm Band (Mockup 2)

Figure 2E. Arm Band

The Arm Band (Figure 2E) was constructed from an adjustable Velcro strap. A plastic bag reinforced with a rigid plastic insert on the inside served as the phone pocket, and was attached to the strap using binder clips. The phone slid into the bag, which held it in place against the wearer's arm.

Landscape Frame (Mockup 3)

Figure 3E. Landscape Frame

The Landscape Frame (Landscape 3E) consisted of a flat plastic plate attached to the measuring wheel shaft using rubber bands. The phone was propped onto the plate at an angle and secured to it with additional rubber bands, orienting the screen horizontally in a landscape/picture-frame position.

Each mockup was presented to Dr. Clark in sequence. The team described each design concept, then asked Dr. Clark to physically handle and (briefly) simulate its use during a 6MWT – holding the measuring wheel in one hand and managing a gait belt in the other. Dr. Clark was observed while in motion with each mockup and was asked follow-up questions after each trial.

After handling each mockup, Dr. Clark rated it on a 1-10 (worst-best) scale across four criteria:

- Cognitive ease: The mental effort required to glance at and read the timer
- Comfort: The physical comfort of the attachment during use
- Visibility/line of sight: How easily the screen could be seen without shifting attention away from the patient
- Ease of attachment/detachment: How quickly and independently the attachment could be set up and removed

The team recorded Dr. Clark's scores, verbal responses, and observable behaviors for each mockup. The team had also planned to solicit Dr. Clark's feedback on a potential auditory supplement to the design, and this was discussed following the individual mockup evaluations.

Results

Results for each mockup are reported below (Table 1E, Table 2E, Table 3E, Table 4E). Scores were assigned by Dr. Clark on a 1–10 scale. Observations describe what was seen or heard during testing without interpretation.

Measuring Wheel Clamp (Mockup 1)

The Measuring Wheel Clamp was clamped onto the shaft of the measuring wheel (Figure 4E). Dr. Clark held the wheel in her left hand, as she normally does during the 6MWT.

Figure 4E. Dr. Clark fitting Mockup 1 onto the measuring wheel.

Table 1E. Feedback on Measuring Wheel Clamp.

	Cognitive Ease	**Comfort**	**Visibility / Line of Sight**	**Ease to Put On / Take Off**
Score	10	10	10	8

Notes	Dr. Clark described working with the mockup as very easy. She noted the added weight of the phone made the wheel feel more anchored in her hand.	Dr. Clark noted a slight sensation at her wrist but did not describe it as cumbersome.	Described as "perfect." Dr. Clark noted she already glances downward during the test to monitor obstacles and distance traveled, placing the screen naturally in her sightline. She also noted it remained within arm's reach for screenshotting while stopped.	Dr. Clark had no difficulty putting on the attachment and recognized the tightening mechanism as familiar. She noted her schedule allows her to set it up before appointments if needed.

Other observations:

- Dr. Clark expressed a desire for the attachment to be slightly more secure.
- Dr. Clark identified the most critical safety hazard as the phone falling off the attachment, which would create a tripping risk for the patient or anyone else walking around the lab.

Arm Band (Mockup 2)

The Arm Band was tested in two placements. In Placement A, the band was worn on the patient's upper arm/bicep. After that trial, the band was repositioned to the PT's own forearm for Placement B.

Table 2E. Feedback on Placement A: Patient's Upper Arm.

	Cognitive Ease	Comfort	Visibility / Line of Sight	Ease to Put On / Take Off
Score	2	1	1	Not scored

Notes	Dr. Clark physically twisted her head and upper body to the side to view the screen during the simulation.	Dr. Clark noted that placing the band on a patient's shoulder may not be feasible in cases where the patient has a wound or injury at that location. She also stated a preference for any attachment to be on her measuring wheel hand rather than her dominant hand.	Described as "a little out of view." Dr. Clark verbally noted she would want the phone screen oriented to face her.	Dr. Clark verbalized difficulty putting the band on independently and described slow setup as a significant issue in a clinical context. No score was assigned.

Other observations:

- Dr. Clark stated she liked this mockup the least of all options.
- Dr. Clark noted that portability was a positive attribute, but it did not outweigh the usability concerns.

Placement B: PT's Forearm

Figure 5E. Dr. Clark using Mockup 2.2 with mock patient.

Table 3E. Feedback on Placement B: PT's Forearm.

	Cognitive Ease	**Comfort**	**Visibility / Line of Sight**	**Ease to Put On / Take Off**
Score	8	5 (potential to increase)	8	Not scored
Notes	Dr. Clark did not have to twist or contort her body to see the screen in this position.	Dr. Clark said the band was not comfortable around her forearm in its current form, but acknowledged that comfort could improve with design changes.	Dr. Clark was able to view the screen without significant body movement. She noted she would still prefer the phone screen to face her more directly.	Dr. Clark stated this placement would face the same setup challenges as Mockup 2.1. No score was assigned.

Other observations:

- Dr. Clark preferred Placement B (Figure 5E) over Placement A but still liked it less than Mockup 1.

Landscape Frame (Mockup 3)

The Landscape Frame was mounted to the measuring wheel (Figure 6E), orienting the phone screen horizontally in a landscape/picture-frame position.

Figure 6E. Dr. Clark using Mockup 3.

Table 4E. Feedback on Landscape Frame.

	Cognitive Ease	**Comfort**	**Visibility / Line of Sight**	**Ease to Put On / Take Off**
Score	10	10	10	N/A
Notes	As with the Measuring Wheel Clamp, Dr. Clark described the mockup as very easy to use. The phone position required no additional head movement or body adjustment to read.	As with the Measuring Wheel Clamp, Dr. Clark noted no discomfort during use. The landscape orientation did not affect how the wheel was held.	As with the Measuring Wheel Clamp, Dr. Clark noted the screen fell naturally within her existing downward sightline and remained within arm's reach for screenshotting while stopped.	Ease to put on/take off was not separately evaluated for this mockup.

Other observations:

- Dr. Clark stated she would be comfortable downloading a free horizontal clock app to support this orientation of the phone screen.
- Dr. Clark recommended making setup easier and making the attachment more durable.

Auditory Supplement (Discussed, Not Physically Tested)

As planned, the team discussed the possibility of an audio alert feature as a supplement to any of the above designs. Dr. Clark described the idea as "a bit of a toss-up," not strictly necessary, but potentially beneficial. This sentiment was largely shared by the team, as the auditory supplement had been treated as a lower-priority item relative to the mockup evaluations. If the feature were included, Dr. Clark specified that it would need to be toggleable so that it could be turned on or off depending on the clinical situation, and that the alert interval should be set to every two minutes to align with the check-in points she currently tracks mentally.

Discussion

The primary finding from user testing is that both measuring wheel designs (Measuring Wheel Clamp and Landscape Frame) outperformed the arm band configurations across most criteria. Both received perfect (relative) scores on cognitive ease, comfort, and visibility, while the arm band placements scored as low as 1 in multiple categories. This result points toward a measuring wheel mount as the preferred approach for further development.

The Arm Band trials helped to clarify what the design must avoid. Placement A required Dr. Clark to twist her head and body to see the screen, received a comfort score of 1, and was described as difficult to set up independently. The repositioned Placement B improved visibility and cognitive ease, but comfort and setup challenges remained. The consistent pattern across both arm band variants is that any design requiring the therapist to redirect gaze too far from the patient, or that adds undue difficulty to setup, will not be accepted.

Dr. Clark seemed to rate both the Measuring Wheel Clamp and Landscape Frame equally. The Landscape Frame's horizontal orientation offers a landscape display that could simplify reading a phone timer at a glance, and Dr. Clark's willingness to download a compatible app removes that as a barrier. However, the ease-of-setup dimension was not formally scored for the Landscape Frame, leaving an open question about whether it is meaningfully harder to configure than the Measuring Wheel Clamp. Dr. Clark's recommendation to improve setup ease and durability applies to both. With that being said, security of the phone attachment was flagged as a non-negotiable safety concern. Dr. Clark explicitly identified a falling phone as the most critical hazard, as it could cause the patient to trip. Any final design must address this with a reliable and secure fastening mechanism.

On the auditory component, Dr. Clark's tepid response suggests it is not a core requirement, but could add value if implemented as a toggleable alert at 2-minute intervals, particularly for the mid-test check-ins she currently tracks mentally.

Limitations

There are some potential limitations to these findings. Testing was not conducted during an actual patient session or in a fully busy lab environment, so it is unclear how the true scenario demands(with noise, movement, and the priority of patient safety) would have affected perceived usability. Additionally, mockups were not evaluated across different measuring wheel sizes or with physical therapists of varying heights, so modularity and adjustability (requirements established during the initial client interview and observation) should be a continued focus in the next design iterations.

Conclusion

The team will move forward refining the measuring wheel mount concepts based on feedback from Mockup 1 and Mockup 3. Priority areas for the next iteration include improving attachment security, simplifying setup, and increasing durability. A follow-up testing session in a more representative clinical environment is preferred before finalizing the design.

APPENDIX F: SAFETY EVALUATION

Scenarios & Design Failures	Implications	Frequency	Impact	Risk Rating	Design Options
Attachment falls off measuring wheel	The phone falls on the ground. There is an object in the way of the paitent and the users walking. The user, paitent, and other people in the walking lab can trip over object. Timing is now inaccurate, or the test has to restart.	About half the time the design is used (3)	minor injury to user / part of design doesn't work and must be repaired or updated (3)	9	While this happens sometimes right now, ideally, it should not happen at all in the final design. Use an attachment method that has a reliable strong grip. We can take inspiration from bike clamps on strong clamps that do not slip.
Attachment hits another person	The affected person may be hurt, especially if they are another patient. Phone may be knocked onto the ground, and the test may need to be restarted.	Once in a while, but much less than half the time (2)	minor injury to others / part of design doesn't work and must be repaired or updated (3)	6	Attach to the measuring wheel in a way that leans towards the inside and avoids potentially hitting people. Currently, Dr. Gina Clark uses the measuring wheel with her left hand, so the "inside" would count as the right side of the measuring wheel.
Attachment is loose and screen is not stable	The physical therapist will not be able to conduct the test accurately and may have to restart the test. The attachment also has a risk of falling off the measuring wheel, causing harm through physical means.	Almost every time the design is used (4)	really irritated user / damaged part of design, still functional (2)	8	Use an attachment method with a strong grip and make sure the parts of the design are tightly screwed together. Use a tight and strong method to hold the phone steady (regardless of its weight), which could come in the form of a strong clamp.
Attachment gets caught on an object	The measuring wheel may be affected and the distance measurment may be inaccurate. This will cause the test to be less accurate and may need to be restarted. The attachment also faces the rsik of falling off, which could harm the user.	Once in a while, but much less than half the time (2)	minor injury to user / part of design doesn't work and must be repaired or updated (3)	6	This could be achieved through minimizing outward sticking components on the measuring wheel attachment (i.e. corners, long bolts). We could test this this by weaving the around the shop and noting if the attachment grazes tables, clothing, etc.
Phone falls off measuring wheel attachment	The phone is a major tripping hazard and may result in hurt patients or physical therapists in SRAL. The test would likely have to be reconducted	About half the time the design is used (3)	minor injury to user / part of design doesn't work and must be repaired or updated (3)	9	This could be achieved through performance testing that includes dropping the measuring wheel, crashing it into something, or shaking it, which all put strain on the stability of the attachment. If the phone/placeholder object stays secure, we can avoid any tripping hazards
Takes a long time to set up attachment	User may need to set up measuring wheel in advance, which takes away valuable time. If this is inconvient, user may revert to current solution	Almost every time the design is used (4)	really irritated user / damaged part of design, still functional (2)	8	Design a clamp which is quick and easy to put on. The current screw clamp takes a while to tighten, so we might use a different type of screw. Consider a new type of clamp such as bike clamps or clips.
User is unable to take screenshot	User has to memorize or note down when the patient is taking a break, which increases cognative load and could impact accurate results if they forget	Almost every time the design is used (4)	mild annoyance to user / superficial but not functional defect on design (1)	4	The phone attachment part should be designed to not over the screenshot buttons on the iphone. This is typically achieved through vertical orientation of the phone. Alternatively, suggest a new timer app which has an easy way to measure laps or record times.
User is unable to see screen properly (due to height)	User has to contort their body to properly see the display, taking away some of their concentration on the patient	About half the time the design is used (3)	really irritated user / damaged part of design, still functional (2)	6	This could be achieved through multiple rounds of performance testing by having students of varying heights try the mockup. From this, we are able to refine the screen angle to make it optimal.
User is unable to properly attach device to measuring wheel	User stops using the attachment and reverts back to current solution	Almost every time the design is used (4)	really irritated user / damaged part of design, still functional (2)	8	We must ensure that the design is user friendly, this could be achieved through multiple rounds of performance testing, as well as a round of user testing to ensure that they are comfortable with the mechanism(s).

APPENDIX G: INSTRUCTIONS FOR USE

The following are steps to follow when using *RollTime* to aid administering the Six Minute Walk Test (6MWT).

The diagram below shows the location of the screw clamp and phone mount knob (Figure 1G).

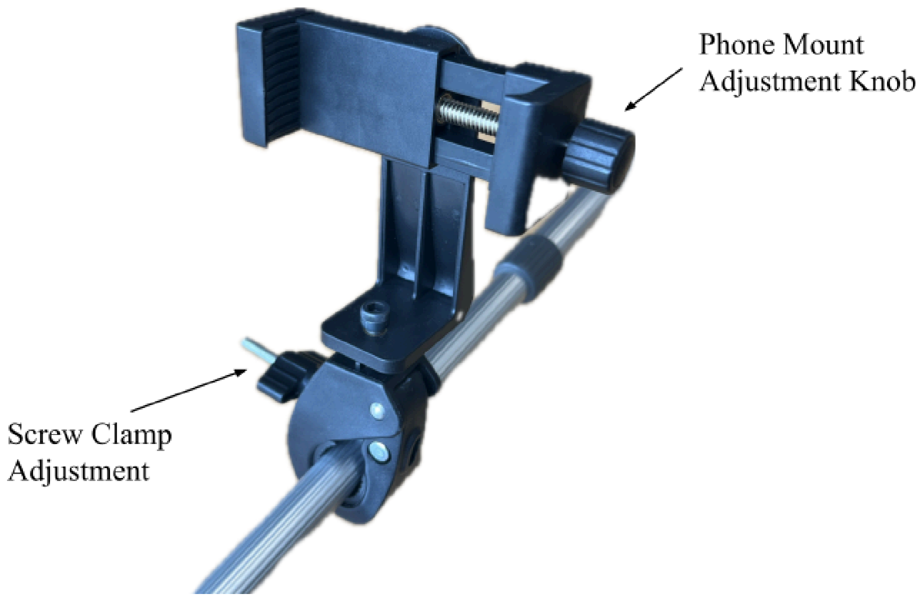

Figure 1G. RollTime on measuring wheel shaft with labelled adjustment screw and knob

Set Up

1. Turn the screw on the screw-clamp counterclockwise until the clamp is wide enough to fit around the shaft of the measuring wheel (Figure 2G).
2. Place the attachment on the shaft of the measuring wheel. Position it approximately 6 centimeters from the bottom of the handle of the measuring wheel.
3. Rotate the attachment so the phone mount is facing upwards and the phone will be held vertically when installed (Figure 3G).
4. Hold the attachment in position with one hand. Turn the screw clamp clockwise until the attachment is securely fastened to the shaft of the measuring wheel and remains stable without support (Figure 4G).
5. Turn the phone mount adjustment knob counter clockwise until the side grips are wide enough to fit the phone (Figure 5G).
6. Place the phone between the side grips. Turn the adjustment knob clockwise until the phone is held securely and does not move or slip out (Figure 6G).
7. Place the measuring wheel on the ground and verify that the phone and attachment are oriented properly. If needed, slightly loosen the screw clamp, adjust the attachment angle, and retighten the screw (Figure 7G).

8. Open the timer app on the phone and set a 6 minute timer. Instruct the patient to begin walking and start the timer.

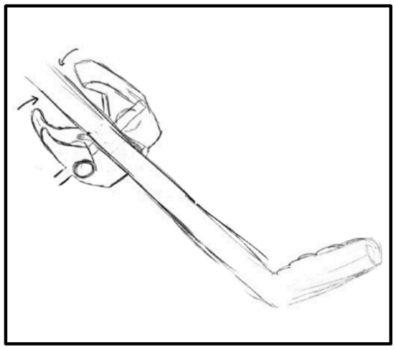

Figure 2G. Wide screw clamp around measuring wheel shaft

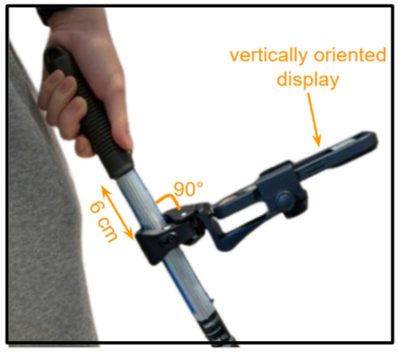

Figure 3G. Location and orientation of RollTime

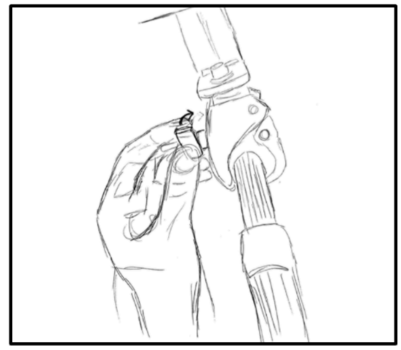

Figure 4G. Fastening RollTime onto the measuring wheel shaft

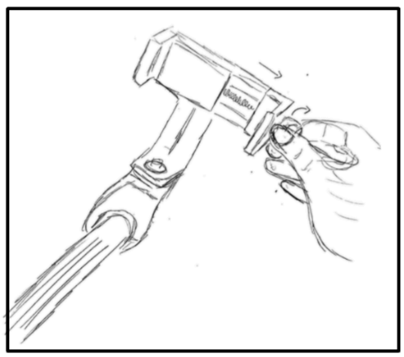

Figure 5G. Widening phone mount adjustment knob

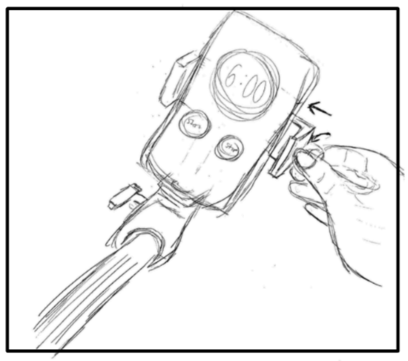

Figure 6G. Fastening phone in mount

Figure 7G. RollTime set up with measuring wheel on the ground

Removal

1. When the test is complete, turn the phone tightening knob counterclockwise to loosen and remove the phone (Figure 8G).
2. Twist the screw clamp counterclockwise and remove the attachment from the measuring wheel shaft (Figures 9G and 10G).
3. Sanitize the attachment.
4. Store the attachment with the measuring wheel for future use.

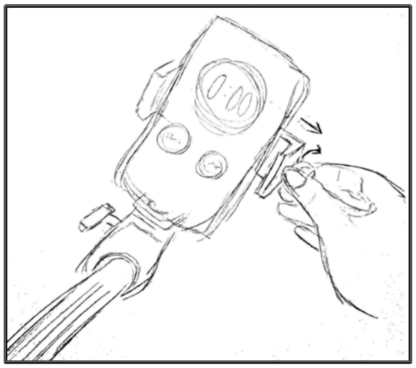

Figure 8G. Loosening phone with adjustment knob

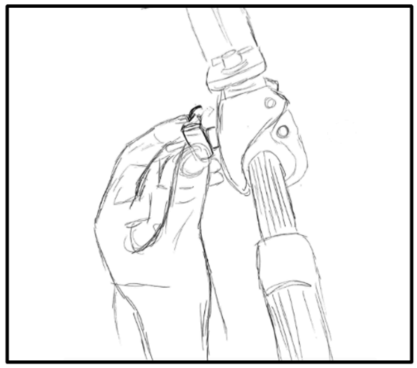

Figure 9G. Loosening screw clamp

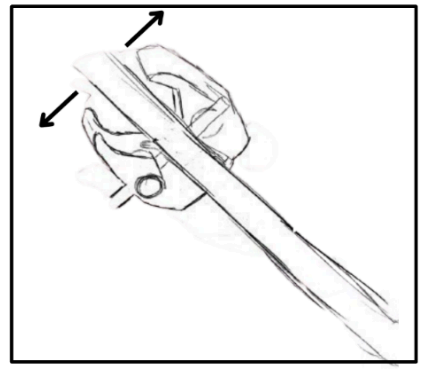

Figure 10G. Removing RollTime from measuring wheel shaft

APPENDIX H: DESIGN REVIEW SUMMARY

Introduction

On May 14th, Esha Chandra, Ethan Park, Jimmy Tsai, and Lois Xie held our in-class design review, presenting our current design to our classmates, our professors, and Segal shop pro Kazuki Guzman. Our design is a measuring wheel attachment with a phone mount that allows physical therapists to keep a timer visible and accessible during the 6 Minute Walk Test (6MWT) while freeing a hand to support the patient. To supplement our presentation, we prepared sketches and 3D renderings and identified key risks from our safety evaluation. We prompted our audience to answer questions regarding clamp efficiency, fall risk, angle adjustment, and weight distribution. Following the design review, our team held a debrief to analyze the feedback and discuss how we would like to move forward and incorporate ideas into our next phase of the design process. Our feedback can be categorized into four distinct categories:

1. Addressing safety risks
2. Positioning feedback
3. Material feedback (Table 1)
4. Mechanical component feedback (Table 2)

Results

Addressing Safety Risks

One of the risks we identified during our safety evaluation was the phone falling out of the attachment, which our team rated as high-priority. Our user emphasized during user testing that a phone or attachment falling could pose a major tripping hazard for patients. In response to this concern, a classmate proposed threading a rope with a clip through the hole on the top of the measuring wheel. The clip would attach to the PT's phone, tethering the phone to the measuring wheel. This would act as a back-up in case the phone mount failed (Figure 1H).

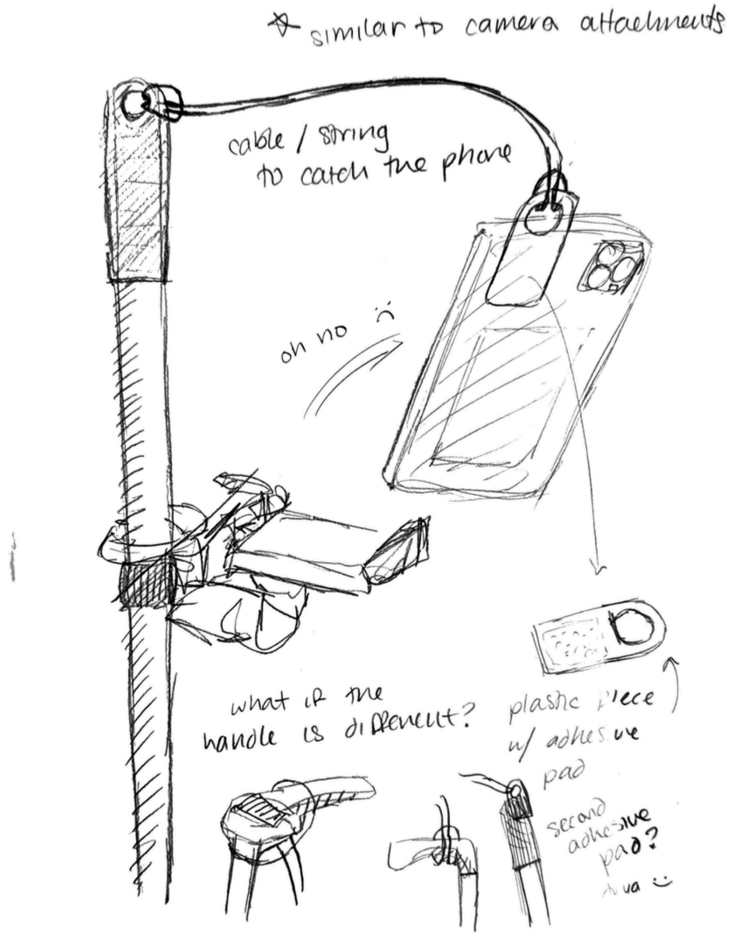

Figure 1H. Safety risk feedback drawing by classmate

Our team weighed the tradeoff of adding this element during our debrief. While the tether would prevent the phone from falling to the ground, we determined that adding this element would increase set-up time, which we are trying to minimize (Figure 1H). Our interpretation is that the tether addresses a symptom rather than a root cause. If the clamp and phone mount are sufficiently secure, the tether becomes unnecessary. This leads us to continue to emphasize clamp security as a priority when designing, and we would revisit the tether element if clamp security were to be compromised in future iterations of the design.

Positioning Feedback

Kazuki suggested raising the screen closer to the top of the measuring wheel to improve visibility. Since our solution is detachable and will be taken on and off frequently, the positioning is varied. However, our team typically places the attachment on the top of the plastic joint that bridges the telescoping rods of the measuring wheel, as this provides extra stability. Kazuki's feedback caused us to realize that our usual placement may have been relying on the plastic joint for stability.

Material Feedback
Our audience identified possible materials to include in different components of our solution, noting multiple benefits they provide (Table 1H).

Table 1H. Material feedback analysis.

Material to consider	Component	Reasoning
Frictional pads or foam	Attachment base	Provides grip if no plastic joint available on measuring wheel
Silicone or rubber lining	Interior of clamp	Protects shaft of measuring wheel from being damaged if clamp is overtightened
Rubber or textured sleeve	Measuring wheel shaft	Improves grip for attachment to be placed over shaft

Mechanical Component Feedback
Our reviewers identified specific issues with the phone mount, ball and socket joint, and measuring wheel clamps. They provided suggestions and model products to explore as we refine each component (Table 2H).

Table 2H. Mechanical component feedback analysis

Component	Identified issue	Suggestion	Possible model products to explore
Phone mount	The current phone mount may not be the most user-friendly option, requiring two hands to operate.	Use a more advanced phone mount	Phone holders in cars with a 3-edge frame  *(Figure. 2H. Advanced phone mount)*

Ball and socket joint	May not require the level of adjustability the ball and socket joint offers.	Less adjustability will improve stability	Elements of tripods  *(Figure. 3H. Phone mount with one axis of rotation)*  (*Figure. 4H. Phone mount with one axis of rotation)*
Measuring wheel clamp	Current design could be slow and inefficient	The less the user has to adjust, the more quick it will be. Minimize the amount of adjustment.	Hose clamps, cam lever  *(Figure. 5H. Hose clamp)*  *(Figure. 6H. Cam lever)*

Action Plan

Our immediate next step is to test the attachment at different positions on the measuring wheel. If performance testing confirms that the attachment performs best when positioned on the plastic joint, we will need to conduct additional performance testing to know if this position is accessible for PTs of different heights. Based on the results of this, we will either make note of this in our instructions for use document, or implement an element that maintains stability of the attachment no matter where it is placed.

We also plan to buy the materials suggested and begin testing them (Table 3). Moving forward, we plan to conduct all testing with full 6MWTs, properly simulating PTs and any fatigue they may experience when using the measuring wheel.

Table 3H. Testing plan for new materials

Material/Component	Testing Approach	Decision Informed
Silicone and foam	Apply to clamp interior and/or attachment base, measure phone slippage under strain in different directions of movement Apply to clamp interior and overtighten attachment, measure damage on measuring wheel shaft	Whether soft buffer materials provide enough friction to improve attachment stability Whether soft buffer materials provide enough cushion to prevent damage to measuring wheel over time
Phone mount	Compare how long current design's phone mount takes to set up compared to advanced phone mount	Whether an advanced phone mount should replace our current design
Hose clamps and cam levers	Compare set up speed against current twist-to-tighten mechanism	Whether to replace the twist-to-tighten mechanism
Angle of phone mount	Performance testing with people of different heights, measure difference in optimal viewing angle	Whether the ball-and-socket joint is necessary, or even if no adjustment is necessary

Beyond feedback, the design review informed us of notable considerations to investigate as we continue refining our design. We plan to calculate the distance between the center of mass and the geometric centroid, understanding the impact on weight distribution and balance. In addition, we will formally document the rationale behind our design choices, defining and quantifying ideal ranges to ensure our decisions are supported by measurable criteria.

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APPENDIX I: PROJECT DEFINITION

Key Information

Project Name: Timing the 6 Minute Walk Test (6MWT)
*Project Partner***:** Gina Clark at the Shirley Ryan Ability Lab
*Team Members***:** Esha Chandra, Ethan Park, Jimmy Tsai, Lois Xie
Current Version: 2 - as of May 10th, 2026

Mission Statement

Design a hands-free timer solution for physical therapists to maintain visual and physical attention on patients while administering the 6 Minute Walk Test (6MWT). By improving timer visibility and allowing therapists to maintain a free hand for patient monitoring, the solution supports a safer and more accurate 6MWT.

Project Deliverables

- Final report (digital copy)
- Final presentation
- Final prototype

Design Constraints

- Budget: Up to $150
- Timeline: 10 weeks, must be completed by Wednesday, June 10th, 2026
- Cost: User hopes to be able to easily replace prototype if it were to break without significant financial burden
- Observation Constraint: Unable to observe end-user working with patients due to HIPAA constraints

Users and Stakeholders

End User**:** Gina Clark, user and project partner, uses the device to aid her in timing the 6MWT
Patients at SRAL**:** Completes the 6MWT under the end user's provision, likely physically and/or cognitively impaired
Physical Therapists at SRAL**:** Administer the 6MWT to patients at SRAL, who may desire to use the solution for the end-user

User Scenarios

The user in the illustrative scenario below is based in part on an interview with our project partner, Gina Clark, in which Dr. Clark described her experiences with the 6MWT.

Jacky is a physical therapist at the Shirley Ryan Ability Lab. Almost every day, she performs a 6MWT with various patients of varying degrees of mobility. Depending on how likely her patient is to fall, Jacky will equip her patient with a gait belt, harness, or provide no more assistance than a hand on their back. Then, standing close behind the patient and with her measuring wheel, she will set a timer for six minutes on her phone and begin walking with her patient. Although Jacky is used to performing the 6MWT with her patients, she notices that it is often difficult to maintain focus on the patient, the measuring wheel, and keep track of the time that has passed. She finds it frustrating that, when trying to check her timer, she must quickly take her phone out of her pocket and potentially compromise contact with the patient and/or a grip on her measuring wheel. Jacky wishes that there was a better way to keep track of the time while not having to lose control of the measuring wheel or her patient.

Requirements

The end goal of all requirements below is to prioritize patient safety and maintain accurate results.

Needs	Metrics	Units	Target Value	Allowable Value
Frees up a hand to hold the patient	- Amount of time user is in contact with attachment during test - Amount of time user is in contact with user interface to take a screenshot	Seconds	- 0 - < 5	- 0 - < 10
Allows for timer to be accessibly viewed	- Range out of her line of sight - Visibility of timer - Font size, screen brightness - Distance from user	Degrees *refer to Figure 1I below table*	~70	~60
Allows for user to interact with timer display	- Arm range of motion from hinging hips - Distance from top of measuring wheel to the attachmentattachment	Degrees *refer to Figure 1I below table*	~35	~50
Ensures accurate results	- Does not require lag between her starting the timer and the patient beginning to walk	Seconds	< 2	< 5
Holds fast/is secure	- Whether it withstands varying amounts of force applied through various simulations of real-world tests (i.e. dropping the measuring wheel on the floor, running into tables)	n/a	n/a	n/a

Allows for proper sanitization	- Material that is able to withstand being sprayed with 70% alcohol (isopropyl or ethanol) and wiped dry - Material that is able to withstand being sprayed with chlorine/ hypochlorite-based disinfectants - Material that is sterile and impermeable (non-porous) Including but not limited to: plastic, metal, PLA	n/a	n/a	n/a
Adjusts for physical therapists of various heights	- Adjustable height range - Adjustable viewing angle	Inches Degrees	> 12 45 - 90	> 6 55 - 75
Costs a low price to create	- Total cost of construction under $X - Assembly time	USD Hours	< $100 < 2	< $150 < 3
Allows for easy setup and removal	- Setup time and removal time	Seconds	< 30	< 60

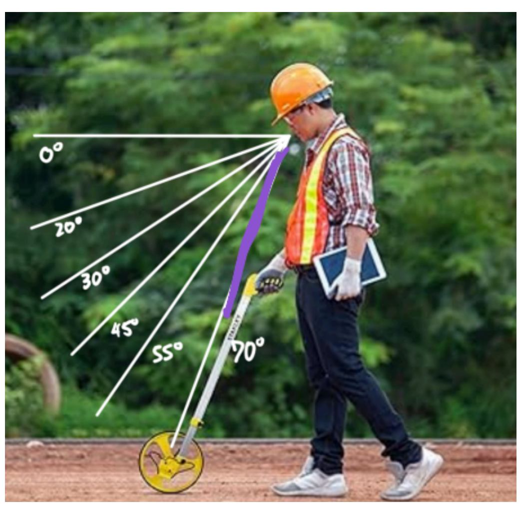

Figure 11. Range of eyeline

APPENDIX J: INSTRUCTIONS FOR CONSTRUCTION

This document provides step-by-step instructions for assembling *RollTime*, a phone mount designed for a measuring wheel pole. The *RollTime* primarily consists of the pole attachment and the phone holder, held together with a screw.

These instructions are designed for Dr. Gina Clark and staff for repair or making additional mounts. By following this documentation, users will be able to assemble the phone mount from the components bought online and diagnose issues that may arise during the day-to-day use of the product.

Materials

The following components should be gathered before assembly of the *RollTime*:

1. Hocoder Phone Clamp
2. 1/4"-20 Socket Head Screw
3. 1/4" Zinc Plated Washer
4. EszkozTA Phone Adjuster Clamp

Procedure

Figure 1J. Phone mount

1. Place the phone holder flat on a flat table, with the screw-insert side down

Figure 2J. Phone mount with screw

2. Screw the ¼”-20 screw into the insert

Figure 3J. Phone mount with screw attached in

3. Fully turn clockwise until the screw is unable to turn

Figure 4J. Zinc washer placed on screw

4. Place the 1/4" zinc washer on the bottom of the phone holder, through the 1/4"-20 screw

Figure 5J. Screwing on the phone mount.

5. Screw the phone holder + screw + washer onto the pole attachment

Figure 6J. Completed assembly of RollTime

6. Turn fully clockwise until the attachment cannot turn any longer.
   This should be in the correct orientation of the phone holder as detailed in the image.

If there are complications with the alignment of the phone holder and the clamp, look to add 2 washers between the phone holder screw insert and the head of the screw. Once added, align the phone holder and the clamp and tighten it down while the two are aligned.