

**A critical review of the task related training (TRT)
mobile app prototype and its suitability for the delivery
of TRT locomotor circuit class training for people with
stroke in an inpatient hospital setting in Singapore:**

A Physiotherapy perspective

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ABSTRACT

Background: Stroke is the leading cause of adult disability worldwide (Tetzlaff et al., 2020), and can result in locomotor disability, impacting functional independence and participation (Knox et al., 2018). As a result, identifying interventions that reduce locomotor disability while increasing functional independence is critical. The rise of digital health has resulted in a plethora of mobile technology-based innovations that open up new avenues for stroke rehabilitation (Henson et al., 2019). By facilitating physical, cognitive, and social activity, the use of tablet technology and mobile apps provides a platform for increasing the variety (Rinne et al., 2016), dose (Stütz et al., 2017) and intensity (Norouzi-Gheidari et al., 2012) of stroke rehabilitation in the hospital and community setting (White et al., 2015). Mobile apps have the potential to support the delivery of evidenced based interventions like task-related circuit class training (CCT) which has been shown to be more effective than conventional physiotherapy in improving walking speed, walking endurance and some aspects of balance in people with stroke (English et al., 2017). The physiotherapy department at Jurong Community Hospital (JCH), National University Health System in Singapore, wanted to see if their current stroke CCT programme could be delivered digitally to keep up with technological advancements. The purpose of this critical review was to determine the suitability of Task Related Training (TRT), an app in its early prototype stage, to support locomotor CCT for stroke patients at JCH.

Method: This critical review used 1) a think aloud usability method to assess the usability and suitability of the TRT app prototype from a physiotherapy perspective, and (2) comparator methods that critiqued the app's content using motor learning and task related training principles, and tasks reported in the CCT literature for people with stroke.

Results: Initial user testing revealed that the TRT app was well received in terms of usability and suitability. Examining the app's content revealed that it is closely aligned with motor learning and TRT principles, as well as the tasks in the CCT evidence base. From the perspective of a physiotherapy user, the TRT App has the potential to support the delivery of the JCH CCT programme.

Conclusion: Future directions should see designers of rehabilitation technology consider the recommendations outlined in this review and conduct future iterative user testing with physiotherapists, therapy associates and people with stroke in Singapore. Near-live encounters with the device over extended periods of time in the CCT context would also be important. Future research should also look at validating the device efficacy for delivering locomotor CCT programmes in people with stroke.

ATTESTATION OF AUTHORSHIP

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Signature:

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INTRODUCTION

In Singapore, stroke is the ninth most common condition for hospital admission and the leading contributor of burden and disability among adults (NRDO, 2019). As the number of people with stroke increases, hospital stay shortens and increased care and more rehabilitation services are delivered in the community. Novel solutions are needed to assist both people with stroke and significant others in the rehabilitation process to maximise activity and participation for people with stroke (Marwaa et al., 2020). A proposed option is to integrate mobile technology, such as smart phone applications, alongside traditional rehabilitation to deliver services that address expanding healthcare requirements while limiting rehabilitation expenditures (Marwaa et al., 2020).

The aim of this dissertation is to evaluate the suitability of the task TRT app prototype in its current form for delivering locomotor CCT to stroke patients in an inpatient setting at Jurong Community Hospital (JCH). This critical review is the first step of this process and has three key objectives:

1. Assess the suitability of the TRT app prototype in its current format for providing TRT CCT in an inpatient hospital environment in Singapore and determine what app requirements must be met to ensure usability and suitability in this rehabilitation context through my own user testing.
2. Determine whether the TRT app prototype is consistent with TRT, and motor learning principles as described in McLoughlin's 2020 "Ten guiding principles for movement training in neurorehabilitation" and to identify areas that may require further development.
3. Determine whether the locomotor tasks and task progressions within the TRT app prototype align with the locomotor TRT CCT evidence base in people with stroke, and to identify areas that may require further development.

This project took an overarching pragmatic approach to addressing the research questions. Pragmatism is a paradigm of research in which practical consequences and effects of concepts and behaviours are an integral part of truth and meaning (Shaw et al., 2010). Therefore, study findings from a pragmatic researcher are more practical since they examine the research question from more than one worldview and methodology (Morgan, 2014). A pragmatist approach suits this research project as it utilised several different methods to assess the suitability of the TRT app for the students practice context. These

included user centre design methods and comparator methods to evaluate the content of the app against pertinent literature.

This dissertation consists of five chapters. Chapter 1 provides an overview of stroke, its symptoms, and how it influences locomotor-related abilities. This is followed by a background literature review that describes the principles of motor learning, task-specific training parameters and the evidence for TRT based circuit class training in people with stroke. This chapter also provides insight into the use of technology in hospital and rehabilitation healthcare settings and the benefits of incorporating mobile application technology in stroke rehabilitation.

Chapter 2 provides an overview of the Health System in Singapore and the current stroke rehabilitation services provided by Jurong Community Hospital (JCH). Details about how the stroke service operates including the rehabilitation ethos, facilities, and staffing, available equipment for locomotor rehabilitation, rehabilitation dose, and patient length of stay are provided. This chapter then describes how the current JCH inpatient CCT programme is delivered and the perceived benefits and limitations of its delivery.

Chapter 3 describes the methods undertaken to critically review the TRT app prototype in line with the three main objectives of the research project. These include usability evaluations of the app from a physiotherapy perspective and comparator methods that critique the content of the app compared to motor learning and CCT literature in people with stroke.

The findings from the usability and comparator method evaluations are presented in Chapter 4. Each evaluation process is supported with iterative paper-based wireframes that provide suggestions for improving the app's suitability for facilitating CCT delivery in Singapore.

Chapter 5 provides an integrated discussion of the findings, the implications of these findings for the student researchers practice context, clinical practice, and rehabilitation technology developers and designers, and the limitations of the research project.

Chapter 1.

Background

1.1 STROKE

Stroke is the leading cause of adult disability in both Singapore (NDRO, 2020), and worldwide (Tetzlaff et al., 2020), and the burden of stroke is expected to rise as our population ages (SingHealth, 2018). After a stroke, patients may experience motor, sensory, cognitive, emotional and psychological disturbances (Sianturi et al., 2018). One of the most common limitation post-stroke is locomotor disability (Knox et al., 2018). Locomotion is defined as movement or ability to move from one place to another (Hornby et al., 2020). After the first week following a stroke, only one-third of patients can walk unassisted, and after three weeks, only 50–80 percent of people with stroke can walk unassisted for a short distance (Balasubramanian et al., 2014). The prevalence of locomotor disability continues to rise progressively over time (Stuart et al., 2019).

Stroke rehabilitation is important for minimising disability and maximising functional independence (Kwakkel & Kollen, 2013). Walking capacity (Kim et al., 2017), walking speed, and endurance (Van de Port et al., 2008), balance (Park & Kim, 2016), and muscle strength and endurance (Sunnerhagen, 2007) can be improved by locomotor rehabilitation. However, physical inactivity after stroke is highly prevalent (Billinger et al., 2014). An observation study revealed that as little as 12.8% of the therapeutic day (8 AM to 5 PM) is spent engaging in moderate or high-level functional activities such as rolling, sit to stand and walking activities, and approximately 53% of the time, patients remained in bed (Bernhardt et al., 2004). This lack of activity post-stroke further exacerbates disability (Wevers et al., 2009; Dean et al., 2000).

There is a growing consensus that increased rehabilitation dose (also known as the amount of rehabilitation (Lang et al., 2015), can enhance motor recovery (Lohse et al., 2014), leads to cortical reorganisation and improve functional outcomes after stroke (Ko et al., 2020). Therefore, maximising rehabilitation dosage is vital to reducing disability and improving functional independence after stroke (Birkenmeier et al., 2010; Lang et al., 2015).

1.2 MOTOR LEARNING

Motor learning is the acquisition and alteration of a skilful movement (Shumway-Cook, 2017) and these changes are permanent rather than a temporary improvement in performance (Young & Schmidt, 1992). Motor learning after stroke is the process of regaining function through relearning movement skills lost through injury (Van Vliet & Wulf, 2006). Rehabilitation interventions should be designed to maximise the learning process of motor learning because it consists of several types of sensorimotor learning, cognitive techniques, and other variables (Guadagnoli & Lee, 2004). Both learning and recovery can result in plastic changes in the immature and mature brain, as demonstrated by animal models and functional imaging in humans (Krakauer, 2006).

The theories of motor learning are an essentially an abstract set of assumptions concerning the acquisition and modification of skilful action (Shumway-Cook, 2017) and have been established from current knowledge of the structures and function of nervous system (McLoughlin, 2020). Several models and frameworks have been developed to describe the motor learning process, which can also be used to inform the delivery of stroke rehabilitation interventions (Luft & Buitrago, 2005). These are briefly introduced below.

According to Fitts and Posner's Three-Stage Model of Motor Learning (Fitts & Posner, 1967) there are three stages involved in learning a new skill. These include (1) the cognitive stage, (2) the associative stage and (3) the autonomous stage of learning. In the first stage, the researchers postulate that the learner needs to understand the task, develop strategies that could be applied to accomplish the task, and determine how the task should be evaluated (Shumway-Cook, 2017) At this stage of the learning process the cognitive demands, i.e., attention is high. The second stage of skill acquisition focuses on refining this skill, as the learner has already chosen the best strategy and fewer errors are observed. Lastly, learners progress into the autonomous stage which is characterised by automatised skill routines that require a low degree of attention.

In contrast to the three-stage model, Gentile (Gentile, 1972, 1998) proposed a two-stage model that focuses on the learner's goal and how characteristics of the task and environment affect the achievement of that goal. The first stage focuses on the learner getting a sense of the movement requirements and involves developing movement strategies suitable for achieving the goal as well as understanding the features of the environment that are critical to the movement's success. The second stage is concerned with refinement of the goal and referred to as the "fixation or diversification stage". The

process of refining the movement involves both developing the ability to adapt to changes in the environment and executing the task consistently and efficiently.

Conversely in Schmidt's Schema theory (Schmidt, 2003), in Richard Schmidt proposed that through practice, the strength of motor programs is gradually developed, resulting in a cumulative continuous change in behaviour (Lee et al., 1985). According to the theory, with practice, a more appropriate representation of action can be developed (R. A. Schmidt, 2003). The clinical implication being that it is essential to practice a movement under a variety of different conditions to form an accurate recall and recognition schema (Shumway-Cook, 2017). By contrast, Newell (1991) suggested that motor skill acquisition is based on concept of search strategies. He proposed that motor learning is the process of enhancing the integration between perception and action in a manner that is consistent with the environmental constraints and the task at hand (Newell & Rovegno, 1990). The conjectural underpinning is that with practice and relearning of a movement to accomplish a task, the search for an optimal strategy takes place. Part of the optimal strategies is incorporating perceptual cues with the existing motor response that is appropriate to the task.

The universally acknowledged principle that neural recovery depends on active, skilled use was brought about by the impact of rehabilitation training strategies on the physiology of the central nervous system (Hara, 2015) i.e., motor skill learning stimulates brain plasticity and allows functional improvement. It presumes that by triggering neural plasticity networks, exposure to certain training events and experiences leads to improvement of impairment (Maier et al., 2019). It stimulates neuroplasticity in mobility through functional training- specificity of task - specificity of task (Shumway-Cook, 2017), repetition (Lang et al., 2015), and intensity (Kuys et al., 2019). Neuroplasticity can be defined as the ability of the nervous system to modify its connections, function, and structure in response to internal or external stimuli (Cramer et al., 2011). Neuroplasticity occurs on many levels of the central nervous system (Kiper et al., 2016) and MRI in clinical studies has shown that after stroke, the whole network is reorganised, with activity increasing depending on lesion extension. Harnessing neuroplasticity for clinical application has identified mechanisms that drive the impaired stroke brain to reorganise (Dimyan & Cohen, 2011) in practical and functional ways in rehabilitation (Burns, 2008). Rehabilitation must capitalise on these training strategies and parameters to boost recovery. The demands of these rehabilitation strategies have increased in terms of task-specificity, intensity, and progression while also enhancing mobility (Dobkin, 2004). The brain builds skill upon skill (Pollock et al., 2014).

Therapists curate exercises to enhance motor learning with activities training carefully graded stimuli, with accelerated task complexity, accuracy, or speed that adjust to a participant's specific performance level (Knox et al., 2018). These parameters are the underpinnings of Task Related Training (TRT) where there are re-learning and new learning after stroke. TRT improves physical function via its' repeated, task-focused exercises, under a physiotherapist's supervision, with greater intensity leading to better and faster recovery post-stroke (Rinne et al., 2016). TRT is an intervention that manipulates neuroplasticity to enhance motor rehabilitation (Dimyan & Cohen, 2011).

The conditions in which patients practice these tasks are vital to the process as well as the goal of the intervention. There are training parameters that drives neural plasticity. In this vein, Kleim & Jones (2008) expanded on the five key tenets of a successful training experience — specificity, repetition, intensity, time, and salience. According to animal research, it has shown that repeating competent motions, as opposed to just repeating unskilled actions, causes localised alterations in the region responsible for the movement, Frequency and intensity of intervention is vital for training. Taub and his colleagues in a clinical neuroscience research have frequently demonstrated the value of high-intensity repetitive training (Burns, 2008). To achieve this, the curriculum of learning requires practice. Practice is widely regarded as the crucial factor responsible for the permanent improvement within the ability to perform a motor skill (Guadagnoli & Lee, 2004).

The principles of motor learning involve many facets that are more than just motor processes. Training parameters that influence retention and/or transfer of skills involve many aspects. The patient's ability to draw on prior knowledge and experience to master new task or skill, or learn a new task is affected by the practice conditions. These practise conditions relate to the type of task, the environment as well as individual themselves.

1.2.1 Practice Conditions

Task practice can be structured in the following ways:

- **Massed versus Distributed Practice**

Mass practice is where patients engaged in prolonged periods of work with brief or no rest periods (Maier et al., 2019), and therefore, the amount of training within a session is greater than the amount of rest. It is theorised that distributed practice entails that training is structured so that rest periods that take place between repetitions or sessions, equal to or greater than the amount of time for a training (Maier et al., 2019). However, it was found

that compared to massed practise, distributed practise improved the learning of motor skills and improves the efficacy of motor sequential learning in healthy adults (Kwon et al., 2015) and in post-stroke patients who used the distributed practise approach instead of the massed practise method significantly improved their bed mobility skills (Alagappan, 2019). As a result, performance and learning in a discrete motor task vary depending on whether practise is massed or distributed. However, compared to massed practise, distributed practise improved motor skill learning and the efficacy of motor sequential learning in healthy adults (Kwon et al., 2015), and post-stroke patients who used the distributed practise method instead of massed practise significantly improved their bed mobility skills (Alagappan, 2019).

- **Constant versus Variable Practice**

Kinematic and dynamic factors play a role in motor learning (Krakauer, 2006). The author further reiterates that a study of healthy subjects suggests that a variable training schedule is the best method of retaining motor skills.

Practice is often recognised as the most crucial factor responsible for permanently improving one's ability to perform a motor skill on a long-term basis (Guadagnoli & Lee, 2004). Thus, constant practice refers to when practice of a skill is done where all factors are held constant, skill progress is generally thought to be positively related to the amount of practise (Lee et al., 1985) On the other hand, the construction of a generalised "schema" that is inferred or adapted from experience of various practise environments is believed to be the reason why variation in practise is expected to improve transfer to unpractised movements (Breslin et al., 2012). In constant versus variable practice, variable practice can achieve via 1) the provision of variability within a training sequence of the same task or (2) having randomised the presentation of training sequences. When practise is varied, it is best for retention and transmission of a motor skill (Espy et al., 2021). In contrast, constant practice, patients have minimal variations and are the complete opposite of variable practice. They practice task in singularity. Variable practice offers opportunities for patients to perform task outside their previous range of experience, resulting in better long-term learning and transfer of skill (Schmidt & Bjork, 1992; Simon & Bjork, 2001)

- **Random versus Blocked Practice: Contextual Interference**

A skill can be practised repeatedly in a continual or blocked manner during a work episode (Lee et al., 1985). In blocked practice, in which prior to practicing another pattern, every trial of a particular pattern to be learned must be completed (Simon & Bjork, 2001). In

contrast, in random practice, each task to be learned is interspersed in a semi-random fashion. A blocked practice session usually results in smaller errors than a random practice session, but on retention tests, the opposite is typically observed. In a study by Li & Wright (2000), they found that during the performance of the block-practice participants was superior during training, but when retaining them the performance was less than the random-practice individuals.

- **Whole versus Part Training**

Using interim steps to retrain function is one strategy for helping patients achieve mastery of the entire task before learning the entire task procedure (Shumway-Cook, 2017). It is the process of identifying the components of a movement or skill, and then sequencing those components into a complete movement. In training, each of these components will be practiced separately before being integrated into a sequence. Naylor & Briggs (1963) as proposed the following training principle: at all degrees of task complexity, a whole-task training technique should be preferable than a part task method for a reasonably highly ordered (integrated) work; however, an increased in task complexity in a part task training plan will outperform a whole-task training schedule for a generally disorganised problem (all task aspects independent).

- **Mental Imagery**

Mental imagery is another practice condition that can enhance neuroplasticity to promote motor learning and recovery. Mental imagery is the act of resembling a movement within the mind without producing the actual motor activity (Verma et al., 2011). Evidence suggests that using mental imagery as an adjunct to conventional therapy can improve functional outcomes for people with stroke, with the added benefits of being safe, cost-effective, and providing limitless practise opportunities (Braun et al., 2013; Guerra et al., 2017; Kho et al., 2014).

- **Guided versus discovery learning**

One frequent method used in rehabilitation when learning a new skill is guidance, which involves physically walking the learner through the process (Shumway-Cook, 2017). Evidence suggests that generally simulations with instructional measures provided produce better learning outcomes than those without (Mortazavi & Nadian-Ghomsheh, 2019). Guided learning, however, should be limited to patients who are learning new tasks to familiarise them with the characteristics of the new task. This should take precedence over discovery learning, which involves exposing patients to a variety of graded tasks and

encouraging them to discover the movement strategies and perceptual cues required to learn the task through trial and error (Shumway-Cook, 2017).

1.2.2 Feedback Provision

Feedback not only has an informational value, but also has motivational properties that have a crucial influence on motor learning (Wulf et al., 2010). It has been established that individuals perform better on tasks when given detailed and timely feedback (Ilgen & Moore, 1987). Feedback comes in two forms: Intrinsic and extrinsic. Intrinsic feedback refers to the inherent feedback that an individual receives through their sensory systems in the form of visual information that tells them whether the movement was accurate as well as sensory information about the position of the limbs when the movement is occurring (Shumway-Cook, 2017). Extrinsic feedback augments intrinsic feedback and comes from outside sources, like when a therapist comments on how well a patient stands from a chair (Van Vliet & Wulf, 2006). Feedback that is objective can help patients discern their abilities and build self-efficacy more clearly, and encourage them to set goals that are meaningful to them (Langan et al., 2018). In addition, when feedback generates an external focus, it may be more effective than feedback or instruction that causes an internal focus (Van Vliet & Wulf, 2006).

Thus, to facilitate motor learning, which is a crucial TRT principle, revolves around the type of feedback (knowledge of results and knowledge of performance) and the timing of feedback (concurrent, immediate, delayed) (Stoller et al., 2015; Widmer et al., 2016; Young & Schmidt, 1992). Knowledge of results is provided in the form of explicit feedback (Maier et al., 2019) and refers to information that is given to the patient's learner regarding how successful they were in meeting the environmental goal. Whereas knowledge of performance is more movement-driven, pertaining to the manner in which a certain skilled is executed (Ilgen & Moore, 1987). Both are widely regarded as critical variables in the acquisition of skills (Salmoni et al., 1984). Patients are empowered to make logical decisions and assess the efficacy of those choices when they have the necessary knowledge and the ability to analyse the advantages of having control over their resources. This in turn affects their own behaviour to improve their quality of life (Fumagalli et al., 2015). These feedbacks are optimal for motor learning however the most effective way to provide feedback to improve motor learning is still up for debate (Janelle et al., 1995).

1.3 TASK RELATED TRAINING AND CIRCUIT CLASS TRAINING IN PEOPLE WITH STROKE

Task related training (TRT) is a treatment strategy that involves the practice of context-specific motor tasks and the provision of feedback (Hubbard et al., 2009). The TRT approach is based on motor learning principles and reinforces neuroplasticity through training of function using behavioural neuroscience principles (Bayona et al., 2005) such as salience (Kleim & Jones, 2008), specificity (Shumway-Cook, 2017), repetition (Lang et al., 2015), and intensity (Kuys et al., 2019). The underlying principles of TRT result in a plethora of evidence-based interventions in stroke rehabilitation. One of which is TRT Circuit Class Training (CCT) (English et al., 2017; Kim et al., 2017).

CCT enables stroke patients to practise meaningful locomotor tasks at a series of sequential workstations in an intensive, repetitive manner that can be progressed continuously as the patient's function improves. (Frimpong et al., 2014; Bonini-Rocha et al., 2018). CCT is typically delivered in a group setting, with more than two participants per therapist concurrently, resulting in a lower staff-to-patient ratio (Van De Port et al., 2012). This implies cost-effectiveness, especially given the inflated cost of stroke rehabilitation healthcare.

A recent meta-analysis concluded that CCT involving locomotor and balance-based exercises is more effective than conventional physiotherapy treatments at improving walking speed, walking endurance and some aspects of balance in people with stroke (English et al., 2017). The study further reiterates that people affected by stroke can practice their skills in a supervised group setting, increasing their practise time without increasing staffing or jeopardising patient safety (Hornby et al., 2020). Task-specific training CCT has also been shown to benefit stroke patients in the acute, sub-acute, and chronic stages with varying degrees of severity (Bovonsunthonchai et al., 2020; Jeon et al., 2015). Moreover, CCT can promote motor learning and improved physical function by supporting participants to learn new motor tasks by observing one another (Wulf, 2010). The advantages of CCT go beyond simply improving physical function. These include increased peer support and social interaction (McKenna et al., 2015), larger amounts of practice (Lee & Kim, 2009), the development of new coping mechanisms (Morris, 2012), increased independence (Jones & Riazi, 2011), improved mood (Gezer et al., 2019) and a decrease in post-stroke depression (Aguiar et al., 2018). CCT can also be structured as a series of individualised activities within a group setting, or it can remain generic across participants. Either way, task progressions should be tailored to the patients' individual

needs and functions in order to create a challenge point that promotes motor learning and aid functional recovery (Knox et al., 2018; Marigold et al., 2005; Dite et al., 2015; Ling & Fisher, 2004; Rose et al., 2011).

1.4 REHABILITATION TECHNOLOGY

The role of technology in healthcare has expanded, specifically in assisting patients and therapists in various health-related processes such as diagnosis, health maintenance, service improvement, monitoring and rehabilitation (Morilla et al., 2017). This can help patients acquire functional skills, knowledge, and deep learning by utilising easily accessible resources (Maćznik et al., 2015). Such benefits encourage learning from a variety of perspectives, influencing strategies for learning and imparting knowledge. From the perspective of rehabilitation experts, technology is increasingly being incorporated into their daily work and education, with claimed benefits including access to quality content that supports lifelong learning, flexibility of accessibility, personalisation of the learning experience, improvement of communication networks, and enrichment of the workplace (Maćznik et al., 2015).

Conventional rehabilitation can significantly improve motor function; however, its effectiveness and benefits are frequently limited by a number of factors. Rehabilitation has traditionally required a significant amount of time, labour, resources, and is dependent on patient compliance, and can be limited in its availability based on geographical location (Pollock et al., 2014). For some patients it results in modest and delayed improvements (Saposnik et al., 2014). One way in which to remedy these inadequacies is to incorporate technology into rehabilitation.

High tech robotic and virtual reality systems, for example, can help augment rehabilitation to improve functional performance in daily activities and participatory roles by providing new options for repetitive movement training (Fasoli et al., 2004). Rehabilitation robots can deliver therapist-prescribed interventions with greater versatility with relative ease because they can be programmed with a wide range of treatment variables and parameters (e.g., repetitions, level of resistance, range of movement, and speed of movement). The last decade has seen rehabilitation robotics and virtual systems gain market share, but despite their efficacy (Norouzi-Gheidari et al., 2012), they are not commonly utilised due to reasons including steep cost (typically \$10,000-\$100,000), cumbersome size, patient suitability (Langan et al., 2018) and access to specialist rehabilitation centres (Wagner et al., 2011).

An alternative approach to these costly technologies, is the use of more readily available technology resources such as the internet for delivery tele-health, commercial gaming systems, wearable accelerometers, such as the Fitbit and applications (Apps) on mobile devices, like tablets and smartphones (Langan et al., 2018; Thomson et al., 2016). Mobile devices can provide the user with valuable data to enhance and improve patient care (Chan et al., 2015).

Mobile Apps are low-priced, and more widely available, making them ideal for democratising computerised physiotherapy therapy, especially in under-resourced settings, such as chronically disabled patients (Rinne et al., 2016). They are also compact and have the capacity to enhance rehabilitation outcomes by increasing accessibility rehabilitation in both rural and urban environments, to minimise travel time and cost for patients, increase participation and compliance in therapeutic activities and facilitating shared decision-making in a patient-centred rehabilitation context (Langan et al., 2018). Therefore, it is not surprising that tablet technology and mobile applications have generated interest in the stroke rehabilitation research and clinical practice communities.

1.5 MOBILE APPLICATIONS FOR STROKE REHABILITATION

By facilitating physical, cognitive, and social activities, the use of tablet technology and mobile apps provides a platform for increasing the variety (Rinne et al., 2016), dose (Stütz et al., 2017) and intensity (Norouzi-Gheidari et al., 2012) of stroke rehabilitation both in the hospital setting and following discharge from hospital (White et al., 2015). Although there has been a growing interest in the use of interactive technologies for stroke recovery (Iosa et al., 2012), there is a dearth of evidence demonstrating the effectiveness of tablet technology and an understanding of how apps can be incorporated into stroke recovery (Paul et al., 2016; Pugliese et al., 2019; Zhou et al., 2018). Furthermore, many lack transparency when it comes to describing the theoretical underpinnings of the app itself (White et al., 2015).

There is also a scarcity of research on the use of tablet technology and mobile apps from the perspective of stroke survivors and other potential users such as family members or relevant health professionals such as physiotherapists (Kurland et al., 2014). A recent study conducted focus groups to explore the experiences and perceptions of physiotherapists and occupational therapists regarding mobile tablet and web-based apps in supporting person-

centred rehabilitation after stroke (Marwaa et al., 2020). Findings revealed that participants perceived these technologies to be engaging and beneficial in the rehabilitation process, that they can support communication and documentation, but they also described barriers to their use, such as a lack of confidence in using the technology, time constraints, and that they advocated for a more user-friendly solution that was personalised for the individual who had experienced a stroke.

Studies have also shown that usability testing is important for successful app development (Brown et al., 2013). Iterative user-centred testing early on in the development process can help developers and designers to understand target users' needs and experiences with the product (Alpert et al., 2017; Årsand & Demiris, 2008; Jordan et al., 2018) and can help to iron out any prototype issues, that if not anticipated can lead to poor product uptake or sustained use (Daniels et al., 2007; Hatami Kaleshtari et al., 2016; Wildenbos et al., 2018).

In summary, the absence of clear theoretical underpinnings, robust research evidence, and usability testing regarding the use of tablet and mobile app technology in the stroke population and rehabilitation will impede research development and implementation in practise (White et al., 2015). As a result, the student researcher welcomed the opportunity to assess the suitability of the task TRT app prototype in its current form for delivering locomotor CCT to stroke patients in an inpatient setting at Jurong Community Hospital, National University Health System in Singapore, and provide insights and recommendations to the app's developers and designers at this early stage of development.

Chapter 2. Practice Context

2.1 AN OVERVIEW OF THE HEALTH SYSTEM IN SINGAPORE

The Singaporean healthcare system offers primary healthcare, hospital care, long-term care, and other integrated services to its citizens. Singapore has an extensive island-wide network of outpatient polyclinics and private general practitioner (GP) clinics for the provision of basic medical care, preventive healthcare, and health education (Bai et al., 2012). Inpatient, outpatient, and emergency department services are all part of hospital care (How & Fock, 2014) and the public hospitals offer 80% of hospital treatment, in contrast to primary care. The public hospitals are structured by regions with five clusters: Alexandra Health Pte Ltd (AHPL), Jurong Health Services (JHS), National University Health System (NUHS), National Healthcare Group (NHG) and Singapore Health Services (SHS). There are two leading private providers Raffles Medical Group and Parkway Health. The rehabilitation systems are historically structured around acute, episodic care, which is critical for patients in hospital. Presently, Singapore is moving towards holistic healthcare, taking the aging population and the corresponding rise in chronic diseases into consideration (Khoo et al., 2014). Additionally, an aging population would require regular care that should not only be accessible in acute hospitals, but also in the community (How & Fock, 2014). As a result of this shift towards community rehabilitation care, the current goal is to develop early intervention strategies to reshape services for certain chronic conditions, such as stroke, (How & Fock, 2014). The first hospitals in Singapore to be designed and built as an integrated healthcare development are NTFGH and JCH (NTFGH, 2020). Medical records and treatment plans are integrated so that patients benefit from co-management by doctors between the two hospitals. By managing the two hospitals as one unit, patients and caregivers benefit from seamless coordination of care and processes.

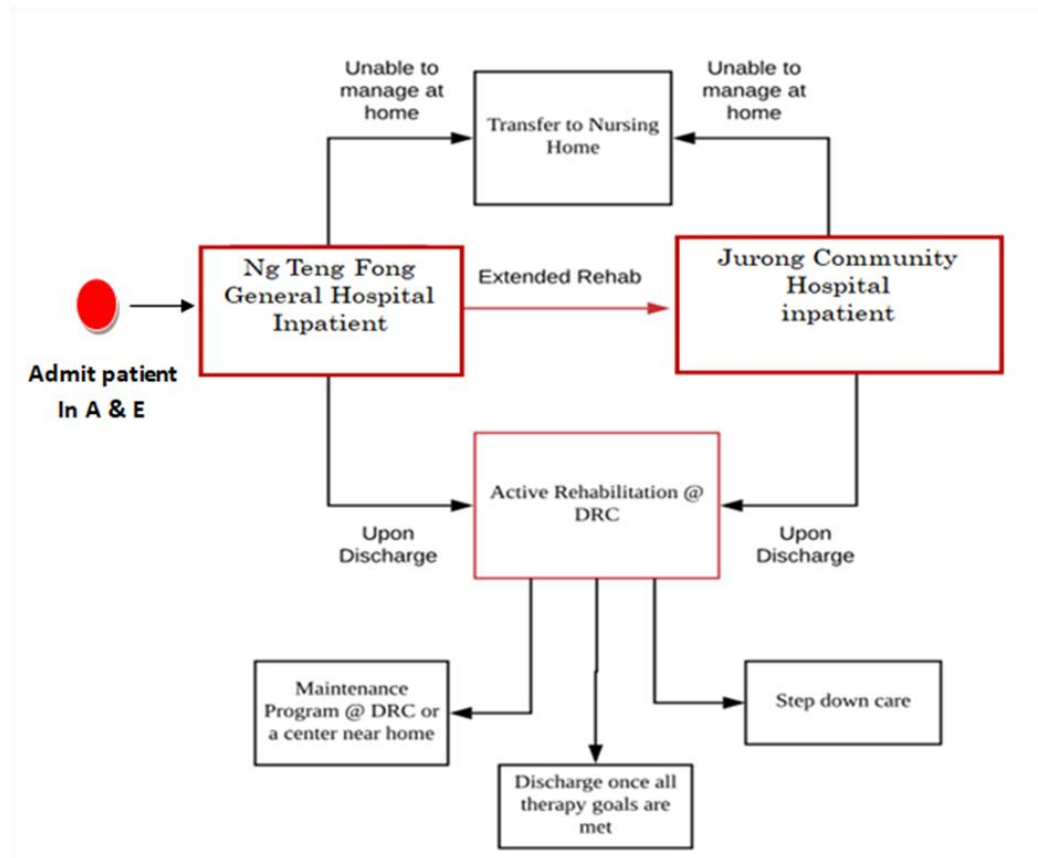
2.2 THE STROKE REHABILITATION SERVICE AT NTFGH AND JCH, SINGAPORE

The Stroke rehabilitation services at NTFGH and JCH are based on international guidelines and evidence-based practice (NDRO, 2020). Stroke patients who are admitted to NTFGH will be seen as an inpatient by the core therapist team within 24 hours of

admission. The rehabilitation team is part of the seamless integrated hospital-to-hospital system. Both hospital teams have a core therapist team that consists of physiotherapist, occupational therapists and speech and language therapists. Patients are seen by the bedside for assessment and therapy prior to being transferred to JCH for extended inpatient rehabilitation once medically stable (See Figure 2.1). Jurong Community Hospital (JCH) has 400 inpatient beds and offers post-acute and rehabilitation services. There are two JCH rehabilitation gyms, one for inpatients and another for outpatients. The inpatient team consists of 20 qualified physiotherapists and 13 therapy associates and in the outpatient gym three qualified physiotherapists and two therapy associates. Patients, who are admitted to JCH, will be evaluated by doctors, who will then refer them to therapists for assessment and treatment planning where the average length of stay is three weeks. Following the assessment, the patient will be brought to the gym to participate in therapy, which can be done in tandem with OT counterparts or individually. Each therapist can have a session that lasts up to an hour. The frequency of therapy sessions is dependent on the needs of the patient and ranges from 3-7 sessions per week. These sessions exclude other relevant services such as speech therapy, psychology, and group-based day-to-day activities.

Singapore's public healthcare systems made significant strides in leveraging technology to meet the country's healthcare challenges. As a result, smart technologies such as drones, robots, electronic medical record systems and other touch-free technology are incorporated into the day-to-day care of NTFGH-JCH patients. NTFGH-JCH stroke services utilise Telestroke, a tele-health system where stroke patients receive timely and accurate evaluation and treatment, with real-time remote access to stroke specialists 24 hours a day. Acute stroke patients no longer must be referred to other hospitals for urgent care.

Figure 2.1 Flowchart representing a stroke patients' journey



An array of technology is available at JCH to support locomotor rehabilitation, these include; Andago by Hocoma an over-ground gait trainer for locomotor training, Alter G an anti-gravity treadmill to enhance freedom of movement, Ekso robotic exoskeleton and bionic leg for weight-bearing and gait training and Balance Master for biofeedback on balance, posture, and force exertion. In addition, JCH is Singapore's first hospital to have a mobility park where there are stationary life-sized buses, taxis, and train carriages to simulate a public transport setting as well as having ramps, steps, textured surfaces to mimic post-discharge environmental terrains. This is accompanied by the JCH life hub which features a three-room mock-up apartment. Under the guidance of therapists, patient use the present simulated outdoor landscapes and mock-up apartments as part of the patient rehabilitation process to assist patients acclimatise to their home surroundings (JCH, 2020). The aim is to help patients reintegrate back into the community and prepare them for discharge.

JCH continues to advocate for the use of technology to supplement conventional rehabilitation to support optimal outcomes for its stroke patients. Therefore, determining whether its' current locomotor CCT programme can be delivered digitally with the use of an app warrants further investigation.

2.3 JCH'S CURRENT CCT PROGRAM DELIVERY

Physiotherapists at JCH will invite mobile stroke patients to participate in the CCT programme, which provides a combination of strengthening, balance, and locomotion-related exercises. To participate patients are required to be medically stable, able to ambulate with close supervision, for a minimum of 10 metres with or without aids, good safety awareness, consistently follow 1 step commands, tolerate more than 30 mins of supervised exercise and are motivated and willing to participate. They cannot participate in CCT if they have infectious diseases precaution labels.

Patients attend the CCT programme once per week for a minimum of 3-week's or up to the length of the patient's hospital stay. Each session lasts for one hour with a 40–45-minute work duration. There are four key stations each of which involves exercising for up to 10-minutes with a maximum of 5-minutes rest time between each station. The staff to patient ratio is 2:3 and the staff are either a qualified physiotherapist or therapy associate. Patient numbers range between 3-6 people per session.

Exercises are selected specifically to improve balance, cardiovascular endurance, strength and locomotor related tasks. Station 1 utilises the AlterG, an anti-gravity treadmill. The objective of this station is to walk on the treadmill at a stipulated speed for 10 minutes. Patients are advised to walk at a comfortable cadence without exerting themselves. If they get out of breath or fatigued, they are permitted to slow down, to stop, and to rest as necessary; but to resume walking as soon as they are able.

Station 2 consists of the NuStep a recumbent cross trainer that allows patients to be seated whilst exercising. NuStep combines the movement of a bicycle, stair stepper and a cross-country ski machine. Patients are expected to move both upper and lower extremity at a comfortable speed without stopping.

Station 3 utilises the Uppertone an upper extremity machine that supports following four exercises - chest press, rowing, deltoid press and lateral shoulder raises. It features a resistance system using weights that can be used for strength, endurance and power training. As part of the CCT, this station focuses on upper limb strengthening exercises as the CCT programme provides a combination of strength, balance and locomotion exercises.

Station 4 the last station consists of over ground balance and walking practice. It includes seven different tasks; sit to stand (10 repetitions), transfer practice from chair to chair, walking, tandem walking, walking over obstacles, turning, and walking whilst carrying goods for specified distances. These tasks are completed on a 20-metre walkway. Patients will attempt this once along the walkway. Some of these tasks are based on components of the Berg balance scale.

Each station can be adapted to the patient's own capabilities and progressed as required. However, the rehabilitation parameter intensity or difficulty is not well established during these sessions and is neither set nor consistently monitored during or between sessions. Presently progressions are based on observations of the therapist in charge. Nor are there any CCT specific outcome measurements completed prior to or at the end of the programme.

2.4 THE TASK RELATED TRAINING APP PROTOTYPE

JCH would like to evaluate whether their CCT programme can be delivered via a mobile application alongside trained clinicians as part of their inpatient stroke program. The TRT mobile application prototype has been developed by the Rehabilitation Innovation Centre, at AUT University, New Zealand and is designed to provide a tablet-based programmatic locomotor and balance task-related training intervention. The app embeds rehabilitation principles with an individualised task-specific focus that reflects patients' goals, with the aim of delivering a maximally tolerated dose that supports progressive challenge and sufficient repetition that can be monitored and supported by trained clinicians. The TRT app is still in the early stages of development but exists in a digital wireframe format, however not all back-end functionality of the app is complete. There are two digital wireframe sets one for the therapist and one for the patient.

2.5 AIM AND OBJECTIVES

It is the purpose of this critical review to evaluate the suitability of the task TRT app prototype in its current form for delivering locomotor CCT to stroke patients in an inpatient setting at JCH. This critical review is the first step of this process and has three key objectives:

1. Assess the suitability of the 'TRT' app prototype in its current format for providing TRT CCT in an inpatient hospital environment in Singapore and determine what app requirements must be met to ensure usability and suitability in this rehabilitation context through my own user testing.
2. Determine whether the 'TRT' app prototype is consistent with TRT, and motor learning principles as described in McLoughlin's 2020 "Ten guiding principles for movement training in neurorehabilitation" and to identify areas that may require further development.
3. Determine whether the locomotor tasks and task progressions within the 'TRT' app prototype align with the locomotor TRT CCT evidence base in people with stroke, and to identify areas that may require further development.

Chapter 3. Methods

While there are several tools available to evaluate health apps (Camacho et al., 2020; Chan et al., 2015; Dansky et al., 2006; Henson et al., 2019), none of them lend themselves to assessing apps that are in the early development stage. Moreover, there is no standardised method for comparing, validating, regulating, or approving the very apps designed for the rehabilitation field. As a result, the methods used in this critical review are supported by Jake-Schoffman and colleagues (2017), which describes various methods for evaluating the usability, content and efficacy of mobile health apps. This critical review will include three methods for addressing the project's objectives, as outlined below.

3.1 STAGE 1: USABILITY EVALUATION

The objective of stage 1 was to assess the suitability of the TRT app prototype in its current format for providing TRT CCT in an inpatient hospital environment in Singapore and to determine what app requirements would need to be met to ensure usability and suitability in this rehabilitation context. This was completed through the student researcher's own user testing.

The concept of involving end users or consumers in the design and testing process of a product is known as user-centred design or human-centred design (Miaskiewicz & Kozar, 2011). Usability testing is an important part of the digital application development process because it allows potential end-users to provide feedback on whether the product meets the users' actual expectations, while also increasing the likelihood of successful app implementation (Daniels et al., 2007). In the context of this project, usability testing involved assessing the TRT app prototype from a physiotherapy user perspective (the student researcher) using a think aloud method when registering and setting up a TRT CCT programme for a hypothetical stroke patient. This usability method involves participants verbalising their thoughts and experiences as they work through the user interface of the product (Richardson et al., 2017). This resource-efficient method provides useful feedback on the product design and functionality.

This method was carried out on both the physiotherapist and patient interfaces of the digital wireframe app. The think aloud process commenced as soon as the app interface

activated and was videoed, and audio recorded to capture the student researchers' thoughts in real-time. Observation notes were penned during the process. Testing was repeated until new insights ceased during the app interaction. A transcription of all verbalised thoughts was undertaken verbatim. Data was then loosely coded deductively under the following predetermined categories usability, visibility, workflow, content, understand-ability, usefulness and navigation. Definitions for each of these categories are provided in Table 3.1. Based on the coded data paper-based wireframes were proposed to simulate the appearance and function of additional screens and or modifications to the current prototype that could be integrated into future iterations of the TRT app.

Table 3.1. Predetermined categories for user testing

Categories	Definition
Usability	Ease of use of the app, ability to use with minimal effort, i.e., time, clicks, mental energy
Visibility	Ability to quickly recognise key features and instructions provided in the app
Workflow	Ability of the app to fit into the natural order of events in a patient encounter
Content	The relative ease in which the user can engage with text and multimedia features. In this context it relates to accuracy and or appropriateness of the app text and multimedia, patient information, intervention details and relevant documentation
Understandability	Ability to quickly comprehend meaning of text, instructions, and the purpose of app components
Practical Usefulness	Improves speed or decreases workload during encounter and it is adaptable to user expectation
Navigation	Ability to move easily through the app and locate relevant information or features

3.2 STAGE 2: COMPARATOR EVALUATION- TRT & MOTOR LEARNING EVIDENCE-BASE

The objective of stage 2 was to determine whether the app is consistent with TRT, and the motor learning principles described in McLoughlin's 2020 "Guiding principles for movement training in neurorehabilitation" and to identify areas that may require further development. This was evaluated using the 'selecting a comparator method' proposed by Jake-Schoffman et al. (2017). This method involves comparing the app's content to

clinical guidelines or evidence-based protocols, in this case the McLoughlin's 2020 guiding principles. Such comparisons can enhance the app's credibility among researchers, clinicians, and patients alike (Breland et al., 2013).

The McLoughlin, 2020 Guiding principles for movement training in neurorehabilitation provides a broad conceptual framework consisting of ten movement training principles that are designed to facilitate a shared language, which supports evidence-based clinical practice and interdisciplinary working, research involving the development of movement-based interventions and educational contexts (Faux et al., 2018; Harrington et al., 2010). These principles were derived from the concepts of motor control and learning, behavioural neuroscience, exercise science, and self-management (Jones & Riazi, 2011; McKenna et al., 2015). The ten movement training principles are:

1. Actual and predicted bodily state
2. Feedback
3. Error-based learning
4. Reward-based learning
5. Cognitive selecting and planning
6. Practice and variability
7. Biomechanics
8. Physical capacity
9. Attention
10. Beliefs and self-efficacy

Based on McLoughlin's (2020) definitions, only the guiding principles that specifically relate to motor learning and underpin TRT principles were used for this critical review. The TRT app was assessed against each of the relevant guiding principles to ascertain whether these principles were embedded within the app. First the student researcher indicated whether the movement principle was captured fully, partially, or not present within the app. This decision was supplemented with evidence in the form of screenshots and extracted text descriptions. Next the evidence extracted from the app was evaluated against the detailed description of the relevant guiding principle and its examples provided in the McLoughlin, 2020 article. Where the description of the principle was insufficient, the referenced literature cited in the description of the principle was sourced to support interpretation. This helped to ensure the principle could be sufficiently linked to TRT. If

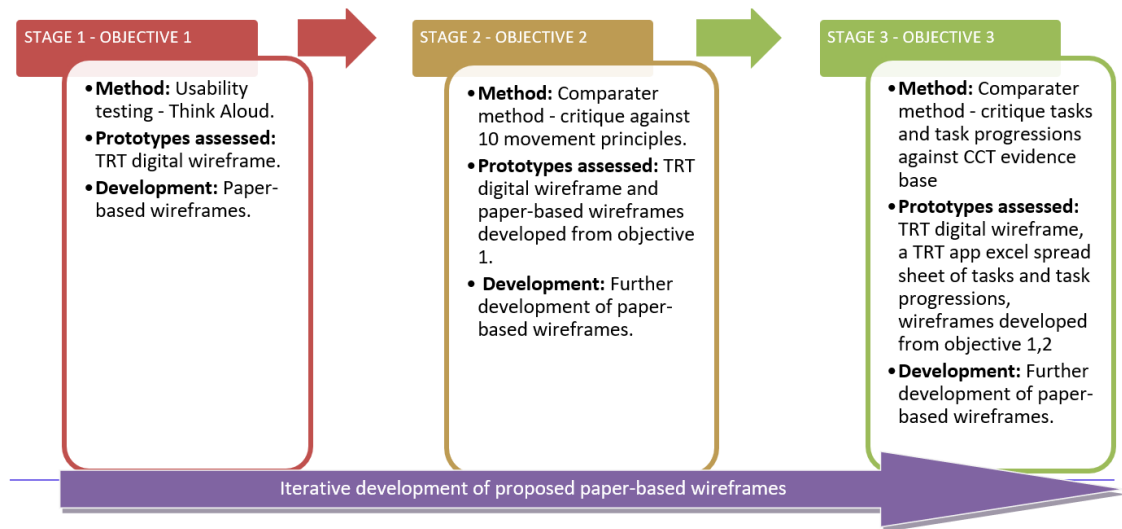
principles were not well addressed or absent in the app, an explanation of their relevance for future iterations was offered and supplemented with paper-based app wireframes.

3.3 STAGE 3: COMPARATOR EVALUATION- LOCOMOTOR CCT EVIDENCE IN PEOPLE WITH STROKE

The objective of stage 3 was to determine whether the locomotor tasks and task progressions featured in the TRT app align with those documented in the locomotor TRT CCT evidence base in people with stroke and to identify areas that may require further development. Stage 3 also utilised the 'selecting a comparator method' proposed by Jake-Schoffman et al. (2017). The comparator being the Cochrane review "Circuit class therapy for improving mobility after stroke" by English et al., 2017 and a systematic review that was completed by the student researcher's HEAL803 Special Topic paper. This systematic review synthesised rehabilitation dosage parameters, the tasks practised, and task progressions reported in locomotor CCT in people with stroke. This was an extension of the English et al. (2017) systematic review and included additional publications that met the inclusion criteria between Jan 2017 and May 2021.

The tasks and associated task progressions described in the CCT literature were mapped against the app content in a table format. Where tasks and associated task progressions were missing from the app, an explanation of their importance for future iterations was provided, and paper-based app wireframes were supplemented. To summarise the stages of this research Figure 3.1 displays the iterative development of paper-based wireframes as part of this reach project, and the prototypes that will be critiqued at each stage of the iterative process.

Figure 3.1 Iterative Development of paper-based wireframes



A schematic representation of the iterative development of paper-based wireframes that will be built as part of this project along with the prototypes that will be critiqued at each stage of the project

Chapter 4. Results

It is recommended that the reader views the current digital wireframes of the physiotherapy and patient app interfaces prior to reading the below results. These can be located on the inversion app login provided.

4.1 STAGE 1- USABILITY EVALUATION

The following results relate to objective 1: Assess the suitability of the TRT app prototype in its current format for providing TRT CCT in an inpatient hospital environment in Singapore and determine what app requirements must be met to ensure usability and suitability in this rehabilitation context through my own user testing.

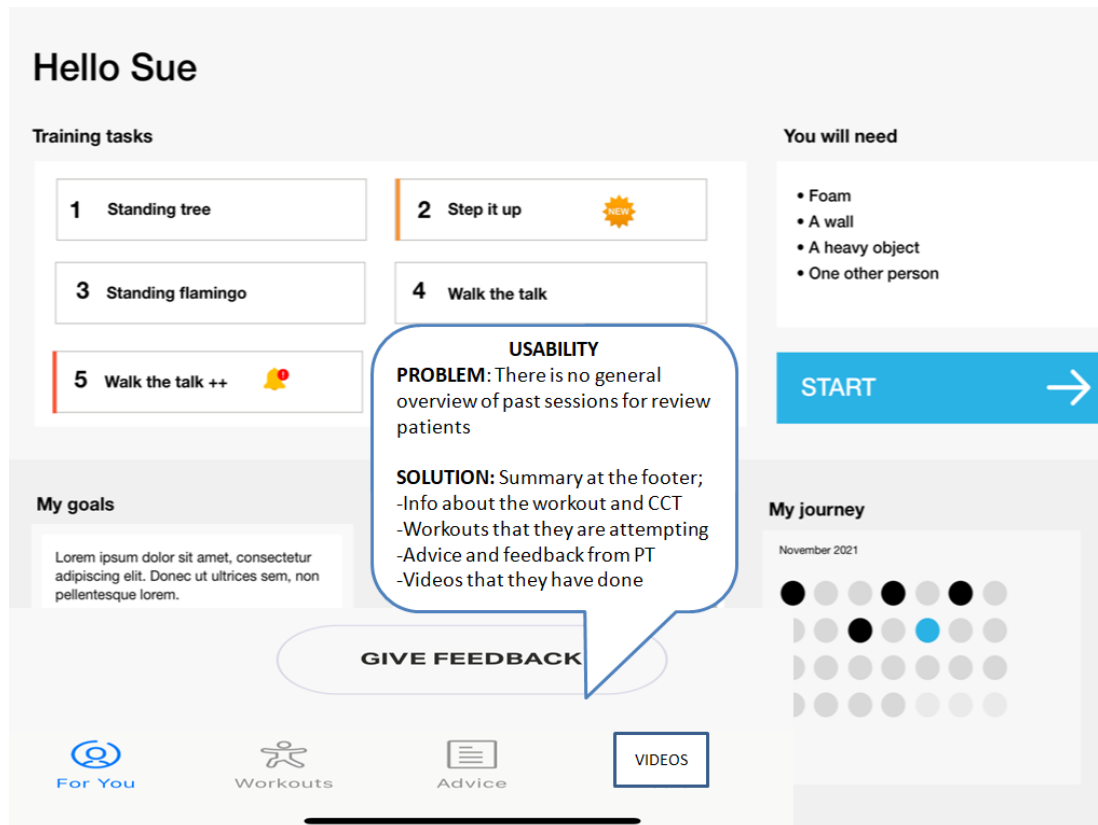
Findings from both the physiotherapist and patient interfaces were considered in relation to the following predetermined categories, usability, visibility, workflow, content, understand-ability, usefulness, and navigation. Once the student researcher had categorised the think aloud data, potential issues, and solutions for each of the categories were documented on snapshots of the relevant app screens as part of the wireframe development. Key examples for each category are reported in the relevant sections below. A copy of all the wireframe amendments can be found in Appendix Section 1 and Section 2 for the physiotherapy and patient app interfaces respectively.

4.1.1 Usability

Usability is defined as the app's ease of use and the ability to use the app with minimal effort, i.e., time, clicks, mental energy (Richardson et al., 2017). From the sign-in screen to the closing screen, the app's patient and physiotherapy interfaces were seamless. The software required very little effort to use. The usability of the programme development segment in the physiotherapy interface was particularly appealing. The user liked how it diverged into three sections: programme goals, training focus and programme settings (see Appendix Section 1 Screen 1.7). It was clear that the physiotherapist was able to distinguish between different sorts of tasks that were selected for the patient depending on their goals which reduced mental energy. Whilst usability of the patient app has not been tested by a patient the addition of a general overview of the patients' prior sessions that could be accessed via the patient dashboard would be helpful. If the app was to be utilised as part of

a CCT programme a quick summary of the tasks completed in the last session, previous performance at each station and any feedback that had been provided by the physiotherapist and any videos of tasks completed would be desirable (See Figure 4.1 and Appendix Section 2 on wireframe 2.2 of the patient app wireframes).

Figure 4.1 Updated wireframe for patient interface to improve usability in patient dashboard

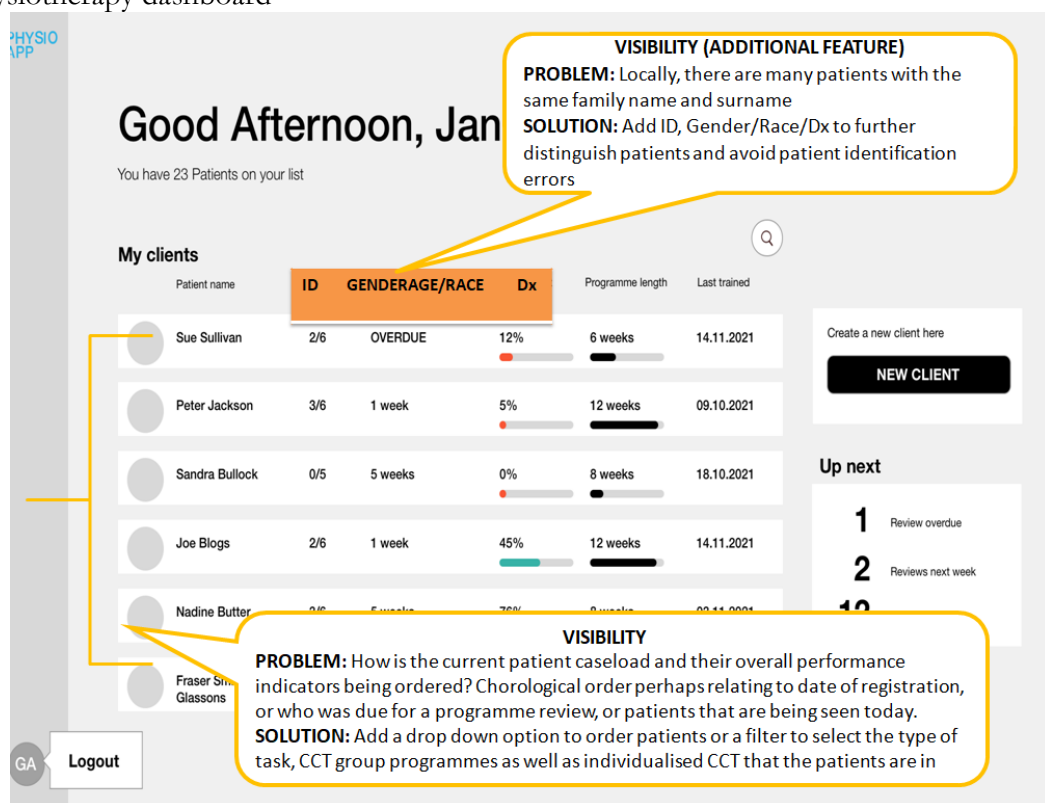


4.1.2 Visibility

Visibility is defined as the ability to quickly recognise key features and instructions provided in the app (Richardson et al., 2017). The user is aware that the app is still in the prototype stage and that visual aesthetics have not yet been implemented. However, both the physiotherapist and patient interfaces were mostly visually comprehensive, with minimal barriers to recognising key features and instructions. The user particularly liked the videos in the patient interface that would support patients understanding of how best to perform the task and could easily be viewed prior to each CCT station. One feature that was not clear was the organisation of the physiotherapist’s current patient caseload and their overall performance indicators that are listed on the physiotherapist’s dashboard (See Appendix Section 1 Screen 1.2). The user wondered where they were displayed in chronological order

relating to date of registration, or who was due for a programme review. To improve the visibility of the dashboard organisation, the user suggests a dropdown list or a filter to order patients by programme review, level of engagement or date of registration. If the app was to be utilised for CCT programmes to aid visibility, a filter to select the type of task, CCT group-based programmes as well as individualised CCT programmes should also be incorporated into the physiotherapist's dashboard. Another way to improve visibility on the therapist dashboard would be to include the patients ID number, since many patients in Singapore have the same surname or family name (See Figure 4.2A and Appendix Section 1 on wireframe 1.2 of the physiotherapist app).

Figure 4.2A Updated wireframe for physiotherapy interface to improve visibility in physiotherapy dashboard



For the patient interface, increasing the visibility of the patient task instructions on the exercise cue screen would be beneficial. Making these more visible to the right of the exercise cue would make them more easily identifiable if the patient had forgotten the details or the therapist needed to access them when assisting a patient at a specific CCT station (Figure 4.2B and Appendix Section 2 on wireframe 2.9 of the patient app). A countdown timer on the exercise cue screen and rating screens to inform the patient how much rest time they have before starting the next CCT station would also be useful (Figure 4.2C and 4.2D and Appendix Section 2 on wireframe 2.18 and 2.19 of the patient app respectively).

Figure 1 **Figure 4.2B** Updated wireframe for patient interface to improve visibility in patient app

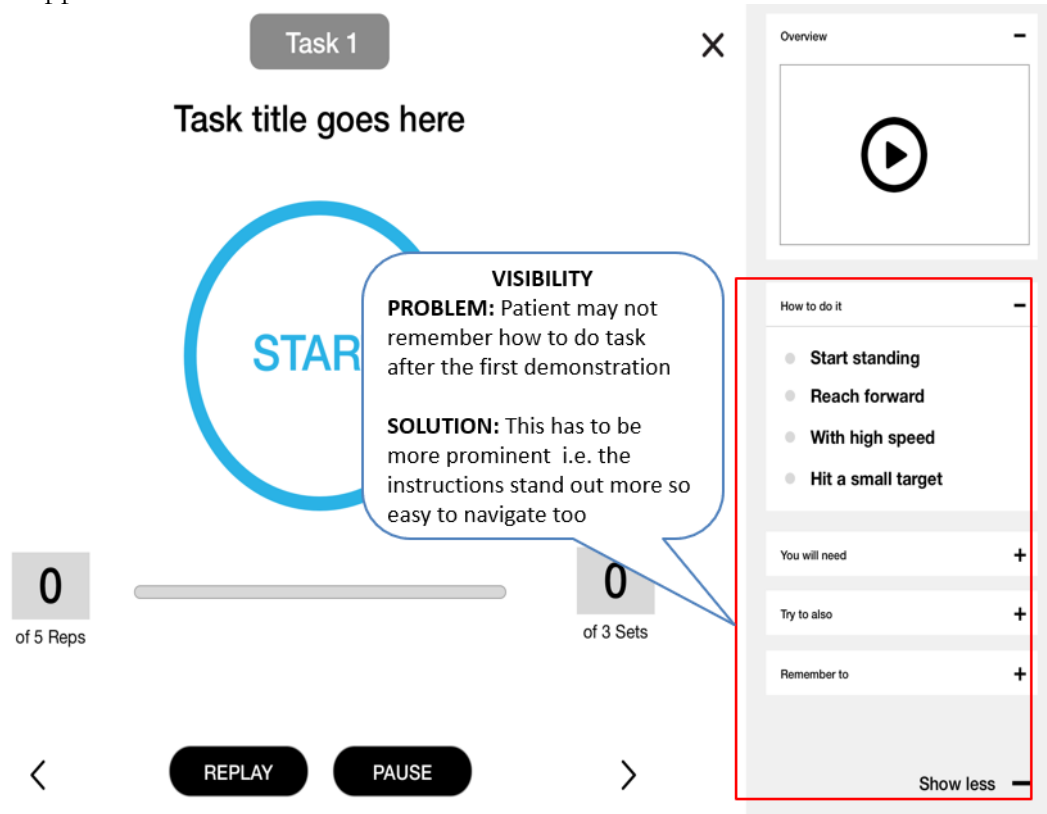


Figure 4.2C Updated wireframe for patient interface to improve visibility in patient app: Timer

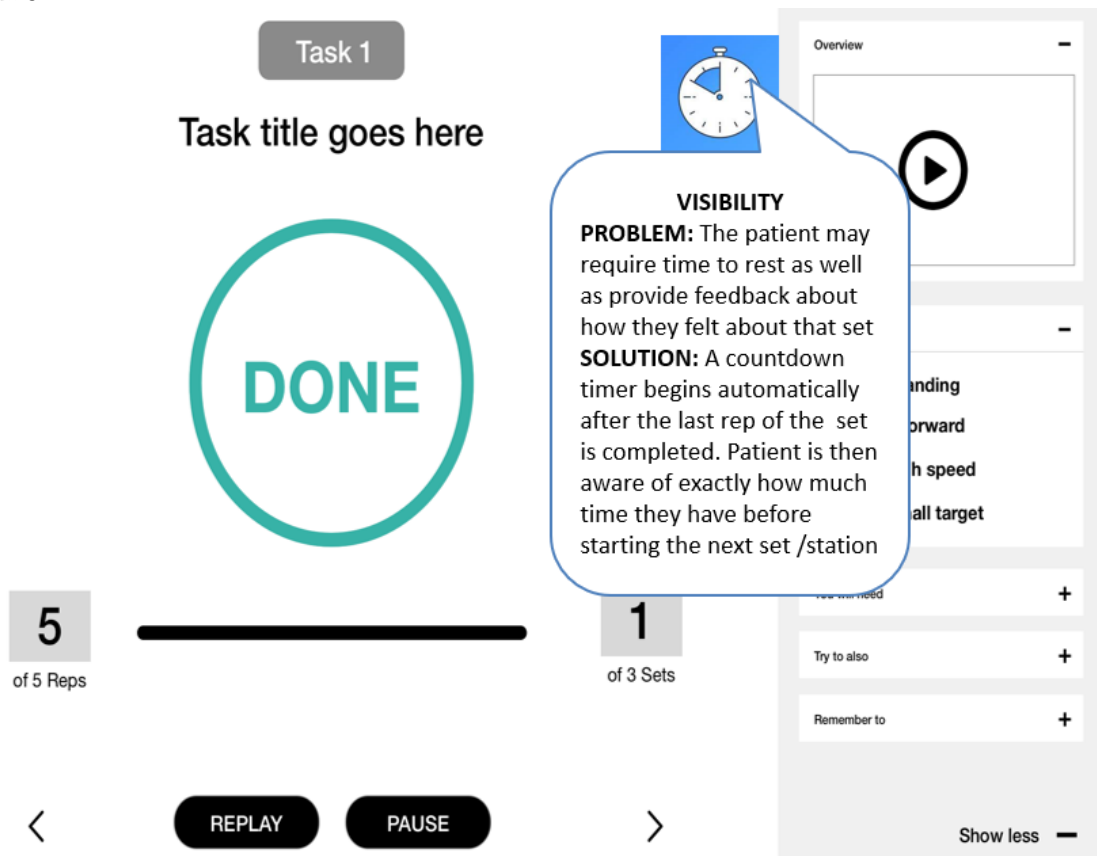
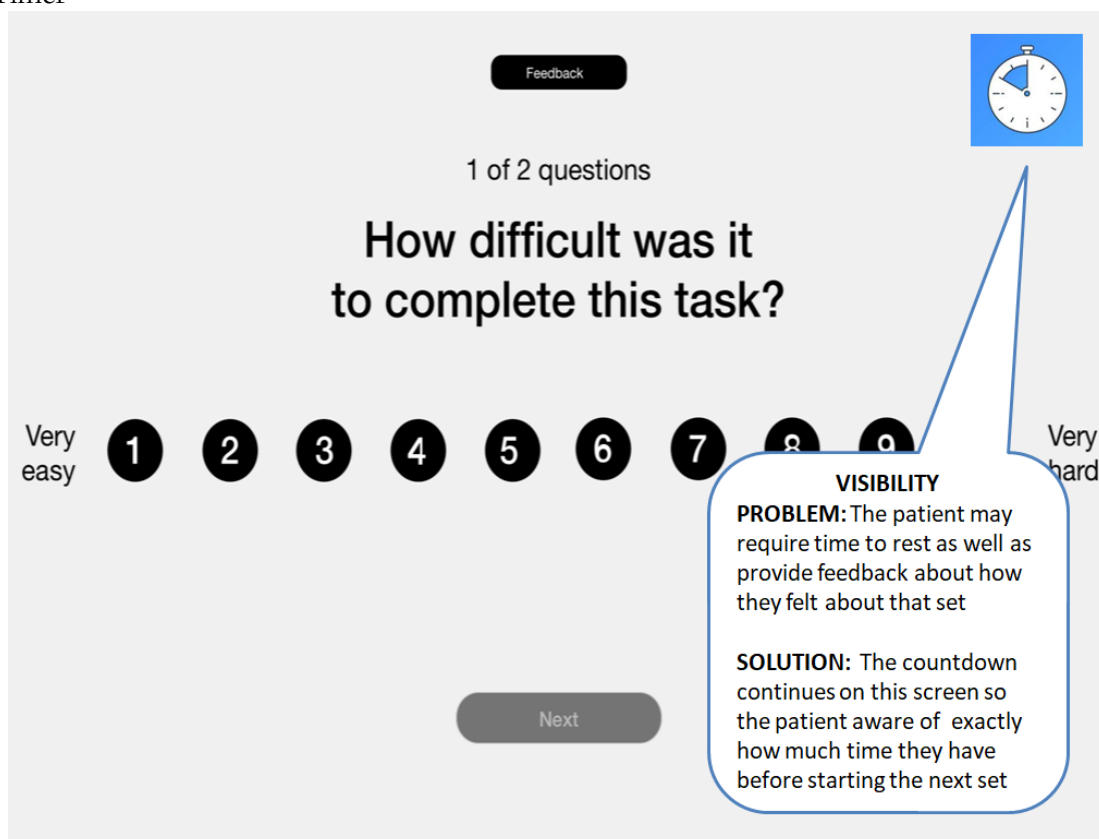


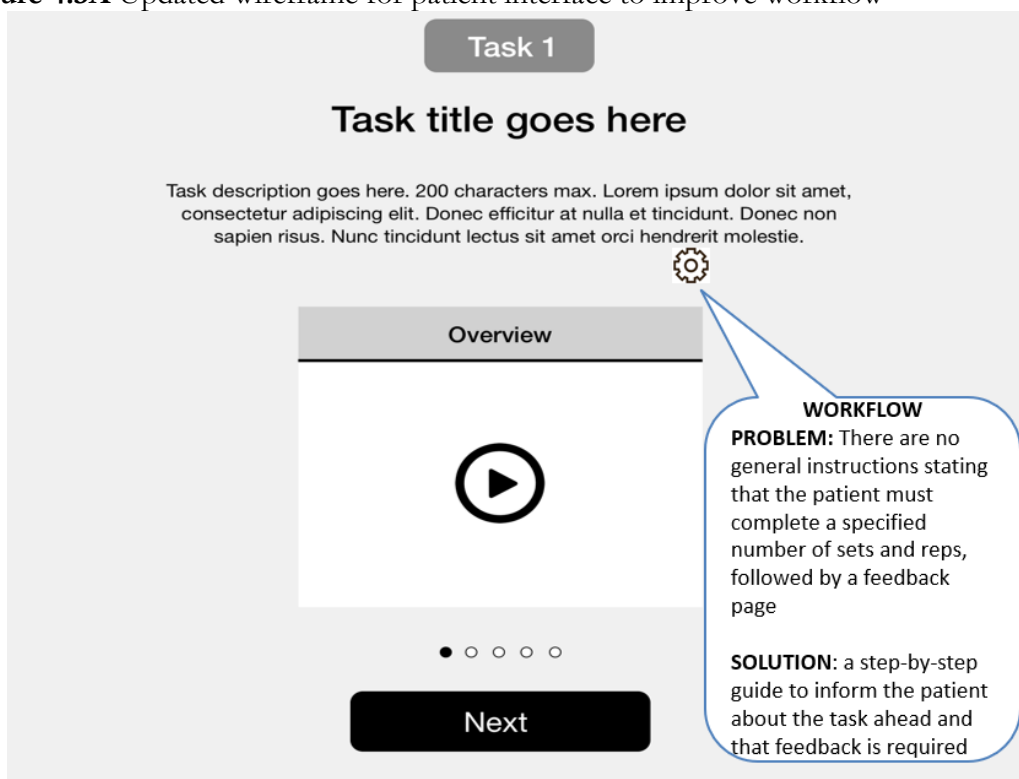
Figure 4.2D Updated wireframe for patient interface to improve visibility in patient app: Timer



4.1.3 Workflow

The definition of workflow is the ability of the app to fit into the natural order of events (Richardson et al., 2017) in a patient and physiotherapy encounter. From the login page for physiotherapy app, it was a seamless transition from client details to the programme and training tasks. Registering and setting up a TRT programme were easily managed and without problems. The patient app flowed smoothly and made chronological sense. Displaying tasks that needed to be completed, accompanied by a video demonstration, what equipment was needed, what to focus on when performing the task, executing the task on the exercise cue screen, followed by a feedback prompt screen where patients rated the task difficulty and confidence. A minor tweak in the workflow would be informing the patient earlier in the workflow how many sets and reps that they will be rating the exercise based on difficulty and confidence after finishing a set or in the case of CCT a particular station (See Figure 4.3A and Appendix Section 2 on wireframe 2.4 of the patient app). This will ensure the patient is better informed about the process prior to performing the exercise.

Figure 4.3A Updated wireframe for patient interface to improve workflow



For this app to be used for individual TRT programs and CCT programmes additional screens upfront in both the physiotherapist and patient interfaces would be required to improve workflow once logged in. This screen would provide a higher level of organisation for the physiotherapy app, allowing the therapist to know what they had on that day, week, and who is enrolled in what type of activity. For example, a calendar can be used to obtain patient lists and class schedules for the day. Furthermore, the screen would need a way to access patient lists, such as a button that takes you to who has individualised programmes and another button that takes you to those patients who are enrolled in a CCT programme (See Figure 4.B and Appendix Section 1 on wireframe 1.1 of the physiotherapist app). This screen for the patient app would provide a better overview of the rehabilitation they have that week, a task overview (the tasks they have completed thus far), the type of TRT CCT sessions they have completed and will complete, and a performance index based on their feedback on their tasks (See Figure 4.3C and Appendix Section 1 on wireframe 2.1 of the patient app).

Figure 4.3B Updated wireframe for physiotherapy interface to improve workflow

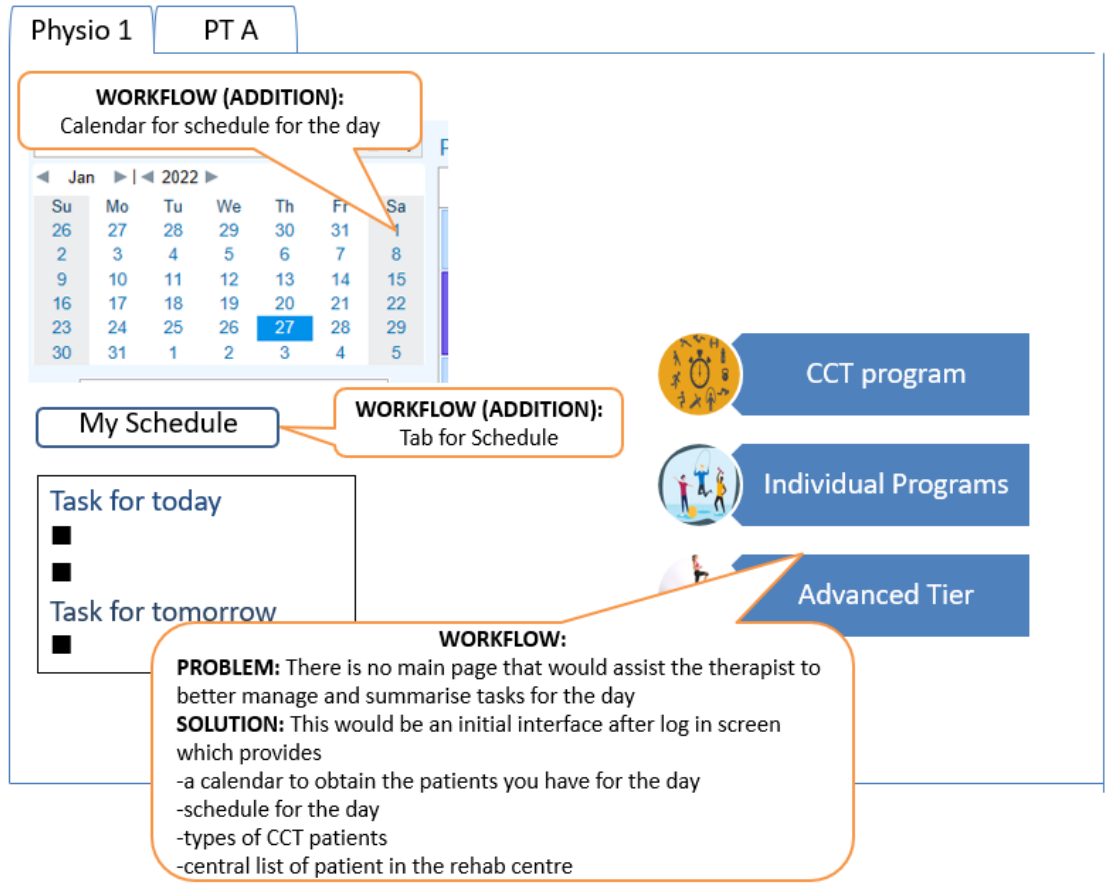
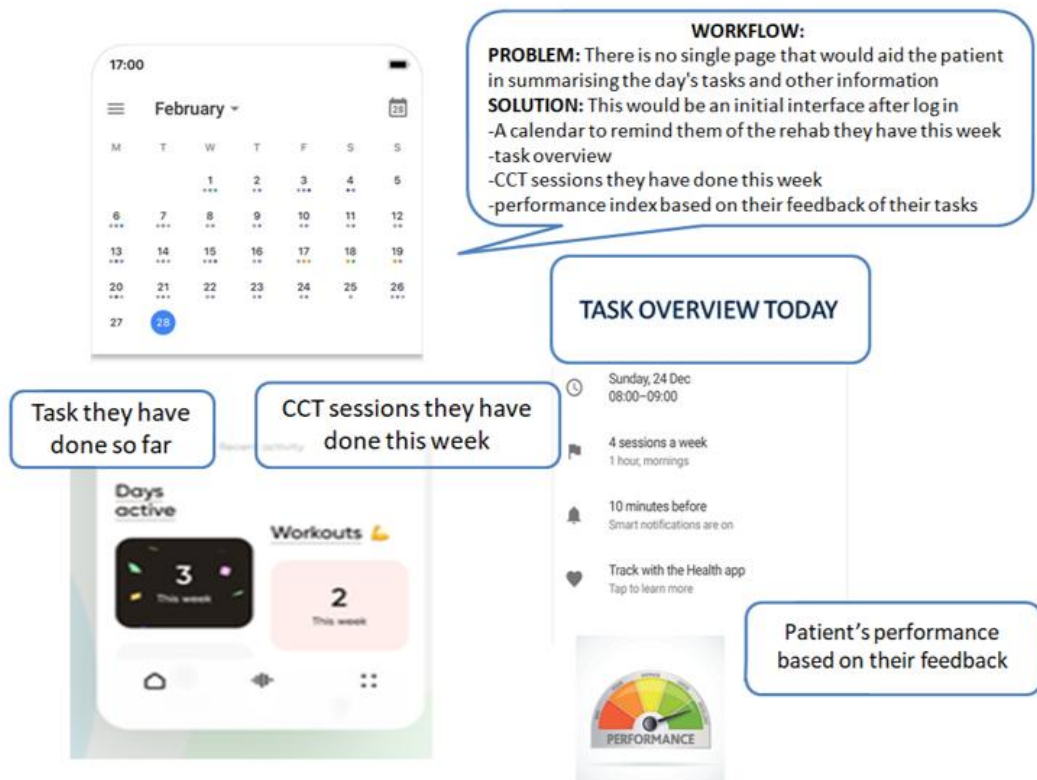


Figure 4.3C Updated wireframe for patient interface to improve workflow



4.1.4 Content

The definition of content is the ease with which the user can interact with the information in the app and relates to the accuracy and or appropriateness of the text and multimedia. In this app the patient information, intervention details, and relevant documentation are particularly important. This app was created with physiotherapists and patients in mind. The user particularly liked that it was setup to support the management of a physiotherapist's desired plans and a patient's expected outcome. It uses evidence-based exercise rehabilitation principles to engage with stroke patients and contains an extensive library of tasks that can be manipulated to suit the individuals' goals. The sheer number of TRT exercises and the associated progressions means that it has flexibility to tailor each patient's training session based on their functional level and the desired challenge point. However, during the session, it does not monitor the patient's real-time response to these tasks. The additional feature of video recording the patient performing the task in real time may provide knowledge of performance to the patient when watched back and to the therapist if they are not present at the CCT station when the patient is performing the task. A camera function would need to be activated by the patient pressing on a camera icon that appears on every exercise cue screen and then minimised to the side on pressing play so that it did not interfere with the visibility of the exercise cue. This additional video content could provide information on task deviations despite demonstration, as well as the number of patient errors and whether or not they are self-corrected with repetition. The videos could potentially be linked to the therapist interface once recorded if both apps were connected to the cloud (See Figure 4.4A and Appendix Section 1 on wireframe 1.13 of the physiotherapist app).

Figure 4.4A Updated wireframe for physiotherapy interface to improve content in physiotherapy app

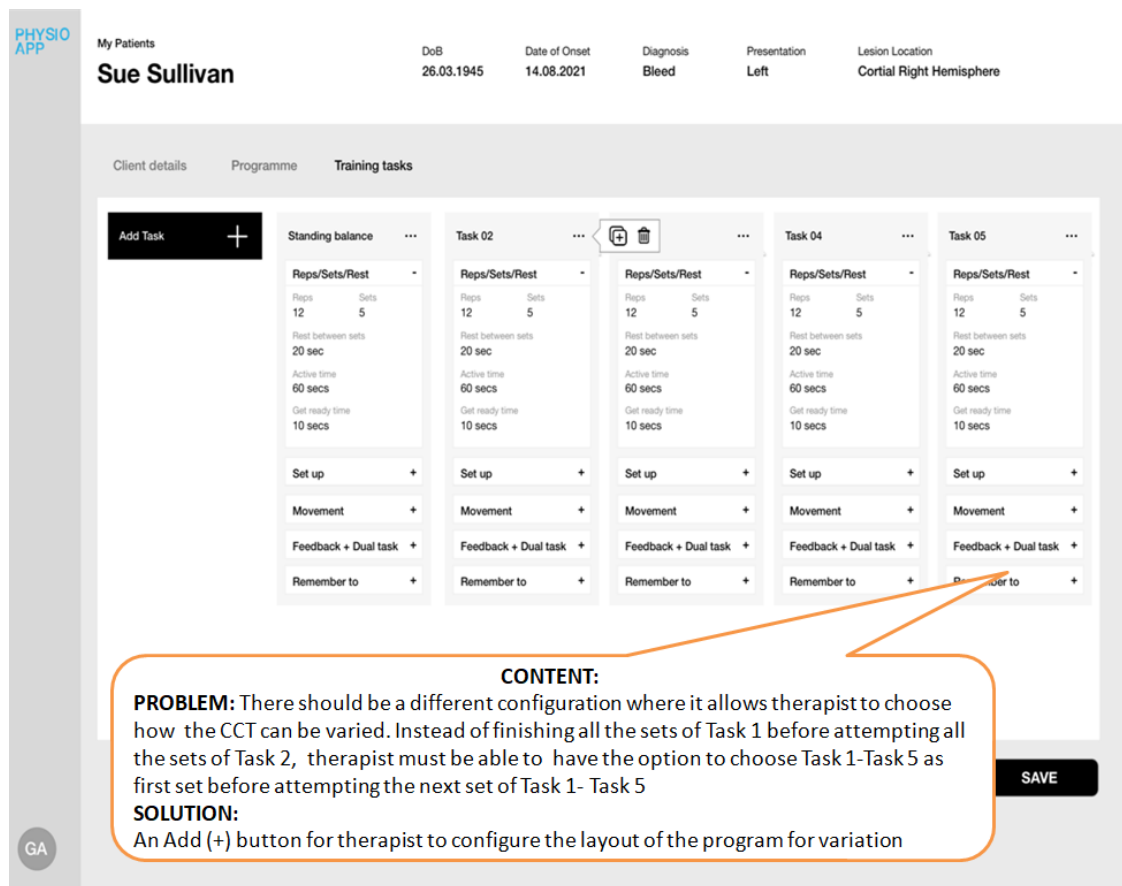
CONTENT
PROBLEM: For task progressions there is no video on for these variations this would likely help patients to visualise the changes made to the task

SOLUTION:
 Add (+) Upload videos that can show variations of the task and video feedback from therapist

CONTENT (Addition)
 The option of recording patient whilst performing a task would be desirable. Future addition could be a function to upload video of patient. The app starts recording patient when they are performing the task so that therapist can feedback

Another content feature that is lacking is the flexibility to support multiple CCT station configurations for individual patients. For example, currently, patients are required to finish all the repetitions and sets of a single given exercise i.e., sit to stand prior to attempting the next exercise i.e., forward walking. During a CCT session, however, the patient may only complete one set of exercises at a station before moving on to the next exercise station and repeating the circuit several times. Alternatively, different but related tasks could be completed at the same station to promote motor learning. If the app is used to deliver CCT programmes, therapists should be able to train patients in a variety of configurations (See Figure 4.4B and Appendix Section 1 wireframe 1.15 of the physiotherapy app).

Figure 4.4B Updated wireframe for physiotherapy interface to improve content in physiotherapy dashboard



Other ways to improve content in the physiotherapy app would be to include a comments box in the clients' registration section where therapists can document any abnormal movement patterns associated with patients' functional goals (See Figure 4.4C and Appendix Section 1 wireframe 1.4 of the physiotherapy app), as well as the inclusion of a separate entry box for patient work history, as this is not noted under social history in Singapore (See Figure 4.4D and Appendix Section 1 wireframe 1.5 of the physiotherapy app).

Figure 4.4C Updated wireframe for physiotherapy interface to improve content in physiotherapy dashboard

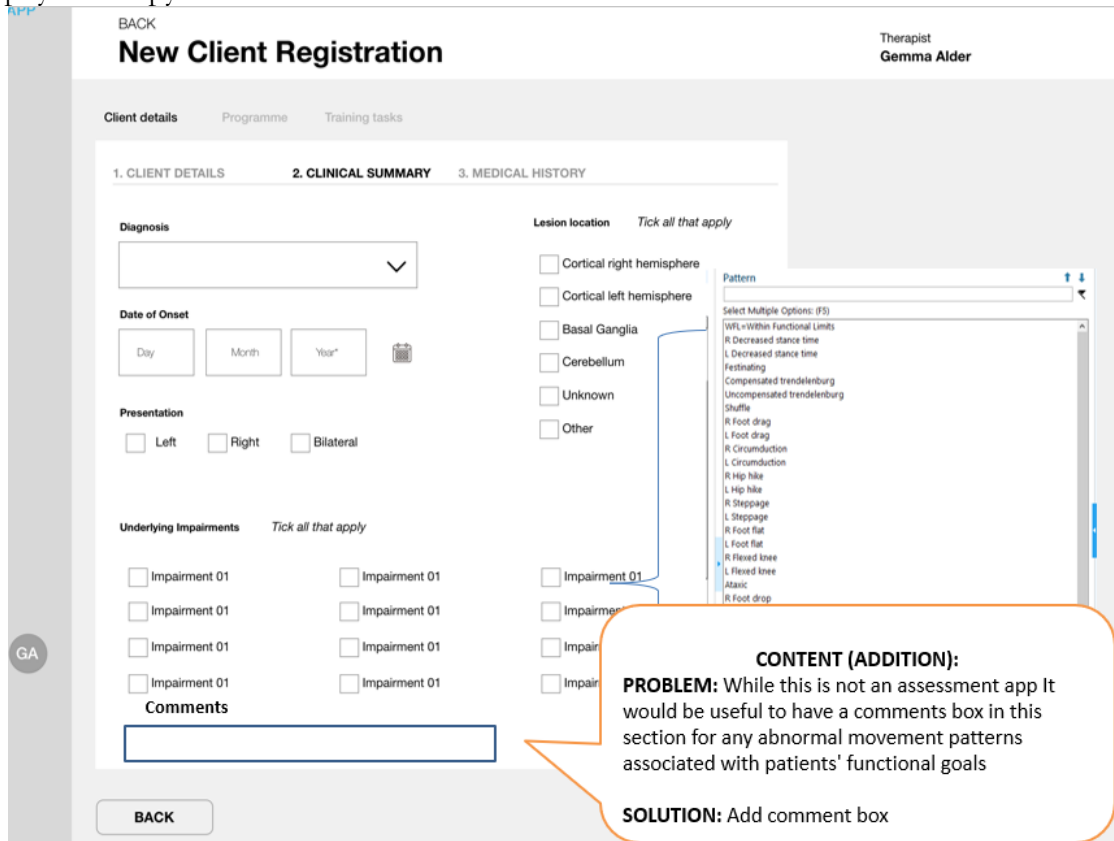
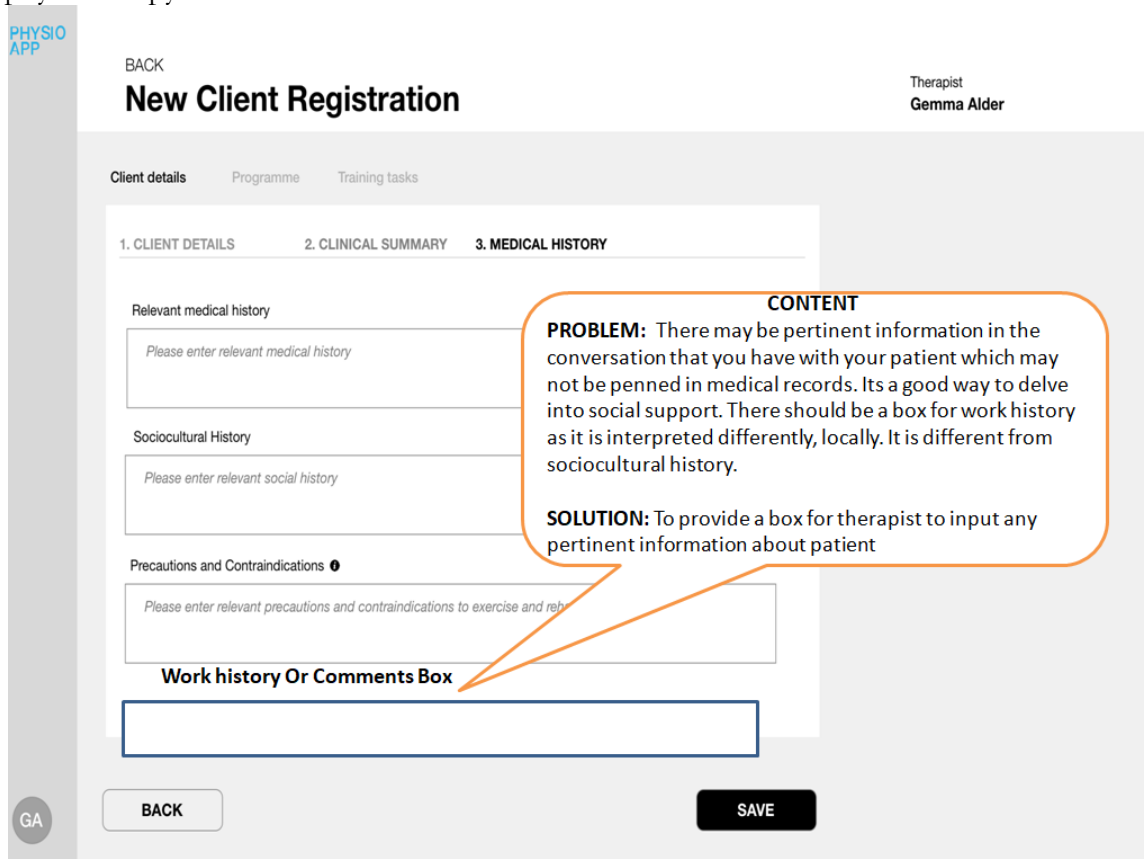


Figure 4.4D Updated wireframe for physiotherapy interface to improve content in physiotherapy dashboard



In the patient app, additional content would include a video that explains the setup of the task before viewing existing videos of how to perform the task (see Figure 4.4E and Appendix Section 2 wireframe 2.4 of the patient app). Currently there are no videos of the task which reflect parameter manipulation. Therefore, adding an 'I' button next to the videos of the task would remind the patient what parameters have been progressed at a given CCT station (see Figure 4.4F and Appendix Section 2 wireframe 2.7 of the patient app). Finally, a comment box for patients to provide feedback beyond the difficulty and confidence performance scales on the rating screen could be useful within a CCT context (see Figure 4.4G and Appendix Section 2 wireframe 2.31 of the patient app).

Figure 4.4E Updated wireframe for physiotherapy interface to improve content in patient dashboard



Figure 4.4F Updated wireframe for physiotherapy interface to improve content in patient dashboard

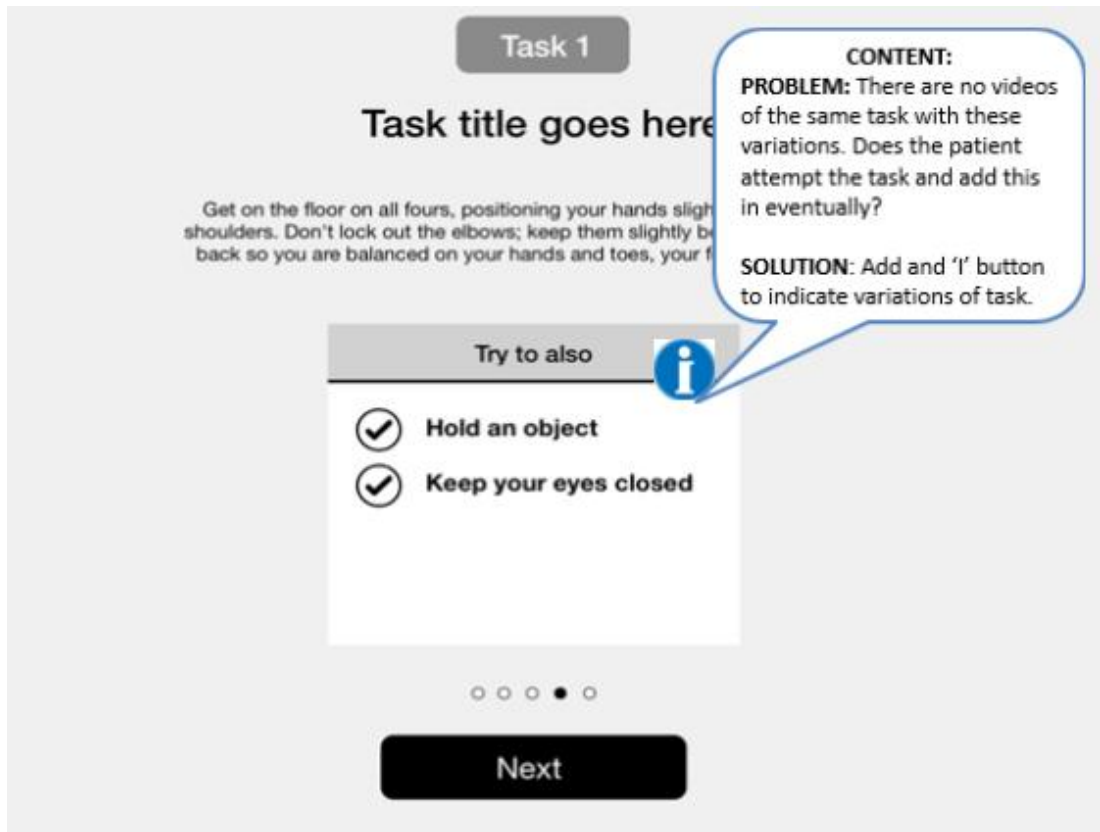
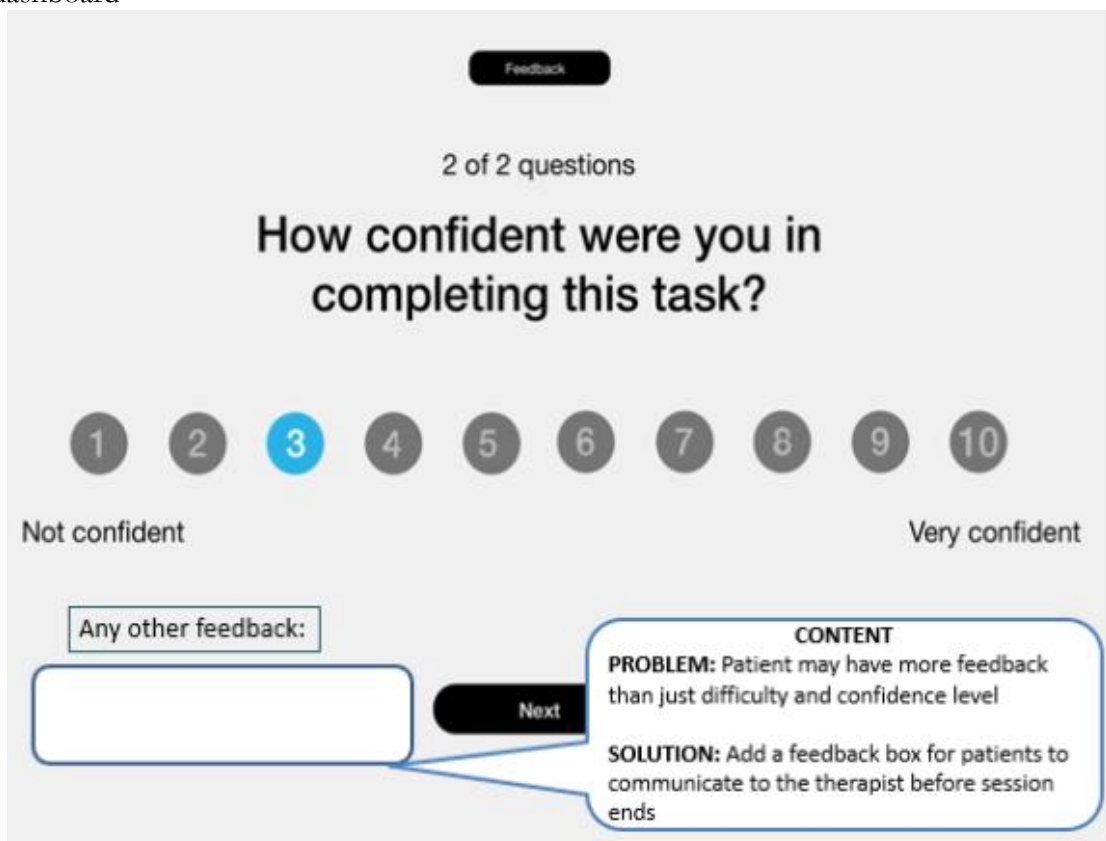


Figure 4.4G Updated wireframe for physiotherapy interface to improve content in patient dashboard

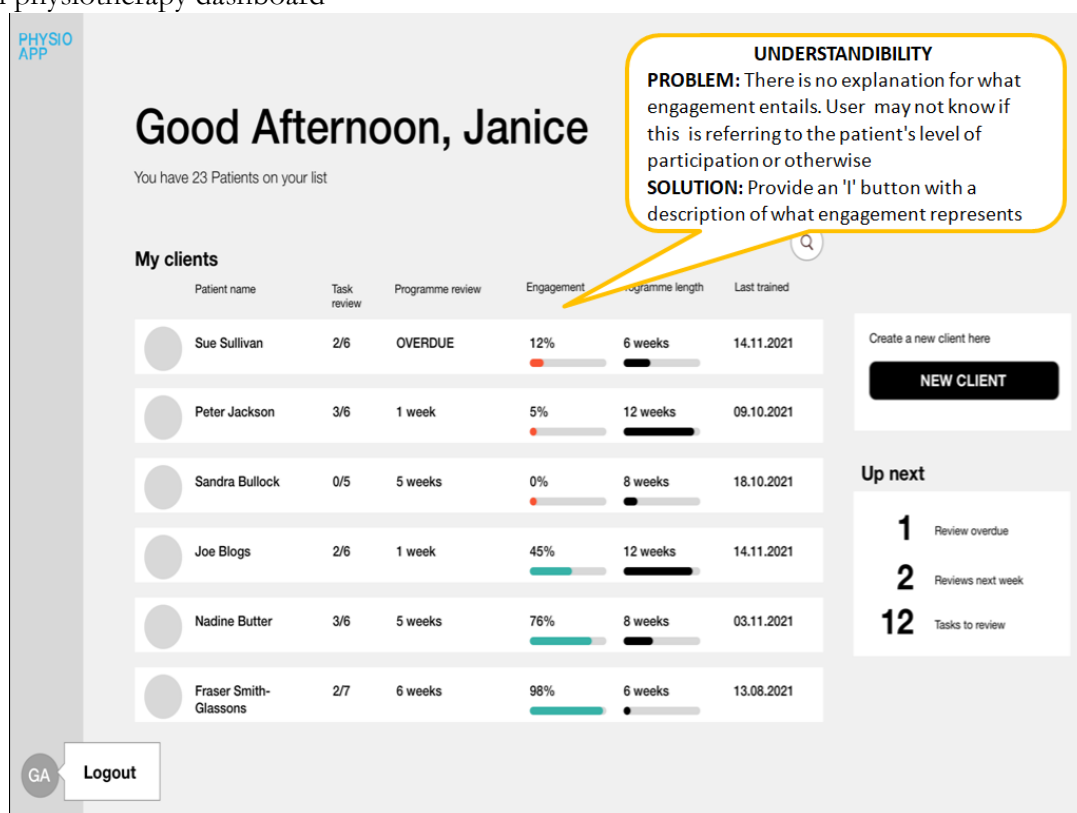


4.1.5 Understandability

Understandability is defined as the ability to quickly comprehend meaning of text, instructions, and the purpose of app components (Richardson et al., 2017). Overall, the physiotherapy and patient interfaces appear to be rather simple to comprehend. Instructions within the app were mostly clear and concise. One future enhancement would be that the app was produced in other languages (Malay, Tamil and Mandarin) if it were to be adapted to the local hospital context.

Some of the features on the physiotherapist dashboard and their purpose were unclear. For example, the term 'engagement' is used as a column heading which provides each patient with a percentage score out of 100. The user assumed this related to the patient's level of participation in some way but does not know whether this related to number of sessions or something else. The addition of a simple 'I' information button that once pressed provides a pop-up description of what engagement entails, could optimise understandability (See Figure 4.5A and Appendix Section 1 on wireframe 1.2 of the physiotherapist app).

Figure 4.5A Updated wireframe for physiotherapy interface to improve understandability in physiotherapy dashboard



Similarly in the patient app some information buttons on the patient dashboard would help clear up confusion of what the assorted colour dots on their calendar represent in relation to their journey so far (See Figure 4.5B and Appendix Section 2 on wireframe 2.2 of the

patient app). A reminder on the exercise cue screen for the patient to complete the feedback after each set, would also be helpful (See Figure 4.5C and Appendix Section 2 on wireframes 2.18 the patient app).

Figure 4.5B Updated wireframe for physiotherapy interface to improve understandability in patient dashboard

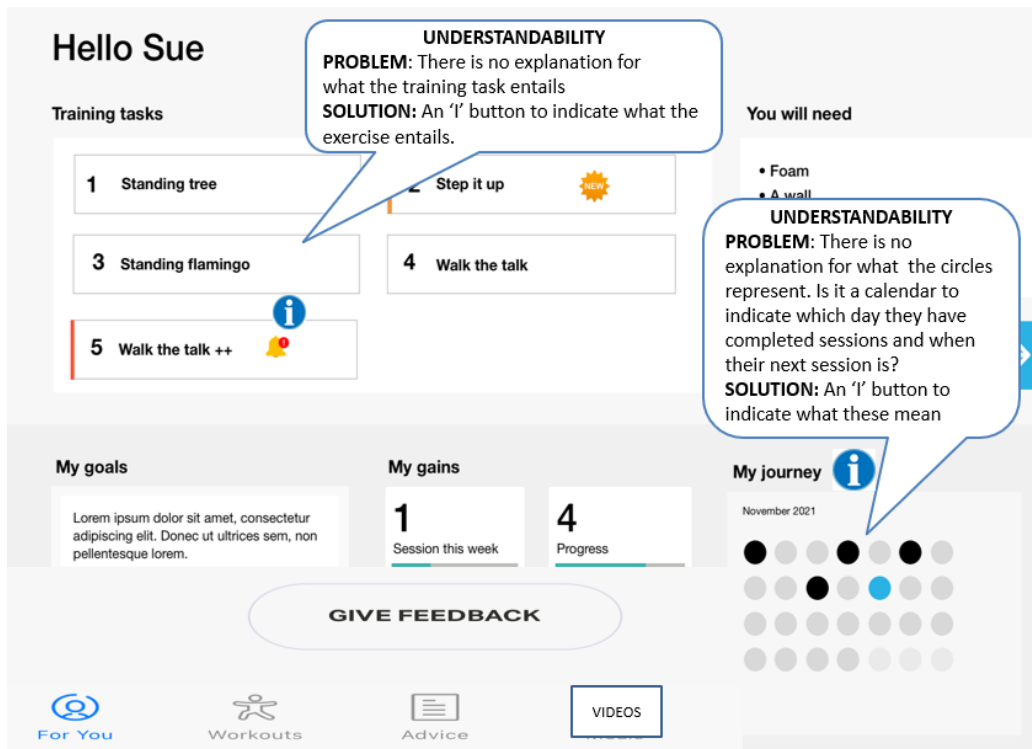
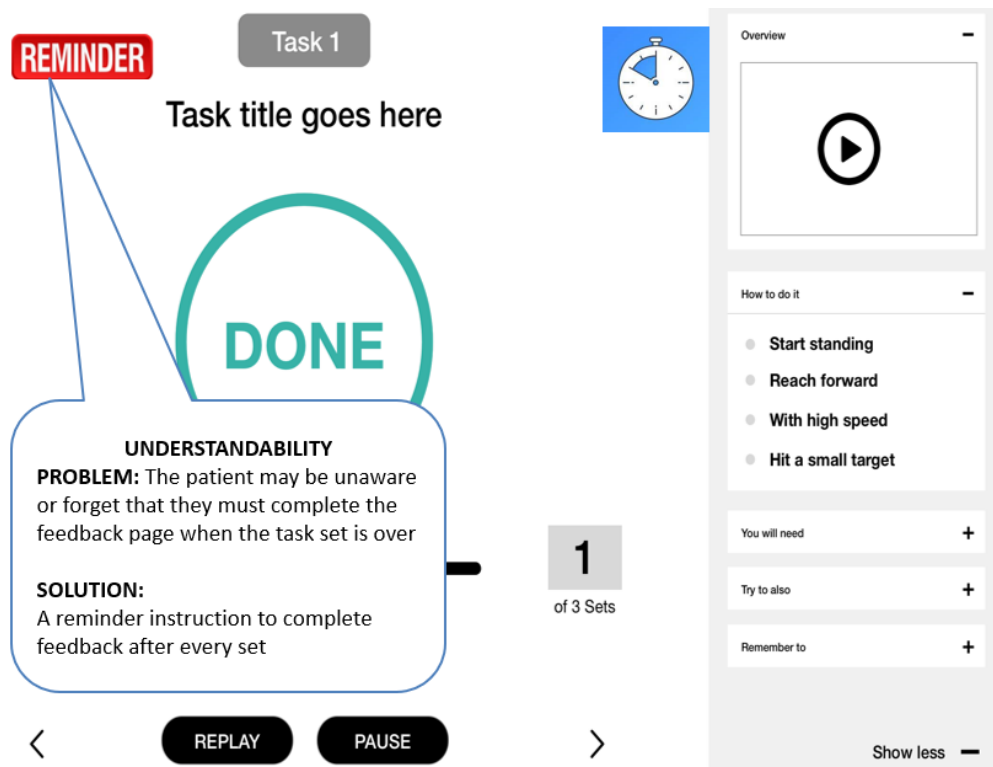


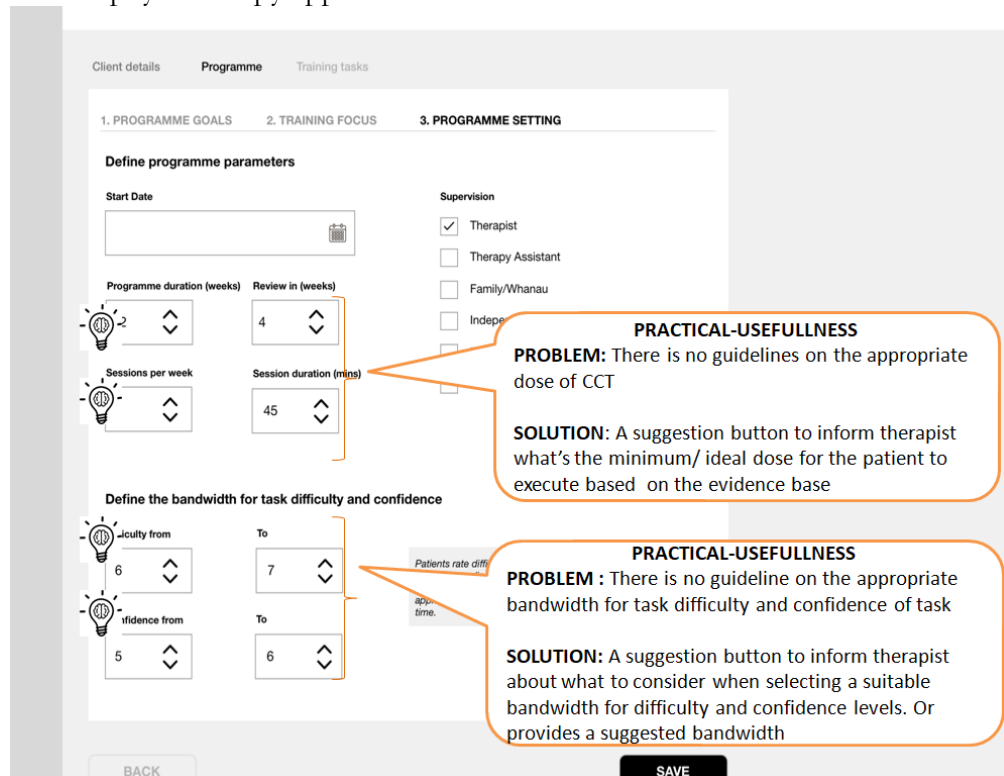
Figure 4.5C Updated wireframe for physiotherapy interface to improve understandability in patient interface: Reminder



4.1.6 Practical Usefulness

Practical usefulness is defined as increasing speed or decreasing workload during an encounter (Richardson et al., 2017). In the physiotherapy interface the use of automatically generated dropdown lists to select patient characteristics (i.e., ethnicity, diagnosis) programme and intervention parameters relating to dose, intensity (bandwidth difficulty) confidence levels and the specific task parameters (i.e., set up, movement parameters, feedback, and dual task etc.) were particularly appealing. The user could see that this could dramatically reduce time spent on documentation and programme set up. This would be particularly useful if you wanted to tweak parameters during the CCT session (See Appendix Section 1 on Screens 1.3, 1.4, 1.9 and 1.13). On the dashboard, there were also notifications to remind the physiotherapist of what patient programmes needed reviewing which was another appealing feature from a time-management perspective. A useful addition to the physiotherapist app would be guidance for the therapist regarding optimal rehabilitation dose parameters (session duration, frequency and programme duration) and the optimal bandwidth in which to set the intensity of the training (See Figure 4.6A and Appendix Section 1 on wireframe 1.9 of the physiotherapist app). For example, the optimal dose based on CCT evidence could be added as default values when setting up a patient programme or a suggestion button that indicates minimal and or optimal dose.

Figure 4.6A Updated wireframe for physiotherapy interface to improve practical usefulness in physiotherapy app



Other suggestions include adding an emergency contact box in the registration screen as the next of kin may not be the patient's emergency contact (See Figure 4.6B and Appendix Section 1 on wireframe 1.3 of the physiotherapist app) and the ability to view patients' programmes side by side. The latter suggestion would be particularly useful during a CCT class when you need to access more than one patient station. For example, where more than one patient appears to have improved beyond their stipulated bandwidth, you would want to go in and adjust each patient's parameters of a task accordingly in real time.

Figure 4.6B Updated wireframe for physiotherapy interface to improve practical usefulness in physiotherapy app: emergency contact

PHYSIO APP

BACK

New Client Registration

Therapist
Gemma Alder

Client details Programme Training tasks

1. CLIENT DETAILS 2. CLINICAL SUMMARY 3. MEDICAL HISTORY

First name

Last name

Address

Email

Phone number

Ethnicity

Date of birth DD MM YYYY

ID number (opt)

Emergency Contact

Next of Kin

Contact number

PRACTICAL-USEFULNESS
PROBLEM: Next of kin may not be their emergency contact
SOLUTION: Add Emergency contact box

GA

BACK

NEXT

4.1.7 Navigation

Navigation is the ability to move easily around the app and locate relevant information or features (Richardson et al., 2017). For the patient interface, the entire app's content is designed to meet the needs of a new user and potentially someone who is unfamiliar with technology or not particularly tech savvy. The patient's app is a great example of an easy-to-navigate and simple-to-use dashboard that displays the patient's goals, all of the training tasks, their progress so far, and a 'start' button to begin the task right away (See Appendix Section 2 Screen 3). The user discovered in the physiotherapist interface that the patient can have up to three quantifiable goals, each with a date by which the patient hopes to achieve the goal (See Appendix Section 1 Screen 1.7). The date by which a goal plans to be achieved should be linked to a trigger to alert the therapist of the timeline. The user needs to know how it will show up in the app, so that physiotherapist can find this date easily. This is to ease navigation rather than the therapist having to flick through screens to find the target date (See Figure 4.7A and Appendix Section 1 on wireframe 1.7 of the physiotherapist app). It is also important that the therapist can tailor the training focus

selection to the patient goals, so the addition of a header or footer in each selected training task will ensure the related goal is visible when the therapist is designing or tweaking the training focus of the programme (See Figure 4.7B and Appendix Section 1 on wireframe 1.8 of the physiotherapist app).

Figure 4.7A Updated wireframe for physiotherapy interface to improve navigation in physiotherapy app

NAVIGATION:
PROBLEM: Having up to three quantifiable goals, each with a deadline, offers a patient a sense of accomplishment. However, having a date in its timeline requires a trigger to alert the therapist—the user needs to know how will it show up in app. This is to ease navigation rather than the therapist having to sieve through the screens to look at the target date
SOLUTION: Alarm button to trigger on therapist dashboard

GA

My Patients
Sue Sullivan

DoB 26.03.1945 Date of Onset 14.08.2021 Diagnosis Bleed Presentation Left Lesion Location Cortical Right Hemisphere

Client details Programme Training tasks

1. PROGRAMME GOALS 2. TRAINING FOCUS 3. PE

Define your client aspiration

To go to my grand daughters wedding in summer

I am writing something

183 characters left

Define up to 3 measurable programme goals

1. To

Enter measurable goal

measured by

Enter measurement

by

DD/MM/YYYY

Alarm

2. To

Enter measurable goal

measured by

Enter measurement

by

DD/MM/YYYY

Alarm

3. To

Enter measurable goal

measured by

Enter measurement

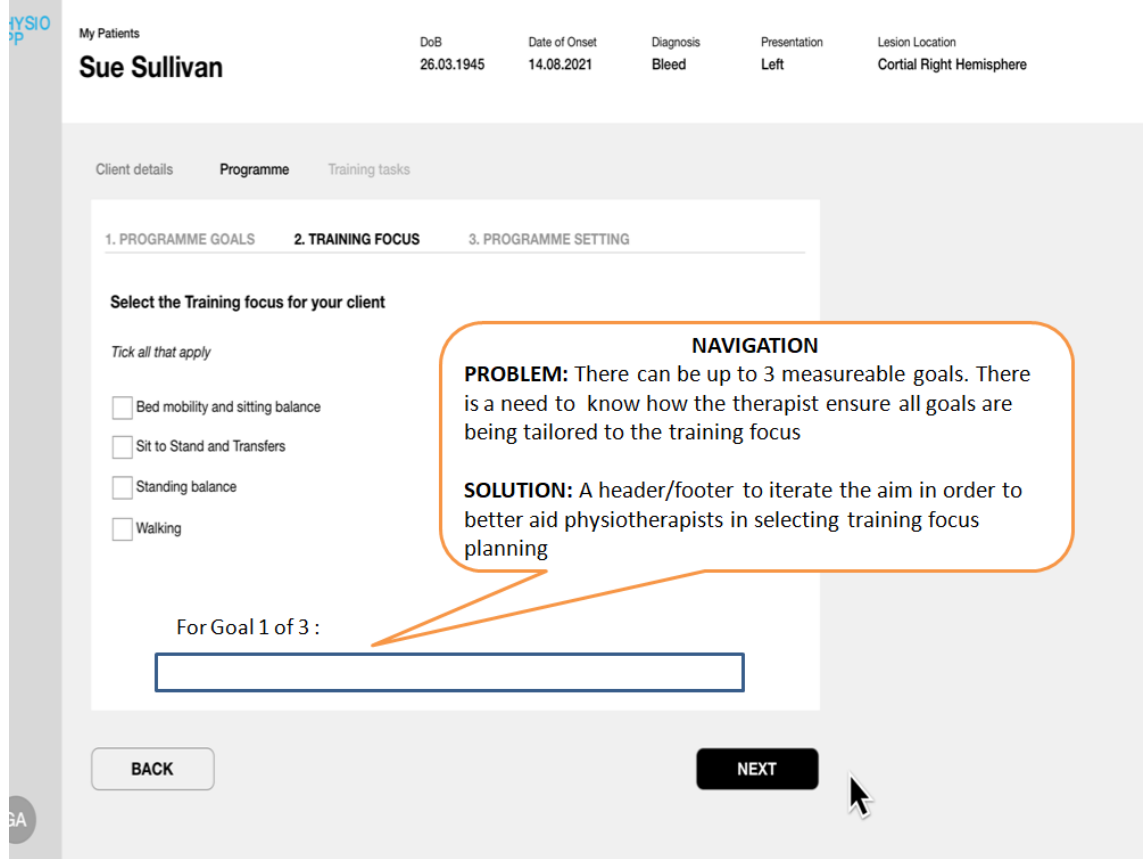
by

DD/MM/YYYY

Alarm

BACK NEXT

Figure 4.7B Updated wireframe for physiotherapy interface to improve navigation in physiotherapy app



4.2 STAGE 2: COMPARATOR EVALUATION- TRT & MOTOR LEARNING EVIDENCE-BASE

The following results relate to objective 2: Determine whether the app prototype is consistent with TRT, and motor learning principles as described in McLoughlin's 2020 "Ten guiding principles for movement training in neurorehabilitation" and to identify areas that may require further development.

Findings from both the physiotherapist and patient interfaces are considered in relation to McLoughlin's Guiding Principles (McLoughlin, 2020) that specifically relate to motor learning principles that underpin TRT. These included the following principles: feedback, error-based learning, reward-based learning, practice and variability, physical capacity, attention, belief and self-efficacy.

4.2.1 Principle: Feedback

This principle refers to the type (knowledge of results and knowledge of performance) and timing (concurrent, immediate, delayed) of feedback provided to support motor learning, a key principle of TRT (Stoller et al., 2015; Widmer et al., 2016; Young & Schmidt, 1992). On evaluation, this principle is partially captured in the patient and physiotherapist apps.

There are several instances in the app where knowledge of results (information on the task outcome) can be found. The first would be the display of completed reps and sets after a given task in the patient app and is also an example of delayed feedback. The second would be the exercise cue which features audio and visual elements to guide the patient when to start the exercise task and when the next repetition will begin. Within this time the patient is watching and listening to see whether they have completed the exercise in time prior to the cue starting again. This provides the patient knowledge of whether they are performing the task at a fast enough speed which may be a parameter that is important for the exercise task they are practising. This is also an example of concurrent feedback, which for some patients could be unhelpful for their learning due to information overload. The third would be the patient rating scales that appear in the patient app after completing a task set. The patient uses a numerical visual analogue scale (VAS) from 1-10 to rate confidence and task difficulty and is also an example of delayed feedback (Appendix Section 2 Screen 2.19). These ratings are recorded over time for individual tasks and are recorded in the physiotherapist app for monitoring (Appendix Section 1 Screen 1.17). This encourages intrinsic feedback from the patient and assists the therapist in understanding whether the

task is at the appropriate challenge point or not, and whether the task parameters need to be changed for the next CCT station, or when the same station is repeated within the same session.

Knowledge of performance, however, is not currently well supported by the app. While it is acknowledged that therapists may be present and able to provide feedback on performance during CCT sessions, this may not be possible at all stations due to the patient-to-therapist ratio. Therefore, findings ways to incorporate feedback of performance into the app would be desirable. Suggestions include adding a comments box on either the patient or therapist app where the therapist can record knowledge of performance that was provided to the patient at a particular station. Or the ability to be able to quickly update the “remember to....” instruction for a given task that is provided in the patient app (see Appendix Section 2, Screen 2.8). These suggestions are particularly relevant when the station may be repeated in the same session and would also an example of delayed feedback (see Figure 4.8A, B, C and D and Appendix Section 3 feedback wireframes 1-4). Finally using video footage that is recorded in the app so the patient and the therapist can review performance of a given task as previously discussed in the usability findings.

Figure 4.8A Updated wireframe for patient interface to improve knowledge of performance in patient app

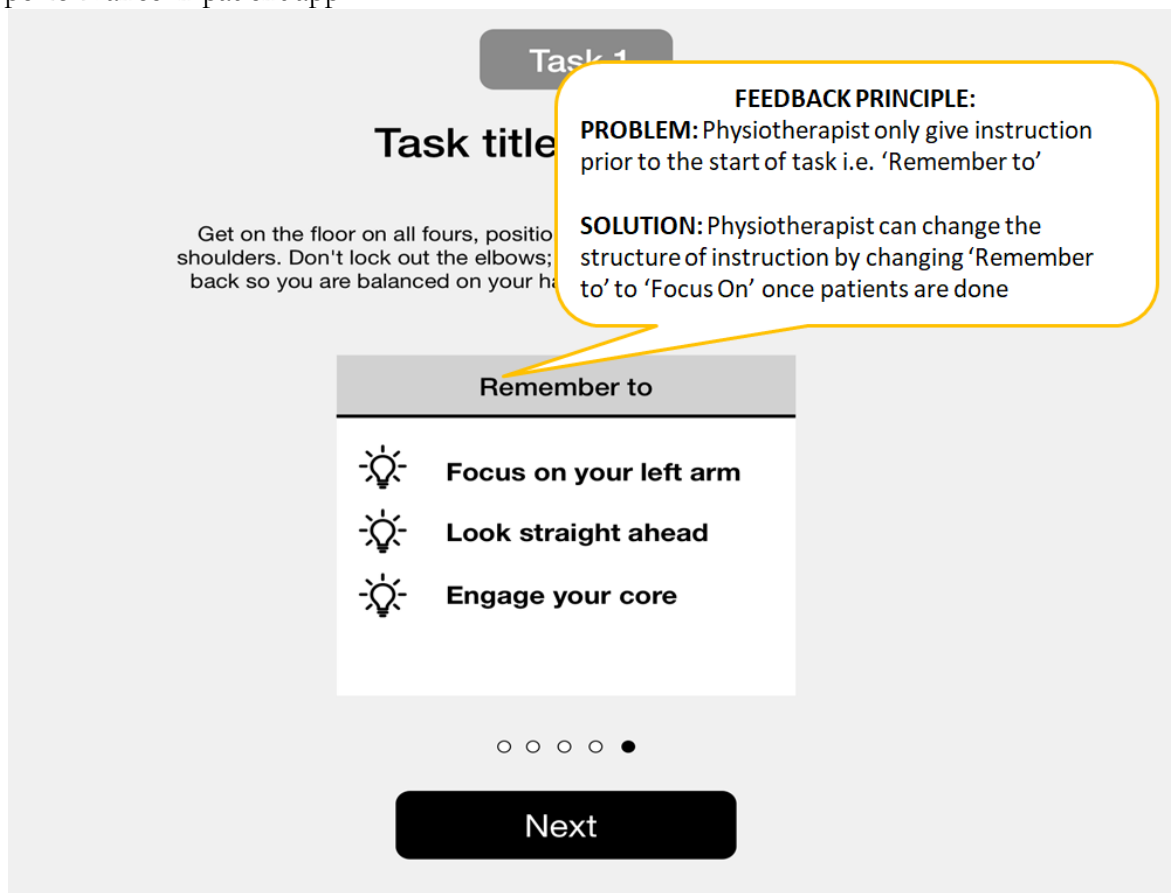


Figure 4.8B Updated wireframe for patient interface to improve knowledge of performance in patient app

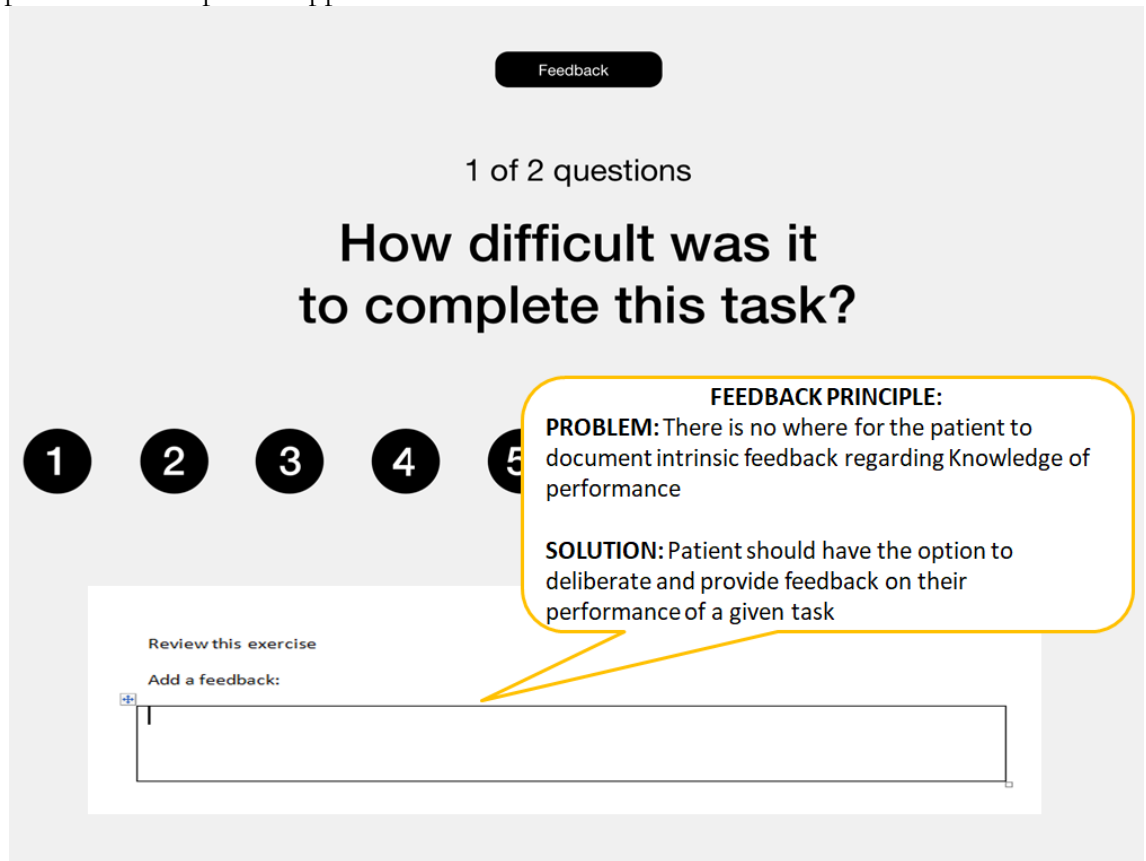


Figure 4.8C Updated wireframe for patient interface to improve knowledge of performance in patient app

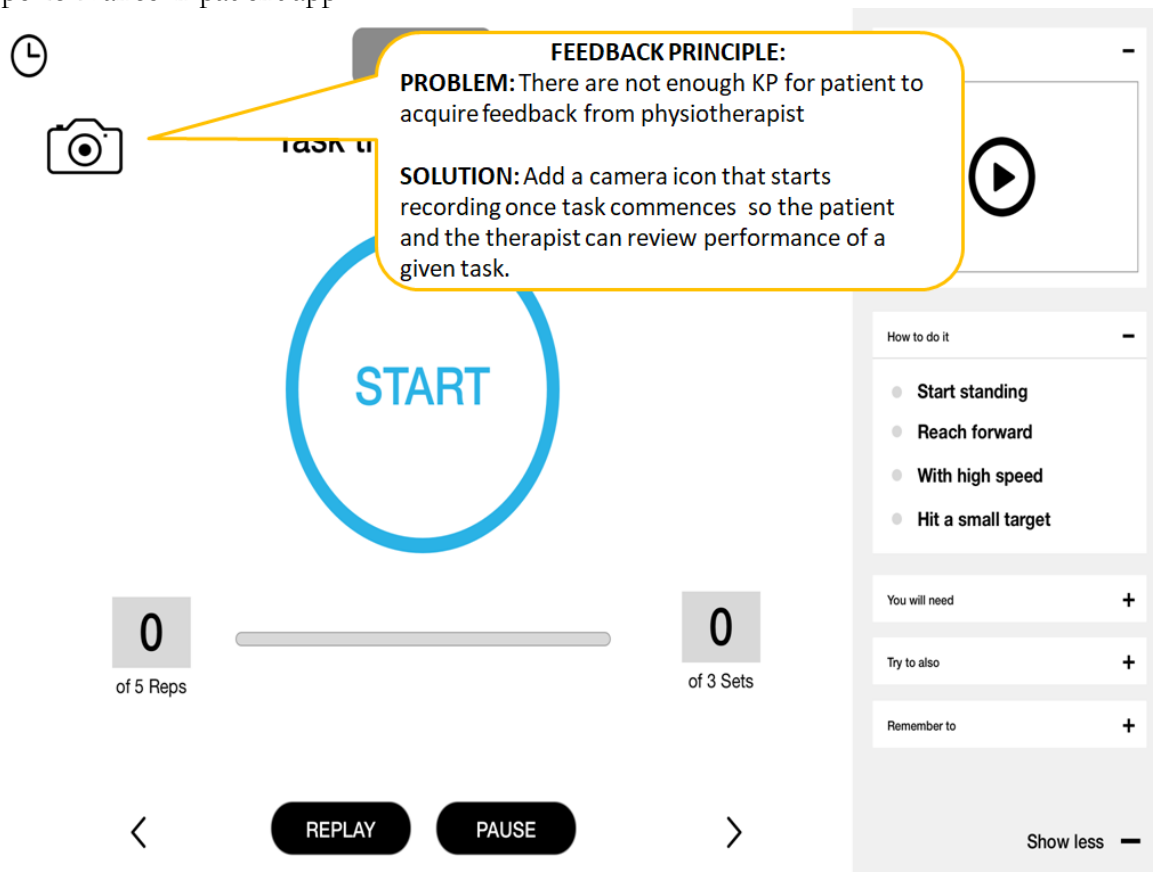
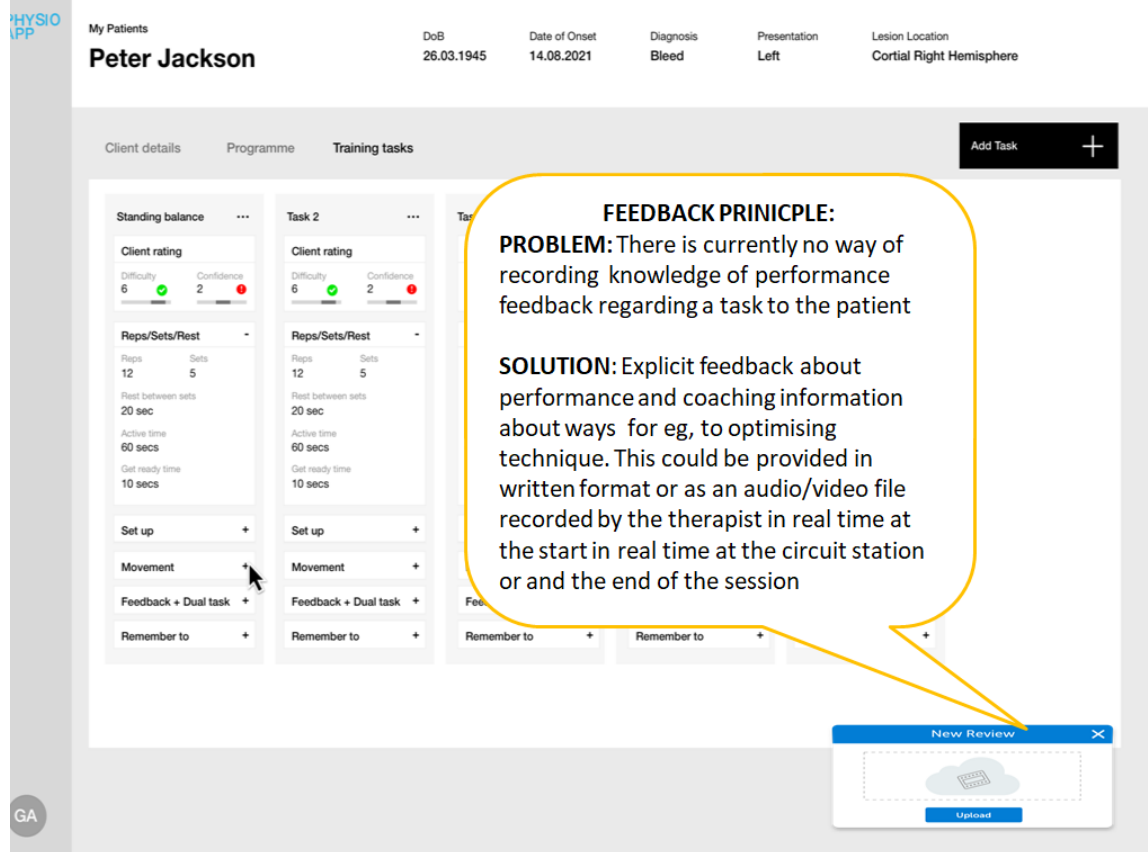


Figure 4.8D Updated wireframe for patient interface to improve knowledge of performance in patient app



4.2.2 Principle: Error-based learning

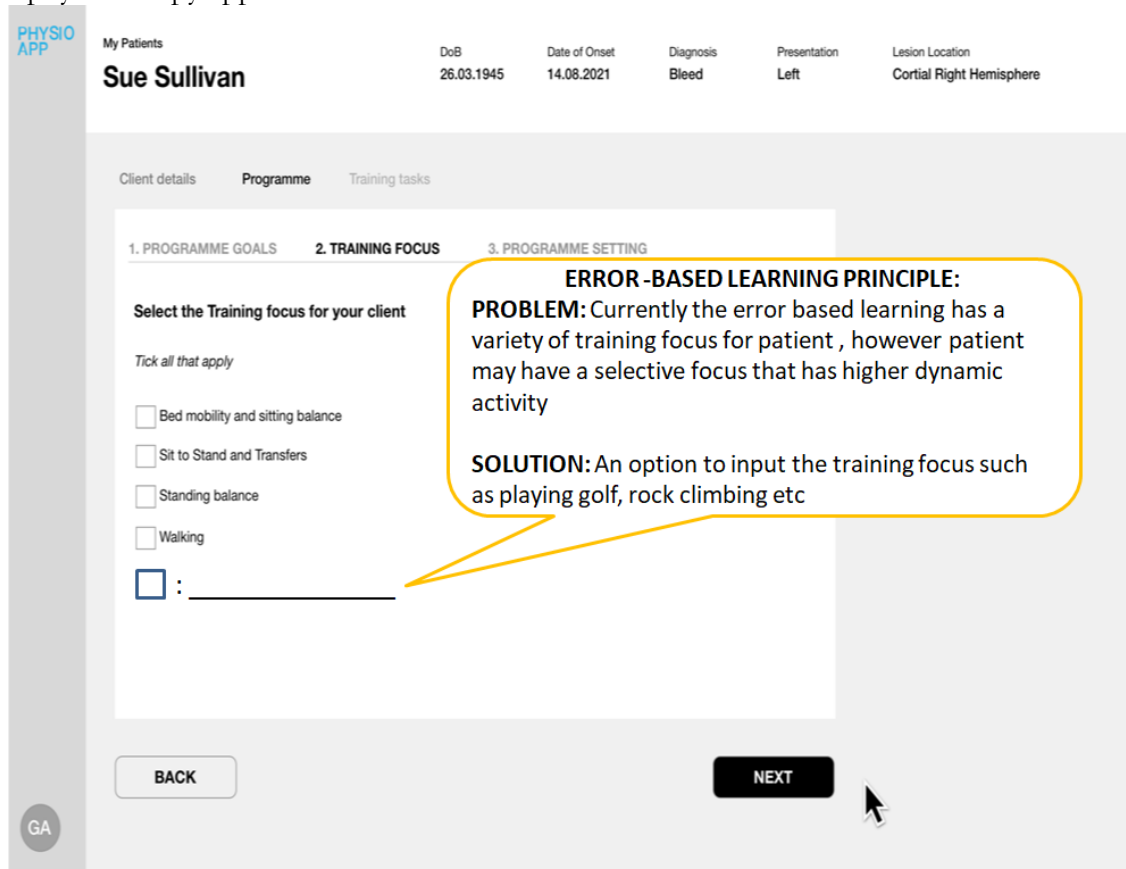
Brains are thought to predict sensory feedback from a movement and compare it to the actual sensory output (Marko et al., 2012). Adaptation occurs when the two differ, resulting in an error signal. This is known as a sensory prediction error (SPE) where the sensations experienced from a movement do not match up with the feed-forward predictions that have been made. Examples of movement errors include the accuracy, timing, direction or force of the movement. With practice, SPEs will reduce due to a process of unconscious, error-based learning which is critical for skill acquisition (Wolpert et al., 2011).

This principle is evidenced within the app because its fundamental aim is to practice by doing. In other words, during repeated task-related training that is progressively challenging, error-based learning can take place. Each task is linked to a specified patient goal and in the physiotherapist app; the therapist selects the training focus that applies to that task specific goal.

This principle also refers to the use of visual targets to aid error-based learning to support optimal movement precision, in terms of timing, direction or force. All of which are

parameters of the task that can be manipulated with the app. (See Appendix Section 2 Screen 2.2 and Section 1 Screen 1.8 and 1.13 respectively). While the training focus currently has a variety of options, the patient may have a specific higher dynamic activity that they would like to pursue and improve upon such as golf, returning to being a carpenter, or rock climbing. Having the option to choose a higher dynamic training focus that is related to participatory goals would thus further support the error-based learning principle (see Figure 4.9 and Appendix Section 3 Error-based learning wireframes screen 1).

Figure 4.9 Updated wireframe for physiotherapy interface to improve error-based learning in physiotherapy app



4.2.3 Principle: Reward-based learning

Saliency and reward are closely related in that it's crucial to take the patient's priorities into account (Chen et al., 2018; Kleim & Jones, 2008). What will keep their interest, keep them motivated, and keep them engaged. Movement training may make movement selection easier if it includes meaningful rewards. This can result in emotional benefits, the accomplishment of a goal, or the therapist creating activities to motivate training through tasks that are difficult but doable, using games and rewards (Caetano Martins et al., 2020; Klimova, 2019).

This principle is partially captured in the patient's interface. On the patient's interface (See Appendix Section 2, Screen 2.2), the dashboard displays the gains the patient has made over the weeks. These include number of sessions completed, progress since they first started relating to challenges they have overcome, levels of confidence and a journey chart that displays the patient's overall progress towards their goals. There is also an element of reward when the patient is congratulated on the completion of a task within their session, and reps and sets are displayed. However, other ways to incentivise training might include gamification, rewards charts, loading success images that display how much you have achieved and how far to go before reaching their goal, reward badges when you have completed X amounts of reps, or when you have rated confidence X number of times and social rewards i.e. sharing results with family and friends, or a CCT specific reward system for members of that class. Another suggestion is to include a deadline for achieving the goals so that the patient can view progress towards them. Suggestions for optimising this principle within the app have been added to the patient app wireframe located in Figure 4.10A and B (and Appendix Section 3 Reward-based learning wireframe screen 1 and 2).

Figure 4.10A Updated wireframe for patient app to improve further support the principle of reward

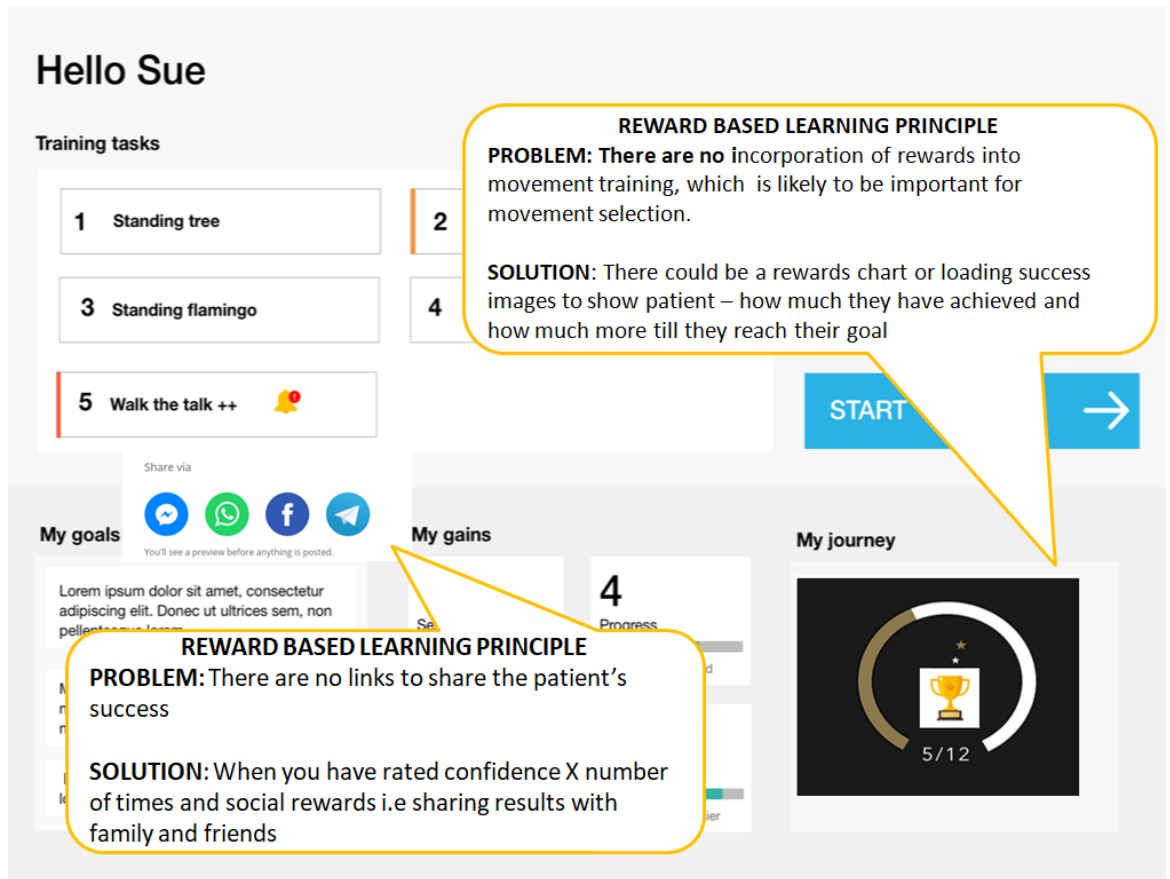
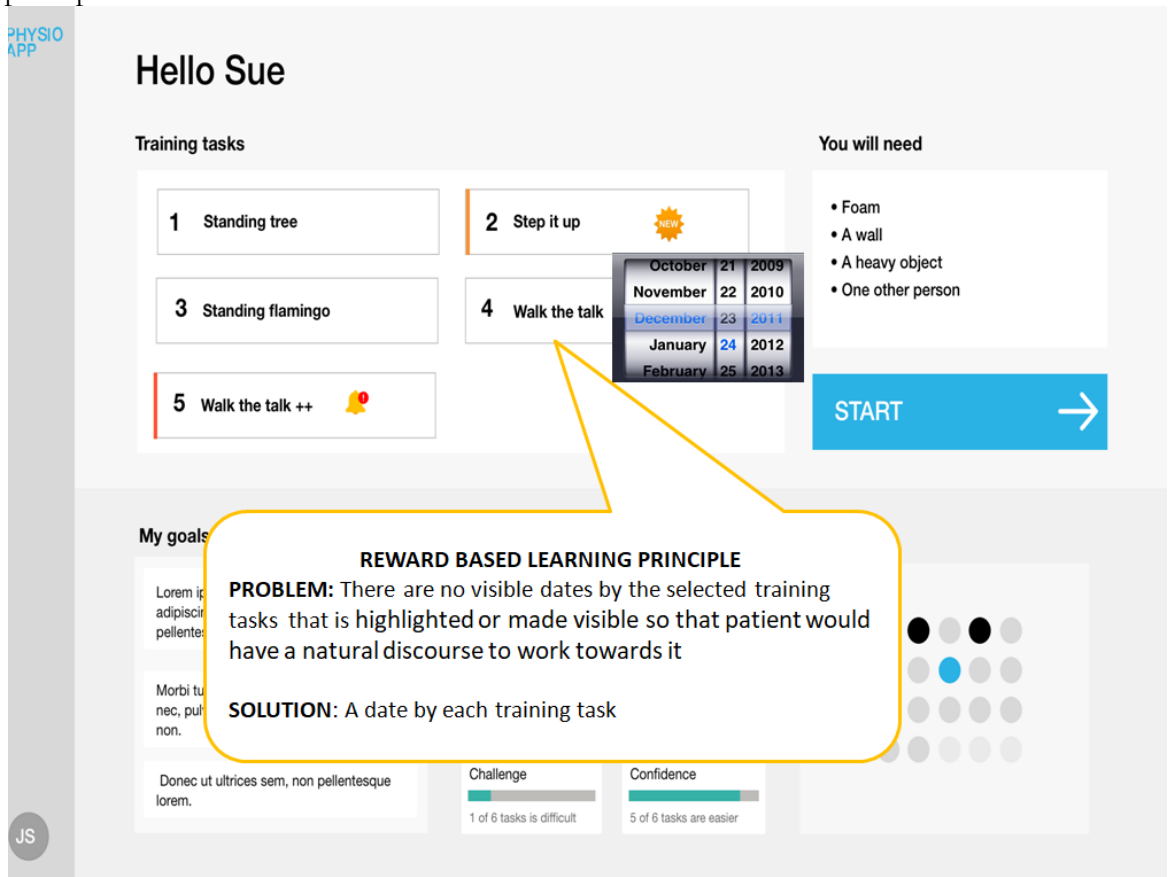


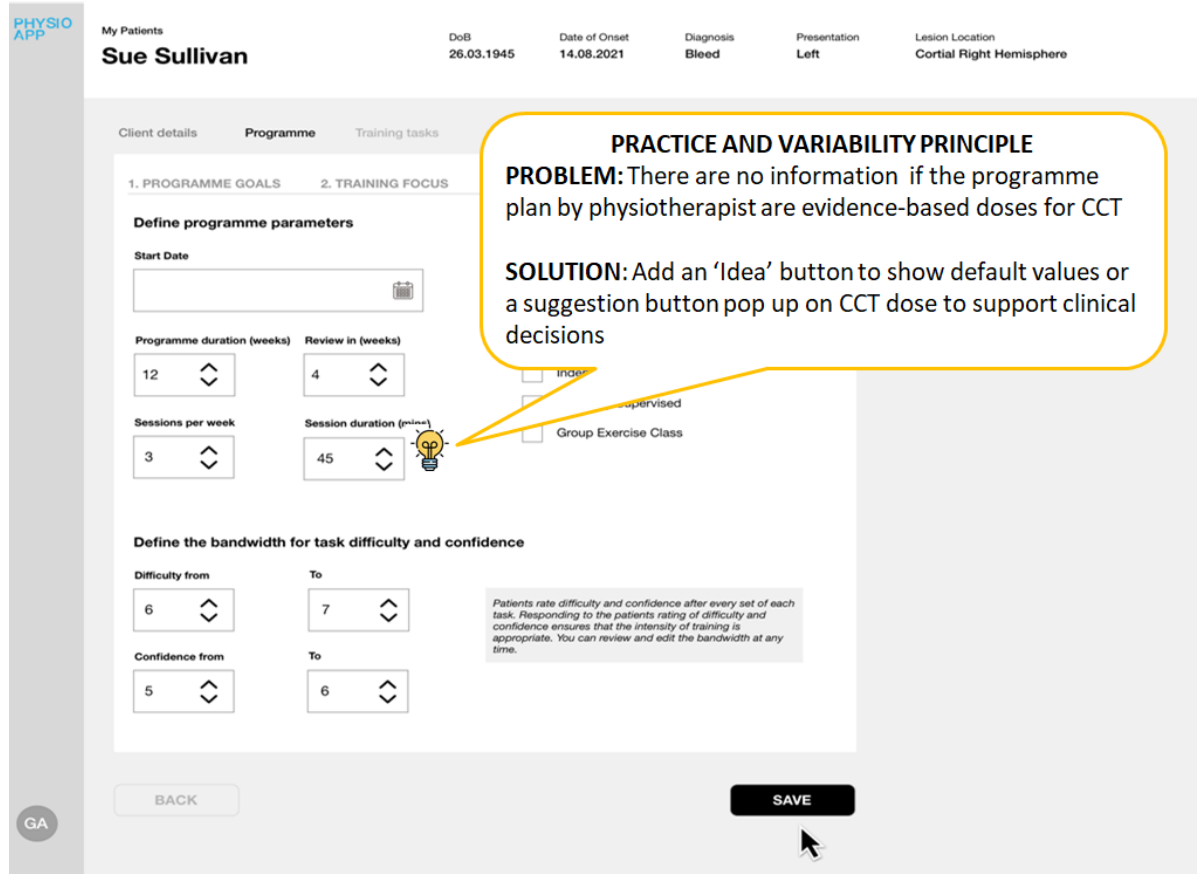
Figure 4.10B Updated wireframe for patient interface to improve further support the principle of reward



4.2.4 Principle: Practice and variability

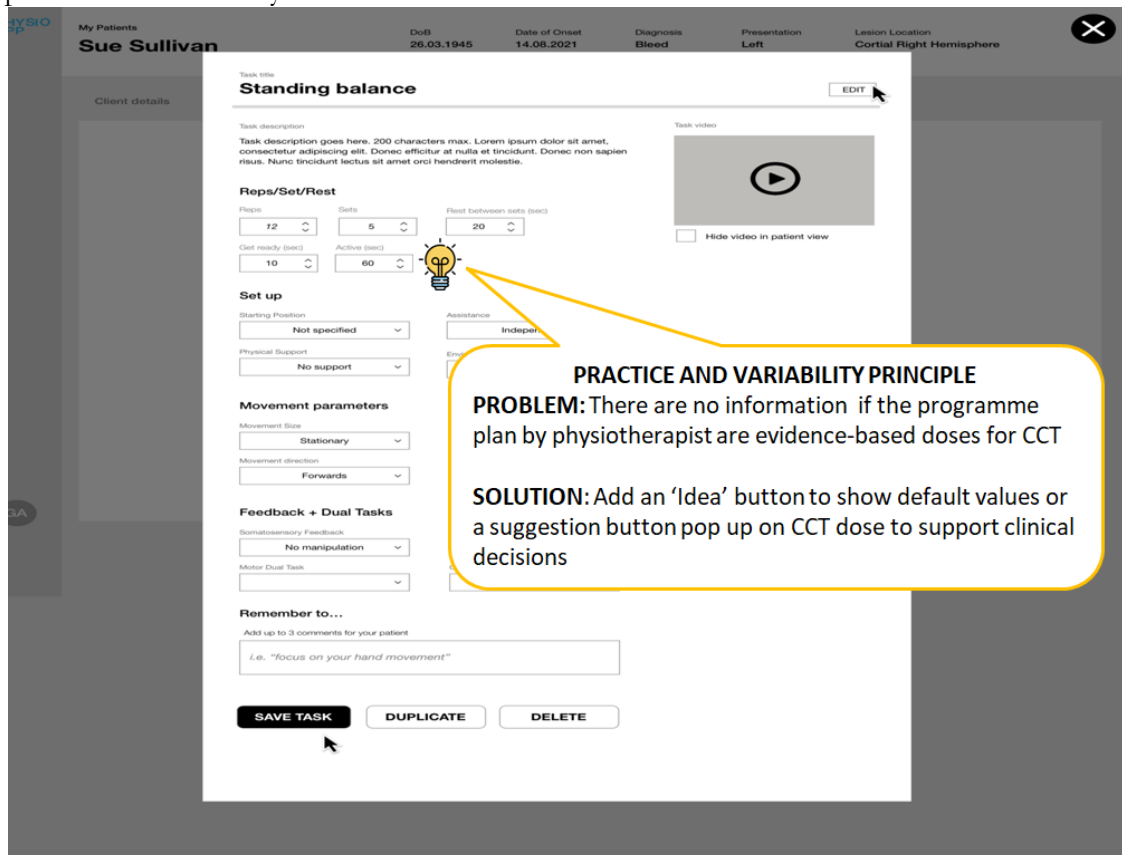
There is a growing consensus that increased doses of task practice enhances motor recovery (Cooke et al., 2010; Lohse et al., 2014) which leads to cortical reorganization, motor learning (Kuys et al., 2019) and correlates with functional outcomes after stroke (Ko et al., 2020). The dose of TRT can clearly be planned and manipulated within the app. The physiotherapist can set the amount of TRT practice by planning the session duration (mins), frequency of sessions (per day/week) and programme length (weeks) for the patient (Appendix Section 1 Screen 1.9). The app can collate this information as the patient progresses through the programme and has the capacity to also calculate the actual work duration i.e., time on task and the rest periods within a session (Appendix Section 1 Screen 1.13). Both of which are parameters that could be manipulated overtime. An improvement in the physiotherapy app from a CCT perspective would be details on evidence-based doses for CCT to support clinical decisions. This could be added as default values or a suggestion button on the programme planning screen as previously mentioned (See Appendix Section 3 Practice and Variability Wireframe 1).

Figure 4.11A Updated wireframe for patient interface to improve further support the practice and variability



This principle also describes the importance of variation and progressive challenge of task practise, which can be embedded within dose in order to optimise motor learning (Lang et al., 2015; Lohse et al., 2014). Therefore, it's important to consider the optimal practice structure and challenge point for the task being trained. Practice structure of a given task can include whole or part task practice, blocked or random practice and constant or varied practice. All of which can be set and manipulated by the physiotherapist within the app. The challenge point for a given task can also be set, monitored and manipulated based on the task difficulty rating scale provided to the patient at the end of every task set (Appendix Section 1 Screen 1.9). An enhancement to the physiotherapy app might include advice on what a physiotherapist should take into account when determining what an acceptable bandwidth to set the challenge point might be best to start with (See Appendix Section 3 Practice and Variability Wireframe 2). Suggestions for optimising this principle within the app is based on Appendix Section 1 screens 1.9 and 1.13 of the physiotherapy app and the wireframes displayed in Figure 4.11A and B. These changes can also be viewed in Appendix Section 3 Practice and Variability Wireframes.

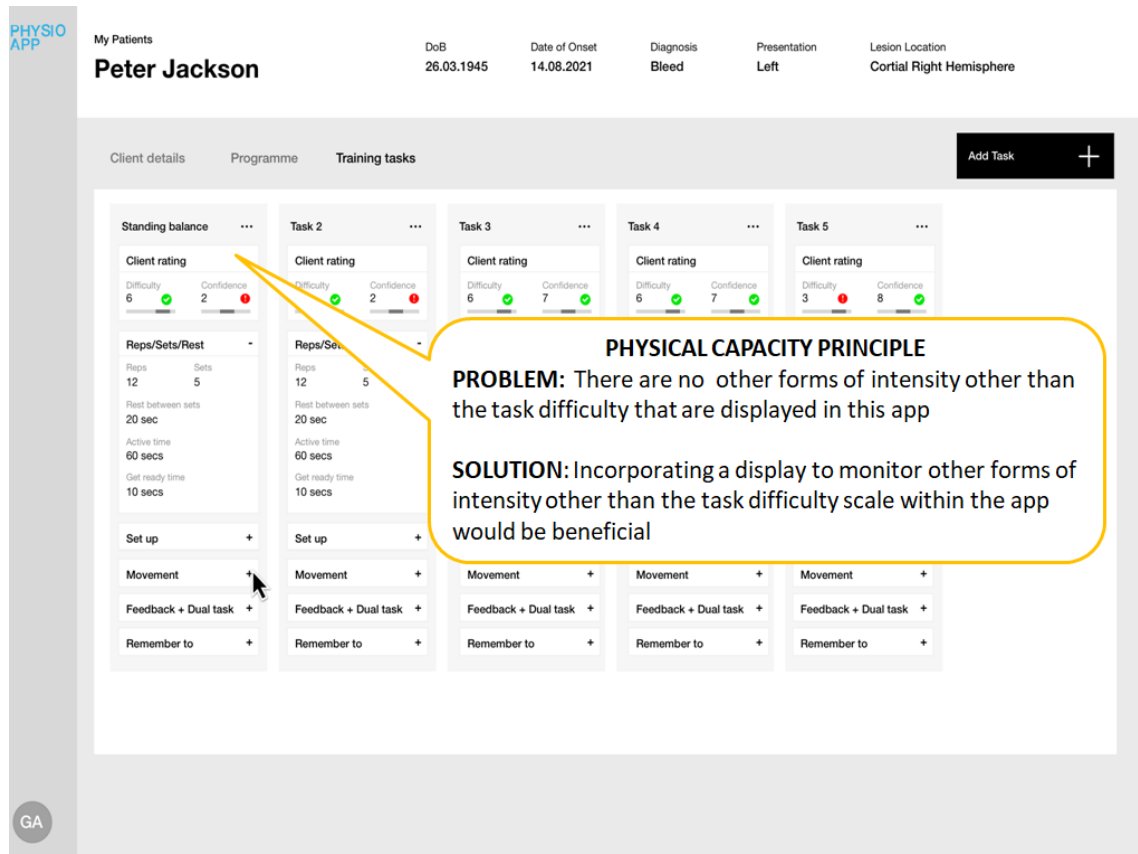
Figure 4.11B Updated wireframe for patient interface to improve further support the practice and variability



4.2.5 Principle: Physical capacity

Stroke patients are prone to inactivity and often a sedentary lifestyle and CCT or TRT programmes can be one way of improving patient's physical capacity. This principle makes reference to training programs that involve muscular strength, power and endurance training (and/ or cardiovascular training (Diermayr et al., 2020; Van de Port et al., 2008). These specific types of training are not the principle focus of the app and therefore there are no protocols that specifically address this type of training in isolation. However, it should be noted that elements of these types of training can easily be incorporated into the parameter selection of a given task to ensure specificity of task training. For example, adding a load during a locomotor-based task or performing the task quickly enough or for long enough to meet the requirements of the task. If one of the goals relates to increasing cardiovascular endurance patients could also wear HR monitors to set and monitor the intensity of the CCT sessions. Having somewhere to monitor other forms of intensity other than the task difficulty scale within the app would be beneficial (See Figure 4.12). The ability to embed strengthening and cardiovascular-based exercises for CCT programmes in future iterations of the app would be significant additions that would also align with the CCT evidence in people with stroke. Suggestion for optimising this principle within the app is based on Appendix Section 1 screen 1.17 of the physiotherapy app and the wireframe displayed in Figure 4.12. These changes can also be viewed in Appendix Section 3 Physical Capacity Wireframes.

Figure 4.12 Updated wireframe for physiotherapy interface to improve physical capacity in physiotherapy dashboard



4.2.6 Principle: Attention

This principle relates to how the patient attends to sensory information to either initiate or regulate a given task (Wulf, 2013). In essence it refers to the use of internal or external focuses of attention to support motor learning. It also supports the need for motor and or cognitive dual task practice to simulate real world scenarios (Yang et al., 2016). All of which are evidenced within both the therapist and patient app. These principles can be addressed in the parameter selection of a given task or in the instructions provided to a patient about the task that they are about to perform. An example of an external focus within the app would be manipulating the size of movement parameter where the use of visual targets can be incorporated to improve the size of the patients step length (Appendix Section 1 Screen 20). In the therapist app, the physiotherapist can provide detail about how the patient should think about performing the task and what to focus on. This detail could easily encourage both external and internal focuses but an example of an internal focus within the app might be ‘remember to focus on what it feels like to lift those toes up to ensure you clear the floor’ (Appendix Section 2 Screen 2.8). Finally, dual tasking is covered nicely in the app with two parameter options, one that focuses on adding motor tasks and one that adds a cognitive task. There are extensive options in the dropdowns of both

parameters that relate to common locomotor-based tasks and there is also the option to customise to ensure these dual tasks are individualised to the patients' goals (Appendix Section 1 Screen 13). No further suggestions are required to reflect this principle in the app.

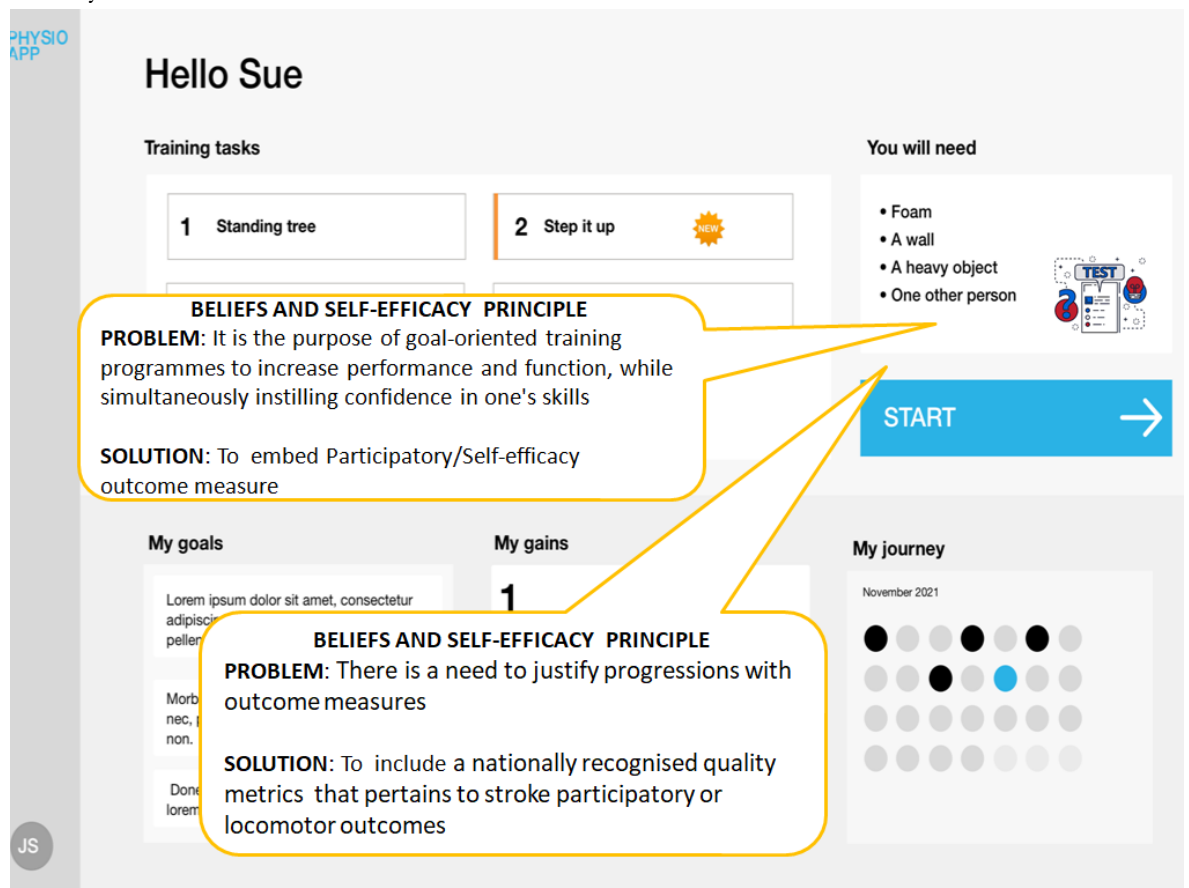
4.2.7 Principle: Beliefs and self-efficacy

McLoughlin (2020) emphasises the importance of having confidence in one's own abilities and believing that training will help one perform and function better. 'Low expectations from exercise' and 'fear of falling' are two major barriers that deter people from exercising (Ellis et al., 2011). People's perceptions of their ability to change events that affect their life are called perceived self-efficacy (Jones & Riazi, 2011). Clinical examples of this principle include offering an individualised rehabilitation plan and inviting patients and/or their caregivers to participate in the design process. It also involves checking for pre-existing negative views about specific emotions, impairments, rehabilitation, confidence levels, listening to the person's thoughts on the training ideas and identifying behavioural strategies that can be utilised during and outside of therapy sessions.

This principle is mostly captured in the app. It is the purpose of goal-oriented training programmes to increase performance and function, while simultaneously instilling confidence in one's skills. In the patient's interface, patient's goals are displayed on their dashboard as a result of the registration process that takes place in the therapist app (See Appendix Section 2, Screen 2.2). Currently the app accommodates up to three measurable goals (See Appendix Section 1, Screen 1.7) and supports an individualised treatment programme. Because the registration process takes place within the therapist app, the planning and designing of the programme and the goal setting can be completed in conjunction with the patient which would support this principle. However, the therapist also has the option to tweak when away from the patient as needed. Assessing potential negative notions about specific exercises, impairments, and treatments, or discussing behavioural strategies that might support motor learning as described in this principle, are not visible in the prototype, but could be added as a reminder during the registration process or as part of the physiotherapist training manual that would accompany the app. The principle also highlights the importance of administering self-efficacy scales before, during, and after the completion of a program with patients. A nice addition to the app is the confidence rating scales which appear at the end of each set of exercises. This is a great way for both the patient and therapist to set and monitor confidence within task performance and could easily be incorporated into the patient goals if confidence was a

concern for a patient. To supplement this principle, it would be preferable to include a self-efficacy-based questionnaire as a pre-post and at intervals throughout the programme as an outcome measure for the CCT programme. In addition, there is a need to measure patients functional progress via outcome measure. Including nationally recognised quality metrics such as the 10-metre walk test, Berg’s balance, Modified Barthel Index and Timed up and go test (MOH, 2018) would be advantageous. Suggestions for optimising belief and self-efficacy provision as well as outcome measures within the app have been added to the patient app wireframe located in Figure 4.13 (and Appendix Section 3 Beliefs and self-efficacy wireframes).

Figure 4.13 Updated wireframe for physiotherapy interface to optimise beliefs and self-efficacy



4.3 STAGE 3: COMPARATOR EVALUATION- LOCOMOTOR CCT EVIDENCE IN PEOPLE WITH STROKE

The following results relate to objective 3: Determine whether the locomotor tasks and task progressions align with the locomotor TRT CCT evidence base in people with stroke and to identify areas that that may require further development.

The TRT app consists of five main training areas. These include (1) Bed Mobility and Sitting Balance (2) Sit to Stand and Transfers (3) Standing Balance and (4) Walking and (5) Higher-level Mobility. Across these five training areas, there are over 40 specific tasks, each of which has a range of parameters that could be manipulated to support specificity and task progression. These parameters include where relevant, the starting position, the amount of assistance and or physical support required, the direction, size, speed, accuracy and smoothness of the movement, the somatosensory visual and vestibular feedback, dual tasking (motor and cognitive), the environmental demands, and the number or repetitions and sets.

This section provides a detailed comparison of the app task content against the English et al. (2017) Cochrane review “Circuit class therapy for improving mobility after stroke” and the 2021 systematic review completed for the student researcher’s HEAL803 Special Topic paper that collated the tasks practiced in locomotor related CCT and their associated task progressions. Overall, the number of tasks and their possible task progressions provided in the TRT app were extensive in comparison to what was reported in the CCT locomotor related TRT literature. The following sections maps out these comparisons.

4.3.1 Training Focus: Tasks addressed in the App and CCT literature

Table 4.1 maps the TRT apps five training areas and their connected locomotor-related tasks available for selection against the CCT literature. Nearly 75% of the app's tasks are reported in the CCT literature. The app tasks that did not feature in the literature were tasks at the lower and higher functional spectrum, such as bed mobility, transfers, and some high-level mobility tasks such as hopping, skipping, and bounding. Reactive standing balance was one type of task that did appear in the CCT literature (Marigold et al., 2005) and not the app.

Table 4.1 Training Focus: Tasks addressed in the App and CCT literature

Bed Mobility and Sitting Balance	Sit to Stand and Transfers	Standing Balance	Walking	Higher Level mobility
Rolling	Sit to stand	Static standing	Forward stepping	Step touch
Bridging	Sliding board transfer	Weight shift	Backward stepping	Step up
Moving L, R	Pivot transfer	Reaching in standing	Sideway stepping	Stairs
Moving up, down	Stand and step transfer	Stepping forward	Forwards walking	Around obstacles
Lying to Sitting		Stepping L, R	Backwards walking	Over obstacles
Static sitting balance,		Stepping backward	Sideways walking	On/off obstacles
Weight shift		Reactive Balance	Turning	Avoiding moving objects
Reaching in sitting				Jumping
Moving in sitting				Hopping
				Skiping
				Bounding
				Jogging
				Running

Note: Dark green cells indicate tasks are included in the App and in the CCT literature, Light Green cells indicate tasks are included in the App with some evidence in the CCT literature, Yellow cells indicate tasks are included in the App but not in the CCT literature, Red cells indicate that tasks are not included in the App but are included in the CCT literature.

4.3.2 Bed mobility and sitting balance task progressions addressed in the App and CCT literature

The TRT app bed mobility tasks include rolling left and right, bridging, moving across the bed to the left and right, up and down the bed and lying to sitting. The options for task progression include the level of assistance, physical support, movement direction,

movement speed, movement accuracy, sensory manipulation, and incorporation of motor or cognitive dual task. Each of these parameters had a range of 4 to 15 drop down options that increased in difficulty. See Appendix Section 4 Table 2 for a full description. These types of tasks, however, were not represented in the locomotor-related CCT literature as the focus was ambulation-based (See Table 4.2). This is because its' inclusion criteria required participants to have the ability to ambulate a specified distance or having a pre-determined FIM score. Therefore, it is not possible to make direct comparison against the literature. The benefits of the TRT app including such tasks means that patients who are in the initial phases of rehabilitation could potentially participate in the inpatient CCT sessions provided at Jurong Community Hospital (JCH) in Singapore. Early stroke mobilisation with increased practise may result in better outcomes for JCH patients if CCT is included in their rehabilitation programme from the start.

Static sitting, weight shift, and reaching near and far are among the TRT app sitting balance tasks. It's worth noting that both the app and the literature only mentioned anticipatory balance tasks; neither described reactive balance tasks in sitting. The sitting balance task progression options available in the app are compared to those described in the literature in Table 4.2. While the CCT literature featured static and dynamic sitting balance tasks few task progressions were described. As highlighted by the green cells in Table 4.2 these included the level of physical support, number of repetitions and sets, movement direction and additional motor tasks (Caetano Martins et al., 2020; Dean et al., 2000; English et al., 2015; Kim et al., 2016; Knox et al., 2018; Marigold et al., 2005; Moore et al., 2015; Mudge et al., 2009; Stuart et al., 2019). It is clear from this mapping exercise that the app surpassed the detail provided in the literature for sitting balance task progressions, based on the large representation of yellow cells in Table 4.2 where consideration had also been given progressing the starting position, the level of assistance, movement size and speed, sensory input and dual tasking (motor and cognitive). A detailed description of all comparator examples for sitting balance can be found in Appendix Section 4 Table 1.

Table 4.2 Bed mobility and sitting balance task parameters addressed in the App and CCT literature

	Rolling L, R	Bridging	Across the Bed L, R	Up, Down the Bed	Lying to Sitting	Static sitting balance	Weight shift	Reaching in sitting (far/near)
Starting position	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Level of Assistance	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Physical support	Yellow	Yellow	Yellow	Yellow	Yellow	Light Green	Yellow	Light Green
Number of repetitions	Yellow	Yellow	Yellow	Yellow	Yellow	Light Green	Light Green	Light Green
Number of sets	Yellow	Yellow	Yellow	Yellow	Yellow	Light Green	Light Green	Light Green
Movement size	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Movement direction	Yellow	Yellow	Yellow	Yellow	Yellow	Grey	Light Green	Dark Green
Movement speed	Yellow	Yellow	Yellow	Yellow	Yellow	Grey	Yellow	Yellow
Movement smoothness/ accuracy	Yellow	Yellow	Yellow	Yellow	Yellow	Grey	Grey	Yellow
Vision and vestibular input	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Somatosensory input	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Motor task	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Dark Green	Light Green
Cognitive task	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow

Note: Dark green cells indicate task parameters are included in the App and in the CCT literature, Light Green cells indicate task parameters are included in the App with some evidence in the CCT literature, Yellow cells indicate task parameters are included in the App but not in the CCT literature, Red cells indicate that task parameters are not included in the App but are included in the CCT literature. If a parameter is not applicable for a given task the cell is light grey.

4.3.3 Sit to Stand and Transfers task progressions addressed in the App and CCT literature

The app included tasks such as sit to stand, sliding board transfer, reach across/pivot transfer, and stand and step transfer. Table 4.3 compares the app's sit to stand and transfer task progression options to those described in the literature. While sixteen studies documented sit-to-stand activities, little information on the progressions that occurred was provided (Blennerhassett & Dite, 2004; Caetano Martins et al., 2020; Dean et al., 2000, 2012; Grau-Pellicer et al., 2020; Kim et al., 2016; Marigold et al., 2005; Marsden et al., 2010; Moore et al., 2015; Mudge et al., 2009; Pang et al., 2005; Stuart et al., 2019; Tang et al., 2014; Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017; Verma et al., 2011). These included the starting position, physical support, number of repetitions and sets, and movement size, and speed, (Caetano Martins et al., 2020; Dean et al., 2000, 2012; Grau-Pellicer et al., 2020; Kim et al., 2016; Marigold et al., 2005; Moore et al., 2015; Mudge et al., 2009; Pang et al., 2005; Stuart et al., 2019; Tang et al., 2014; Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017; Verma et al., 2011) as indicated by the green cells in Table 4.3. Stand and step was the only transfer that appeared in the CCT literature (again, most likely due to the study's inclusion criteria), and only progressions relating to the number of repetitions and sets, as well as the size of the body, were described (Outermans et al., 2010). This mapping exercise clearly shows that the app outperformed the detail provided in the literature for sit to stand and relevant transfer task progressions, as represented by the yellow cells in Table 4.2, where the starting position, level of assistance, sensory input, and dual tasking (motor and cognitive) could also be manipulated. Appendix Section 4 Table 2 contains all comparator examples for sit to stand and transfers.

Table 4.3 Sit to stand and transfer task parameters addressed in the App and CCT literature

	Sit to Stand	Sliding board Transfer	Reach/Pivot Transfer	Stand and Step Transfer
Starting position				
Level of Assistance				
Physical support				
Number of repetitions				
Number of sets				
Movement size				
Movement direction	-			
Movement speed				
Movement smoothness/ Accuracy	-	-	-	-
Vision and vestibular input				
Somatosensory input				
Motor task				
Cognitive task				

Note: Dark green cells indicate task parameters are included in the App and in the CCT literature, Light Green cells indicate task parameters are included in the App with some evidence in the CCT literature, Yellow cells indicate task parameters are included in the App but not in the CCT literature, Red cells indicate that task parameters are not included in the App but are included in the CCT literature. If a parameter is not applicable for a given task the cell is light grey.

4.3.4 Standing balance task progressions addressed in the App and CCT literature

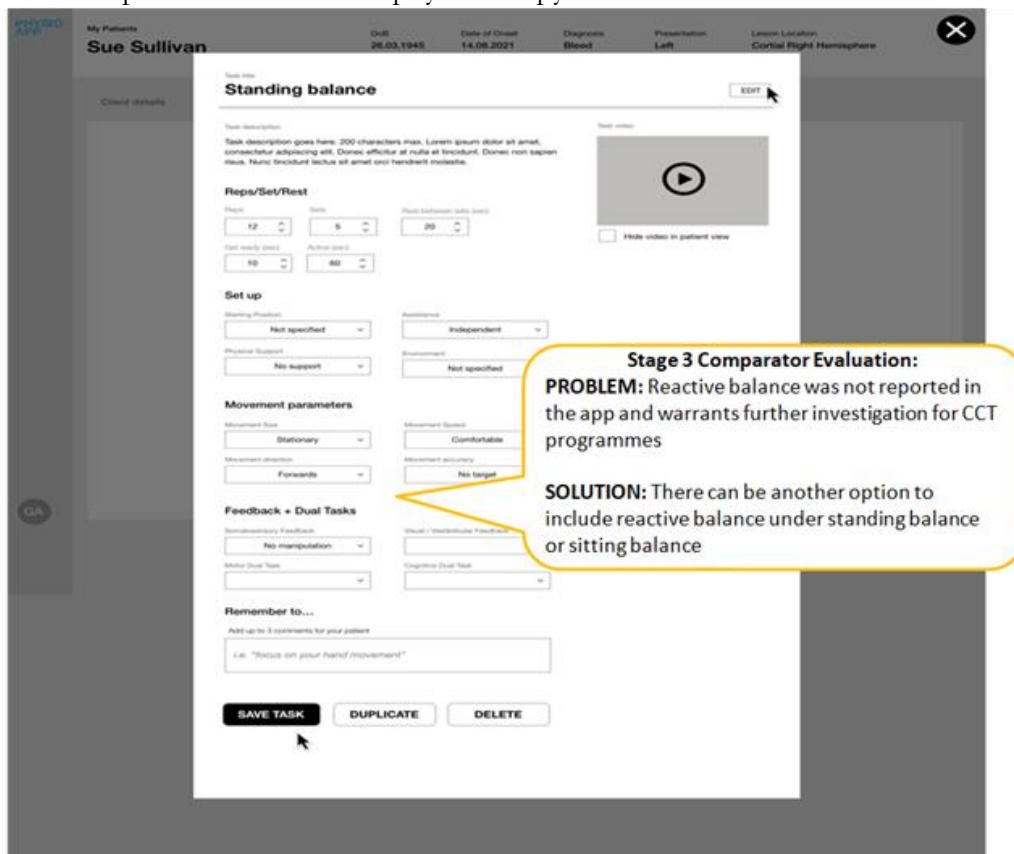
The Standing Balance based tasks featured in the TRT app includes static standing, weight shift, near or far reach and stepping strategies. Table 4.4 compares the app's standing balance task progression options to those described in the literature. Seventeen CCT studies included static standing and weight shift-based exercises (Blennerhassett & Dite, 2004; Caetano Martins et al., 2020; Dean et al., 2000, 2012; English et al., 2017; Grau-Pellicer et al., 2020; Kim et al., 2016; Knox et al., 2018; Marigold et al., 2005; Marsden et al., 2010; Moore et al., 2015; Mudge et al., 2009; Pang et al., 2005; Stuart et al., 2019; Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017; Verma et al., 2011) and five included near and far-reaching tasks (Dean et al., 2000, 2012; Marsden et al., 2010; Moore et al., 2015; Verma et al., 2011). While several studies provided reported on the associated progressions were reported, detail was minimal. Progressions included the number of repetitions and sets, challenging the base of support (physical support), movement direction, manipulating sensory input and engaging in a physical motor task whilst standing such as feet in parallel while reaching for objects and including reaching to objects on the floor (Caetano Martins et al., 2020; Dean et al., 2000, 2012; English et al., 2015; Grau-Pellicer et al., 2020; Kim et al., 2016; Knox et al., 2018; Marigold et al., 2005; Moore et al., 2015; Mudge et al., 2009; Pang et al., 2005; Stuart et al., 2019; Verma et al., 2011). This mapping exercise again demonstrates that the app provided more details on task progressions than the CCT literature (see Table 4.4) with progression options also including manipulation of starting position, level of assistance, physical support, movement speed, size and accuracy, sensory input and dual tasking (motor and cognitive). All comparator examples for standing balance can be found in Appendix Section 4 Table 3A and 3B. The CCT literature did not describe stepping strategy-based tasks are associated progression that are included in the app. However, the CCT literature did report increasing the task difficulty by including reactive balance-based tasks where participants experienced external perturbations in standing (i.e., instructor pushing participant in a controlled manner or participant pushing instructor to destabilise balance and elicit postural reflexes) (Marigold et al., 2005). As mentioned previously, reactive balance was not reported in the app and should be consider for increasing task difficulty. Suggestions for using reactive balance within the app have been added to the physiotherapy app wireframe shown in Figure 4.14.

Table 4.4 Standing Balance task parameters addressed in the App and CCT literature

	Static standing balance	Weight shift	Near/Far Reach	Stepping strategies
Starting position				
Level of Assistance				
Physical support				
Number of repetitions				
Number of sets				
Movement size				
Movement direction	-			
Movement speed	-			
Movement smoothness/Accuracy	-	-		
Vision and vestibular input				
Somatosensory input				
Motor task				
Cognitive task				
Reactive Balance				

Note: Dark green cells indicate task parameters are included in the App and in the CCT literature, Light Green cells indicate task parameters are included in the App with some evidence in the CCT literature, Yellow cells indicate task parameters are included in the App but not in the CCT literature, Red cells indicate that task parameters are not included in the App but are included in the CCT literature. If a parameter is not applicable for a given task the cell is light grey.

Figure 4.14 Updated wireframe for physiotherapy interface for the inclusion of reactive balance



4.3.5 Walking task progressions addressed in the App and CCT literature

Under this training focus the app included the following tasks: stepping forward right or left, stepping backward right or left, stepping sideways right or left, walking forwards, walking backwards, walking sideways to left or right, turning 90°, turning 180°, turning 360°, and step and turn. All of which also were reported in the CCT literature. Table 4.5 compares the app's stepping, walking and turning progression options to those described in the literature.

Eight of the CCT studies include stepping-based stations but few progressions were reported (Caetano Martins et al., 2020; Dean et al., 2000; Moore et al., 2015; Mudge et al., 2009; Stuart et al., 2019; Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017; Verma et al., 2011). Increasing the size of the movement was the most common progression with some studies manipulating physical support, number of reps and sets and movement accuracy with the use of targets (Caetano Martins et al., 2020; Dean et al., 2000; Moore et al., 2015; Mudge et al., 2009; Stuart et al., 2019; Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017). For stepping-based tasks the app surpassed the detail provided in the CCT literature for task progression and as represented by the yellow cells in Table 4.5 where the starting position, level of assistance, movement speed, sensory input, and dual tasking (motor and cognitive) could also be manipulated. Appendix Section 4 Table 3B contains all comparator examples for stepping based tasks.

Nineteen CCT studies including walking-based stations and frequently reported movement size, speed and somatosensory input as task progressions for forward walking. Level of assistance, number of reps and sets, distance walked, movement accuracy and adding a motor dual task were also reported but these studies were limited (Blennerhassett & Dite, 2004; Caetano Martins et al., 2020; Dean et al., 2000, 2012; English et al., 2015; Grau-Pellicer et al., 2020; Kim et al., 2016; Knox et al., 2018; Marigold et al., 2005; Marsden et al., 2010; Moore et al., 2015; Outermans et al., 2010; Pang et al., 2005; Song et al., 2015; Stuart et al., 2019; Tang et al., 2014; Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017; Verma et al., 2011). Whilst the CCT literature offered more detail regarding walking tasks than any other task the app still surpassed the level of detail provided with manipulation of physical support visual and vestibular input and adding a cognitive dual task also being available. Appendix Section 4 Table 4A contains all comparator examples for stepping based tasks.

Six CCT studies included turning based tasks (Moore et al., 2015; Outermans et al., 2010; Pang et al., 2005; Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017; Verma et al., 2011). The descriptions of task progressions were limited but did include manipulating the starting position, level of assistance, number of repetitions and sets, speed of movement and the addition of a motor dual task

(Moore et al., 2015; Pang et al., 2005; Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017; Verma et al., 2011). Similar to the walking to the CCT literature offered more detail regarding turning based tasks than previous reviewed tasks (sitting balance, sit to stand, transfers, standing balance) however the app still surpassed the level of detail provided by also including manipulation of physical support, movement direction and accuracy, sensory input and dual tasking (motor and cognitive). All comparator examples for turning tasks are located in Appendix Section 4 Table 4B.

Table 4.5 Walking based task parameters addressed in the App and CCT literature

	Stepping			Walking			Turning			
	Stepping Forward R, L	Stepping Backward R, L	Stepping Sideways R, L	Forwards	Backwards	Sideways R, L	Turning 90°	Turning 180°	Turning 360°	Step and turn
Starting position				-	-	-				
Level of Assistance										
Physical support										
Number of repetitions										
Number of sets										
Movement size										
Distance	-	-	-							-
Movement Direction	-	-	-	-	-	-				
Movement speed										
Movement smoothness/ Accuracy						-	-	-	-	
Vision and vestibular input										
Somatosensory input										
Motor task										
Cognitive task										

Note: Dark green cells indicate task parameters are included in the App and in the CCT literature, Light Green cells indicate task parameters are included in the App with some evidence in the CCT literature, Yellow cells indicate task parameters are included in the App but not in the CCT literature, Red cells indicate that task parameters are not included in the App but are included in the CCT literature. If a parameter is not applicable for a given task the cell is light grey.

When mapping the walking-based tasks against the CCT literature, some additional observations were made. Verma et al. (2011) utilised mental imagery in addition to walking practice, Caetano Martins et al., (2020) used a metronome beat for over-ground walking, and Kim et al. (2016) manipulated speed and inclination on the treadmill. Currently, the app does not offer motor opportunities for mental imagery task practise prior to actual task practise, nor does it use metronome beats for walking-based tasks. Finally, the app makes no mention of the use of equipment such as treadmills to control speed and inclination. All of these could be important considerations for the 'TRT' app and have been added to the physiotherapy app wireframe located in Figure 4.15, 4.16, 4.17 respectively. These can also be viewed in Appendix Section 4 Wireframe 2, 3, and 4

Figure 4.15 Updated wireframe for physiotherapy interface for the inclusion of motor imagery task

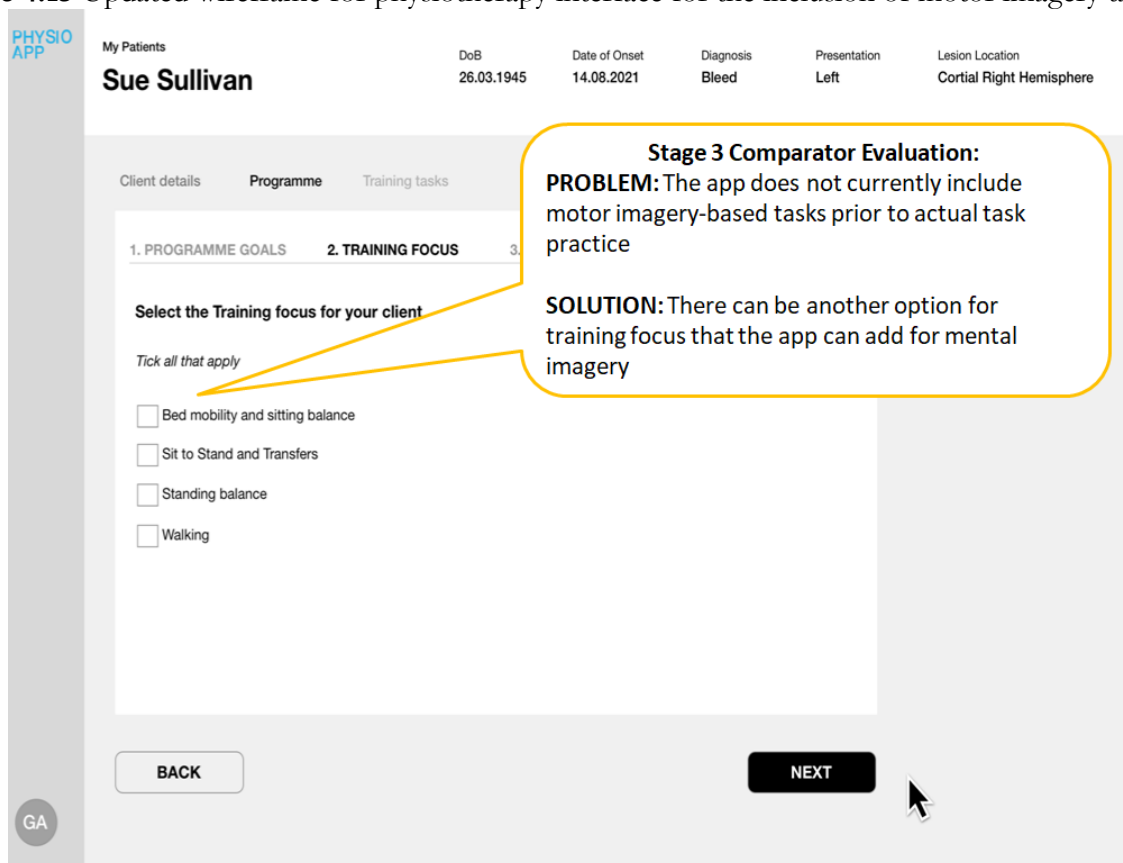


Figure 4.16 Updated wireframe for physiotherapy interface for the inclusion of metronomes

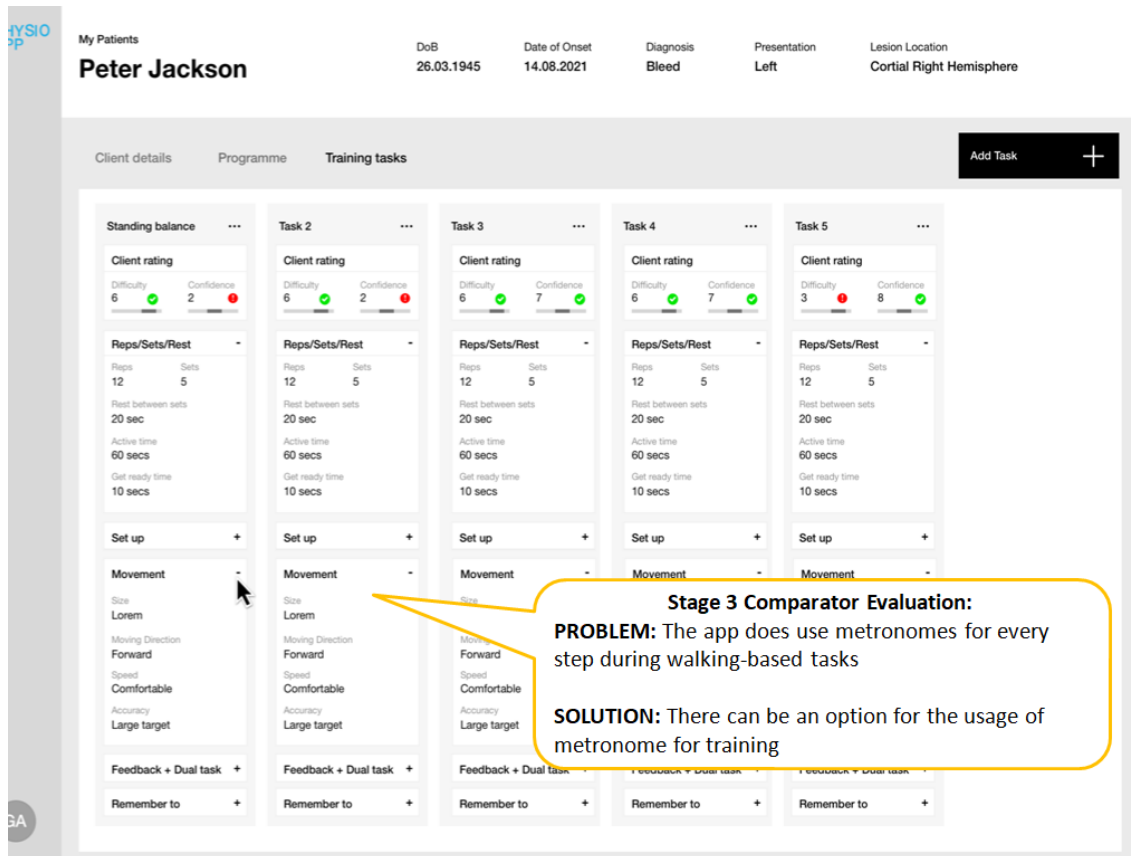
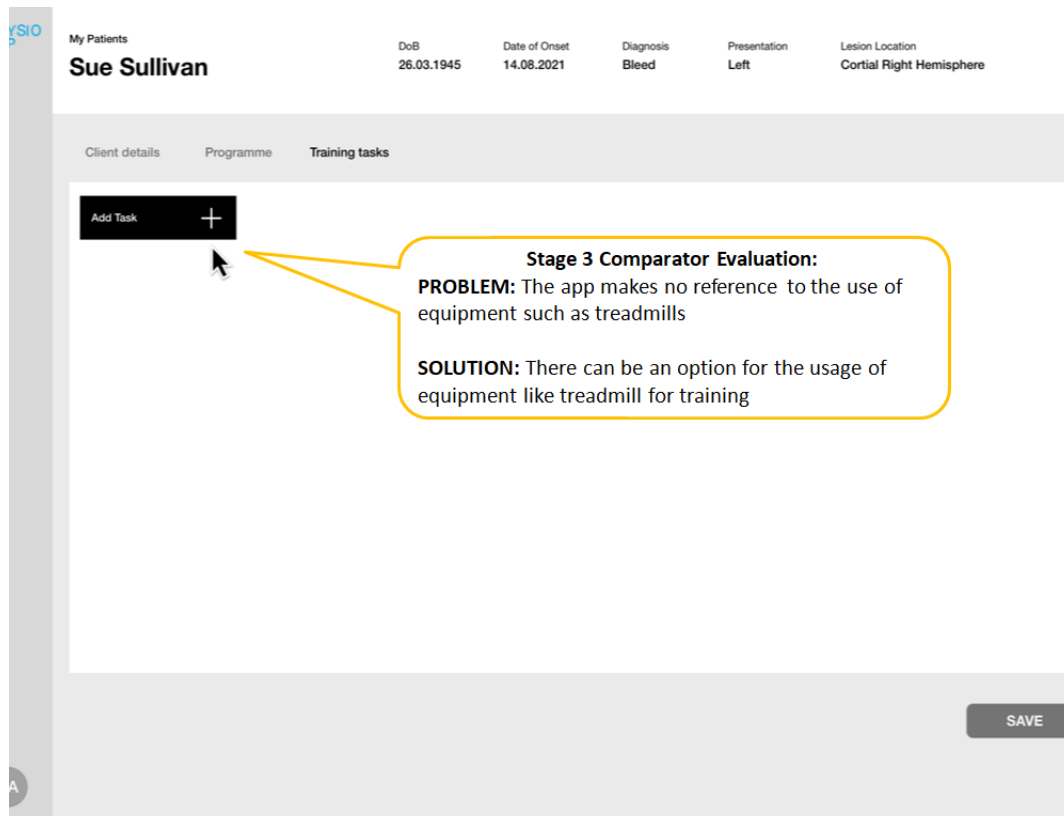


Figure 4.17 Updated wireframe for physiotherapy interface for the usage of treadmill as part of training



4.3.6 Higher-Level Mobility task progressions addressed in the App and CCT literature

Under this training focus the app included the following tasks: step touch, step up and down, navigating around obstacles, stepping over obstacles, stepping on and off obstacles, avoiding moving objects and jumping, hopping, bounding, skipping, jogging and running. Table 4.6 compares the app's high-mobility based tasks and their associated progressions against the CCT literature.

Twelve CCT studies reported step up and down which frequently described manipulating the movement size and direction as task progressions (Blennerhassett, 2004; Caetano Martins et al., 2020; Dean et al., 2000, Grau-Pellicer et al., 2020; Marigold et al., 2005; Marsden et al., 2010; Moore et al., 2015; Mudge et al., 2009; Pang et al., 2005; Tang et al., 2014; Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017). Level of assistance, number of repetitions and sets, movement speed, and the addition of a motor task were reported but only in a few CCT studies (Caetano Martins et al., 2020; Dean et al., 2000; Mudge et al., 2009; Stuart et al., 2019; Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017; Verma et al., 2011). Step touch and stairs were infrequently described in the literature with limited task progression descriptions. These progressions were the same as for step up and down task (Dean et al., 2000; Grau-Pellicer et al., 2020; Marsden et al., 2010; Outermans et al., 2010; Verma et al., 2011), except one study manipulated somatosensory input as a stair task progression (Dean et al., 2000). For test subsection the app surpassed the level of detail provided with manipulation of starting position, movement accuracy, visual and vestibular input and dual tasking (motor and cognitive). All comparator examples for step touch, step up and down and stair-based tasks and progressions are located in Appendix Section 4 Table 4C.

Obstacle negotiation, specifically around and over obstacles was reported in eleven CCT studies (Blennerhassett & Dite, 2004; Dean et al., 2000; Grau-Pellicer et al., 2020; Marigold et al., 2005; Moore et al., 2015; Mudge et al., 2009; Pang et al., 2005; Song et al., 2015; Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017; Verma et al., 2011). However, few studies reported task progressions. Those studies that did had a wider range of types of progressions were seen in other task focus sections. Manipulation included changing the starting position, level of assistance, physical assistance, number of repetitions and sets, movement size, speed, accuracy, somatosensory input and the addition of a motor dual task (Blennerhassett & Dite, 2004; Marigold et al., 2005; Moore et al., 2015; Mudge et al., 2009; Pang et al., 2005; Song et al., 2015; Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017). The app also included visual and vestibular input and dual tasking (motor and cognitive). All comparator examples for obstacles tasks and progressions are in Appendix Section 4 Table 4D.

Finally in the section of jumping, hopping, bounding, skipping and jogging to running, the large number of yellow cells in Table 4.1 (task focus) and Table 4.6 indicate these tasks were did not feature highly in the CCT literature. Only three studies included jumping and jogging to running related activities (Moore et al., 2015; Mudge et al., 2009; Verma et al., 2011) and task progressions were limited to number of repetitions and STS and movement size and speed. Therefore, in this section, the app surpassed the detail provided in the literature. All comparator examples for jumping, hopping, bounding, skipping and jogging to running tasks and progressions are located in Appendix Section 4 Table 4E. Overall, these types of activities were not commonly reported in the CCT literature, this may relate to the functional capacity of the participants included in the studies. However, the inclusion of activities that challenge the dynamic nature beyond the basic walking tasks in the app is an advantage and may help to support the challenge point for higher functioning patients.

Table 4.6 Steps, step and turn, and obstacle task parameters addressed in the App and CCT literature

	Step Touch	Step up/ down	Stairs	Around obstacles	Over obstacle	On/ off obstacles	Avoiding moving objects	Jumping, hopping, bounding, skipping	Jogging to Running
Starting position	Yellow	Yellow	Yellow	Light Green	Light Green	Yellow	Yellow	Yellow	Light Grey
Level of Assistance	Yellow	Light Green	Yellow	Light Green	Light Green	Yellow	Yellow	Yellow	Yellow
Physical support	Yellow	Yellow	Yellow	Light Green	Yellow	Light Green	Yellow	Yellow	Yellow
Number of repetitions	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Yellow	Light Green	Light Green
Number of sets	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Yellow	Light Green	Light Green
Movement size	Light Green	Dark Green	Light Green	Light Green	Light Green	Light Green	Yellow	Light Green	Light Green
Movement direction	Yellow	Dark Green	Yellow	Light Grey	Light Grey	Light Grey	Light Grey	Yellow	Light Grey
Movement speed	Yellow	Light Green	Light Green	Light Green	Light Green	Yellow	Yellow	Yellow	Light Green
Movement smoothness/ Accuracy	Yellow	Yellow	Yellow	Light Green	Light Green	Yellow	Yellow	Yellow	Yellow
Vision and vestibular input	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Light Grey
Somatosensory input	Yellow	Yellow	Light Green	Light Green	Light Green	Light Green	Yellow	Yellow	Light Grey
Motor task	Yellow	Light Green	Yellow	Light Green	Yellow	Yellow	Yellow	Yellow	Yellow
Cognitive task	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow

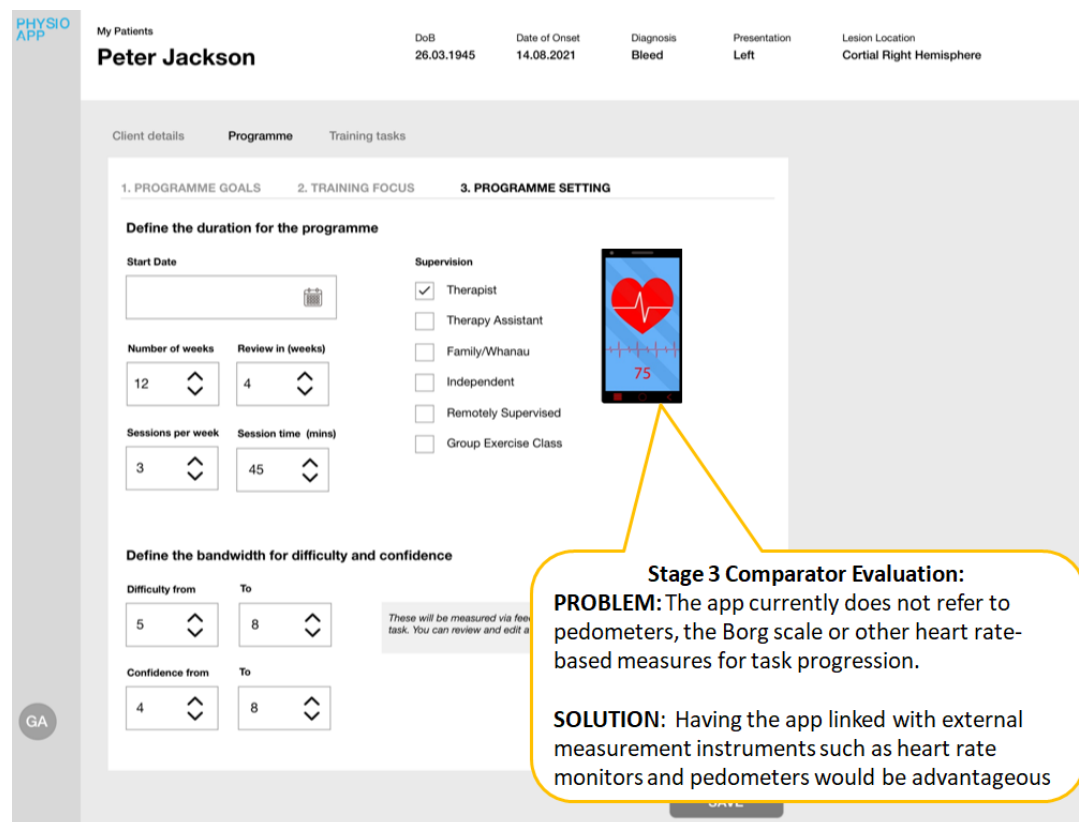
Note: Dark green cells indicate task parameters are included in the App and in the CCT literature, Light Green cells indicate task parameters are included in the App with some evidence in the CCT literature, Yellow cells indicate task parameters are included in the App but not in the CCT literature, Red cells indicate that task parameters are not included in the App but are included in the CCT literature. If a parameter is not applicable for a given task the cell is light grey.

4.3.7 Comparisons for setting and monitoring the task difficult or in the App and CCT literature

The specifics of how and when task progressions were implemented with the CCT literature was limited. The most common description across the studies was that tasks were customised and progressed according to the patients' abilities suggesting that these were often decided by the treating therapist. Only seven of the twenty-four CCT studies included in this critical review specifically indicated how they set and monitored the difficulty, which consequently dictated when task progressions were introduced within and across stations and subsequent CCT sessions. Four studies utilised the Borg rate of exertion scale (Outermans et al., 2010; Moore et al., 2015; Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017), four studies used percentage heart rate reserve (HRR) (Pang et al., 2005; Tang et al., 2014 Outermans et al., 2010; Moore et al., 2015) and one used an app-based pedometer (Grau-Pellicer et al., 2020).

The app does not refer to the use of Borg scale or other heart rate-based measures pedometers, for setting and monitoring task difficulty. Instead, it sets and progresses the task difficulty based on ratings from numerical visual analogue scales (VAS). The patient is asked to rate how difficult it was to perform the task and how confident they felt performing the task. However, having the app linked with external measurement instruments such as heart rate monitors and pedometers would be advantageous. Suggestions for using HR monitors and pedometers within the app have been added to the Figure 4.18 physiotherapy app wireframe. This modification is also visible in Appendix Section 4 Wireframe 5.

Figure 4.18 Updated wireframe for physiotherapy interface for the usage of measurement instruments



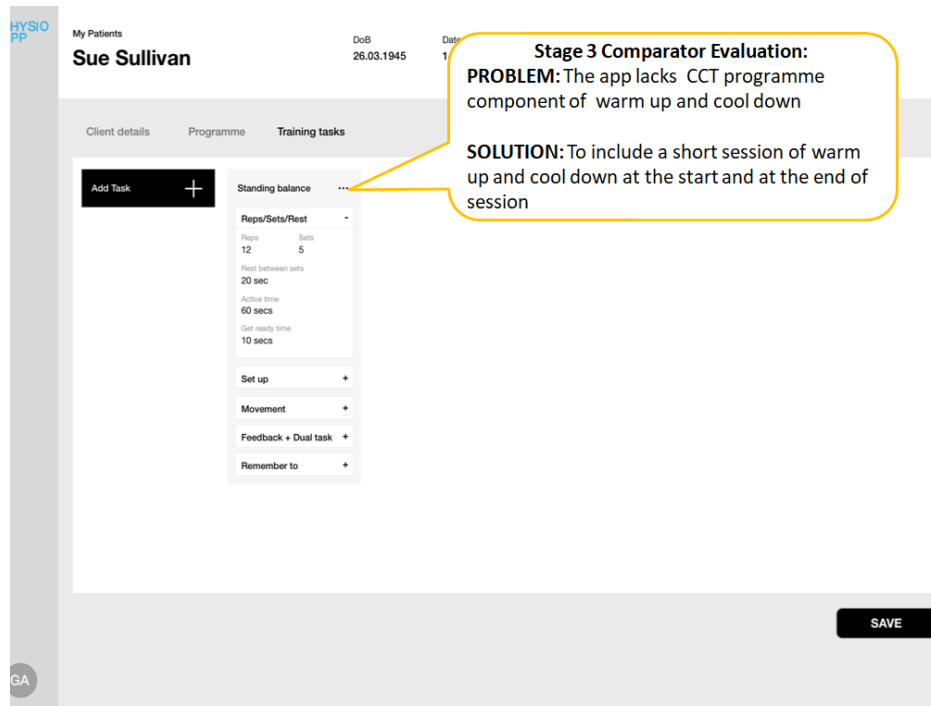
4.3.8 Additional considerations from the CCT literature

Many of the studies incorporated a warm-up prior to commencing the CCT stations and were followed by a cool down. These consisted of simple activities such as stretching (Marigold et al., 2005; Mudge et al., 2009) stationary bikes and treadmills (Blennerhassett & Dite, 2004; Dean et al., 2000; Kim & Yim, 2017; Kim et al., 2016), over ground walking (Kim & Yim, 2017; Marigold et al., 2005; Moore et al., 2015; Pang et al., 2005; Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017), and other light cardio type exercises like marching (Moore et al., 2015). All of which could be easily built into the patient workflow of the app. Suggestions for the inclusion of a warm-up and cool down components within the app have been added to the physiotherapy app wireframe Figure 4.19. This change can also be viewed in Appendix Section 4 Wireframe 6

Finally, the student researcher also noted a number of studies used equipment such as treadmills (Blennerhassett & Dite, 2004; Dean et al., 2000; Kim & Yim, 2017; Kim et al., 2016), stationary cycles (Blennerhassett & Dite, 2004; Grau-Pellicer et al., 2020; Kim et al., 2016; Marsden et al., 2010; Tang et al., 2014; Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017) and ergometry (Grau-Pellicer et al., 2020; Marsden et al., 2010; Tang et al., 2014). Of note only a single station within a circuit utilised high-tech equipment, all

remaining stations focused on over-ground locomotor-related practice. The app could include an option to state whether such equipment is included within a CCT station.

Figure 4.19 Updated wireframe for physiotherapy interface for the inclusion of warm up and cool down



Chapter 5. Discussion and Clinical Implications

The purpose of this critically review was to evaluate the suitability of the Task Related Training (TRT) mobile app prototype for supporting the delivery of a TRT locomotor-based circuit class training (CCT) programme for people with stroke in an inpatient hospital setting in Jurong Health Campus (JCH), National University Health System in Singapore. This was achieved by evaluating the content of the TRT app prototype from a physiotherapist's usability standpoint, and by critiquing the content of the app against motor learning principles and the locomotor TRT CCT evidence base in people with stroke. The key findings of this critical review were as follows: 1) the TRT app was well received in terms of usability and suitability from the perspective of a physiotherapy user and 2) the app's content was closely aligned with motor learning and TRT principles, as well as the tasks practised in the CCT evidence. From the perspective of the physiotherapy user, the TRT App has the potential to support the delivery of the JCH CCT programme. This chapter will first discuss the findings from the usability and compactor evaluations, followed by the implications of these findings for potential users, specifically physiotherapists and people with stroke, as well as designers of rehabilitation technology, and finally, the limitations of the research project.

5.1 USER- CENTERED TESTING – A PHYSIOTHERAPIST PERSPECTIVE

The student researcher used the think aloud usability method to evaluate the therapist and patient interfaces of the TRT app when registering and setting up a CCT programme for a hypothetical stroke patient. Overall, the student researcher (physiotherapist) was very impressed with the TRT app prototype and keen to discuss its potential fit with colleagues, senior management, and patients at JCH, Singapore. On evaluation the devices usability, visibility understandability, practical usefulness, and navigation categories had minor user requirements to support a CCT context at JCH, Singapore. The two remaining categories, content and workflow would require further input from rehabilitation technology designers, particularly in the upfront sections of the app to support the on-boarding and organisation of patients enrolled in the CCT programme. However, it is important to

acknowledge that these are the opinions of a single physiotherapist user. Future usability testing should include physiotherapists, therapy associates and stroke patients from JCH in Singapore. Iterative user testing can improve the translation of technology to clinical practice (Jeminiwa et al., 2019) with the ultimate goal of contributing to better functional outcomes for people with stroke.

5.2 EVIDENCE OF TRT AND MOTOR LEARNING PRINCIPLES WITHIN THE TRT APP

McLoughlin's 2020 "Guiding principles for movement training in neurorehabilitation was employed to determine whether the TRT app was underpinned by TRT, and motor learning principles. Overall, it was evident from this evaluation that these rehabilitation principles had a strong presence with the apps structure. The app accommodates an individualised task-specific focus, that could reflect personalised goals, and support patients to achieve high doses of task practice with extensive options for promoting progressive challenge that consider the task, the individual, the environment and the patient's stage of learning. While feedback provision for the patient is evident in the TRT app, methods to better support knowledge of performance would be an important consideration for future iterations. While this can be provided verbally by the therapist or typed into the app for further sessions the use of video recording to capture patient performance would be advantageous. Evidence suggests providing patients with video footage to provide knowledge of their task performance can facilitate motor learning (Post et al., 2016; Van Vliet & Wulf, 2006) and is an approach that is well adopted by physiotherapists in clinical practice for highlighted how to minimise errors in performance, document progress towards goals and to improve the quality of the rehabilitation process (Marwaa et al., 2020). Furthermore programs emphasising an interactive approach, as well as frequent feedback on patients' effort and progress, have been shown to be effective in increasing patient engagement (Lenze et al., 2012) and improve the outcome of exercise-based rehabilitation (Stoller et al., 2015). Videoing patients are also common practice for physiotherapist at JCH, Singapore and warrants further investigation for its use at CCT stations.

Reward-based learning is another motor learning principle that was partially captured in the app. The dashboard currently displays patient gains and charts that show the patient's overall progress towards their goals. There is also immediate gratification when the patient is congratulated on completing a task during their session, and reps and sets are displayed. Gamification techniques can enhance patient engagement, motivation, and adherence to interventions as well as supporting patients to become more physically, psychologically and

socially active (Adlakha et al., 2020). Furthermore evidence suggests that task retention can be more successful when incentivised activities and gamification principles are employed (Widmer et al., 2017). For example, the use of competitions or point scoring (Burns et al., 2022; Singh et al., 2016) and rewards in the form of immediate feedback during motor skill training (Widmer et al., 2016). Future iterations of the app should continue to build more explicit reward systems to encourage optimal rehabilitation outcomes. Future usability testing at JCH, Singapore during CCT sessions would be an effective way of identifying reward-based user requirements.

5.3 EVALUATION OF LOCOMOTOR CCT EVIDENCE WITHIN THE TRT APP

The final evaluation of the TRT app prototype involved determining whether the locomotor tasks and task progressions included within the app aligned with those described in the locomotor based CCT literature for people with stroke. Through this mapping exercise, it became clear that the app closely mirrored the different task types and relative task progressions described in the literature, and that it frequently provided more opportunities to train different tasks, and greatly flexibility in task setup, and parameter manipulation than described in the literature. This is a significant finding because these studies improved walking speed, endurance, and some aspects of balance in people with stroke (Bonini-Rocha et al., 2018; English et al., 2017; Jeon et al., 2015). In addition repetitive locomotor-related task practice is also strongly advocated for in the international stroke guidelines (Platz, 2019; Wright et al., 2012). As previously stated, evidence-based content can increase the apps credibility among users and relative stakeholders (Breland et al., 2013). Clearly the content provided in the TRT app could better inform the task selection for the generic stations that are currently being used as part of the JCH, Singapore CCT programme.

One type of task that did feature in the CCT literature but not the app was reactive balance (Marigold et al., 2005). Parameters to enable this type of training could easily be added to the relevant sitting and standing balance and walking sections. With regards to monitoring task progressions to ensure progressive challenge and intensive practice a number of studies made reference to subjective and objective monitoring (Moore et al., 2015; Outermans et al., 2010; Pang et al., 2005; Tang et al., 2014). Having the option to select the most appropriate monitoring tool within the app would be advantageous. This would also complement the physical activity and exercise recommendations for people with stroke

guidelines (Billinger et al., 2014) that provide specific guidance around manipulating heart rate reserve, VO₂ reserve and rate of perceived exertion (RPE). During task practice the patient's challenge point is not currently set or monitored within and across the JCH, CCT programme, but the unit does have access to heart rate monitors and staffs are familiar with RPE scales. The student researcher believes that the task difficulty and confidence rating scales currently embedded within the TRT app would be well received by patients and physiotherapists alike, local user testing would be important to understand their usability and acceptable in the JCH CCT programme context.

Finally, other common CCT programme components described in the literature such as a warm-up and cool down (Blennerhassett & Dite, 2004; Dean et al., 2000; Kim & Yim, 2017; Kim et al., 2016; Marigold et al., 2005; Marsden et al., 2010; Moore et al., 2015; Mudge et al., 2009; Pang et al., 2005; Tang et al., 2014; Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017; Van De Port et al., 2012), and educational and or motivational sessions (Harrington et al., 2010, Holmgren et al., 2010, Marsden et al., 2010 Vahlberg, Lindmark, et al., 2017, Vahlberg, Cederholm, et al., 2017). Based on the review of the literature these sessions provided opportunities to discuss goals, strategies to promote physical activity and other positive behaviour change strategies, risk factor modification and falls prevention, and contributed positively to the study outcomes. Apps can be an accessible and cost-effective way to deliver stroke-related education and the promotion of behavioural strategies (Istepanian et al., 2006; Vogel et al., 2017). Therefore, inclusion of educational and motivational multimedia resources would be a great addition to the TRT app and the CCT programme run at JCH, Singapore. These could either be viewed independently or played to the group at the beginning or end of the class to support interactive discussion.

5.4 IMPLICATIONS FOR CLINICAL PRACTICE

This section considers the implications of this critical review for the wider community of potential users, specifically physiotherapists and people with stroke, the developers and designers of the TRT app and the student researchers practice context.

5.4.1 Physiotherapists and patients

While an app is not intended to replace therapist-to-patient interaction, it can be mutually beneficial to both physiotherapists and patients in the rehabilitation process. From a patient perspective the TRT App has the potential to support large amounts of meaningful task practice in an intensive way and can be tailored to support patients with a

variety of functional abilities. Furthermore, it is designed to support independent or group-based practice and could potentially be utilised in different stages of the rehabilitation process i.e., inpatient, outpatient, and community settings. While there is moderate evidence that locomotor-based CCT is effective in improving locomotor and some balance-based outcomes for people with stroke (English et al., 2017), setting up a CCT programme can be logistically challenging. Setting up a CCT programme can be difficult logistically for physiotherapists and service providers, so having a mobile application to facilitate the registration, delivery, monitoring, and documentation of patients' rehabilitation programmes could make the app an appealing option. However, because the TRT app prototype is still in its early stages of development, it is now an excellent time for patients and physiotherapists to provide feedback on the device to ensure optimal use and acceptance, as well as how it can best assist clinical practise.

5.4.2 Implications for developers and designers

It is hoped that the iterative wireframes developed by the student researcher (physiotherapist) provide the developers and designers of the TRT app with insight into how the app could be optimised for an inpatient stroke context in Singapore. There is no clear formula for creating appealing and effective mobile health applications (Chan et al., 2015) and apps are usually conceived and built within the framework of existing healthcare structure (Jeminiwa et al., 2019). As a result, developers should consult with ICT developers and other JCH staff to better understand organisational barriers and potential solutions for customising the app for optimal integration into the hospital's ICT network.

Another important consideration for this context is that users may speak and read in one of four languages, English, Malay, Tamil and Mandarin. A study in 2018 (Hossain et al., 2018) examined public attitudes towards mobile health in Singapore and discovered that multiple language support was rated as a 'very important' feature that would influence their receptivity to using mobile health devices. To maximise the success of implementation and sustained use, programming the TRT app in each language would be critical.

In order to increase the likelihood of the TRT app being successfully implemented at JCH National University Health System in Singapore, the following user requirements should be prioritised prior to further usability testing with basic back-end programming in place:

1. To aid on-boarding and organisation of patients enrolled in the CCT programme optimise the clinical workflow and add recommended content to the app's initial sections

2. Warm up and cool down dropdown options in the physiotherapy app and the workflow of the patient app pre and post CCT stations
3. In addition to the English version provide several digital examples of the patient dashboard, task selection, setup instructions, cue screen and rating scales in Malay, Tamil and Mandarin with basic to support patients during testing
4. Provide basic digital examples of reward-based incentives that could be incorporated into the CCT programme to optimise engagement
5. Integrate an educational video on promoting physical activity after stroke for (video to be provided by JCH)
6. Activate a camera icon to enabling videoing at stations to trial knowledge of performance review between patient and therapist.

Future iterative user testing should also include ‘Near live’ testing to simulate the CCT clinical environment at JCH. This type of user testing would provide developers with a deeper understanding of the potential workflow problems (Saleem et al., 2007) within a single session and repeated sessions.

5.4.3 Student researchers practice context

From a practice context perspective, a clear contrast emerged between the findings of this critical review of the apps content and what is currently being delivered within the CCT programme at JCH, Singapore. Currently the JCH CCT programme is not structured to best support the principles of motor learning and TRT, nor are many of its tasks reflective of those practised in the locomotor CCT stroke literature. While it is acknowledged that locomotion practice is not the sole focus of the JCH CCT programme, (it also addresses upper limb strength at one of the four stations), the stations provide little context specific over-ground locomotor-related training, the amount (time spent and repetition) of practice is low, and manipulation of practice conditions to promote progressive challenge within and across the stations is lacking. On reflection, our team should consider that there has likely been too much emphasis on advocating for the use of high-tech systems such as the AlterG treadmill and NuStep cross trainer, which when not supplemented effectively with over-ground practise, do not support real-world walking and meaningful practise towards patient goals. As a result, motor learning and TRT principles to promote transfer and retention of locomotor skills have been minimised. This is not to say that technology cannot be used to support practise; however, it is necessary to reconsider why it is being used and whether it is the best way to optimise patient outcomes. This critical review has

shown the student researcher how an app can be built on these principles and preliminary user testing indicates that the app has the potential to be suitable for the JCH CCT context.

Moving forwards the JCH CCT programme needs to be designed to better support 1) the principles of motor learning and TRT and 2) be more aligned with the tasks and task progressions reported in the locomotor CCT stroke literature to maximise functional outcomes for JCH stroke patients.

Therefore, the following should be reviewed at JCH:

1. Utilise the task focus comparator mapping exercises (Table 4.1) to identify meaningful and suitable locomotor-based tasks for the patients enrolled in the CCT programme. This can be considered from a generic or individualised perspective as both are supported in the CCT literature but must link back to patient goals.
2. Identify suitable practice structures for a patient based on where they are in the motor learning continuum and consider what form of feedback may best support motor learning for the individual patient.
3. Identify a method by which to set and monitor the task difficulty within and across CCT sessions. This will support manipulation of the parameters of a given locomotor-based task or to identify when additional more progressive tasks are required. This review could be used to stimulate a discussion within the JCH physiotherapy team as to what subjective and or objective measures might work best in the JCH CCT context.
4. Utilise the task progression comparator mapping exercises (Table 4.2-4.6) to assist therapists in identifying suitable parameters which can be manipulated to increase task difficulty. Therapists should consider the task, environment and the individuals' underlying impairments when selecting the appropriate level of difficulty.
5. Examine the current rehabilitation dose (amount) provided by the CCT programme. While the duration of the sessions (60-minutes) is comparable to that described in the literature, the amount of practise (repetitions) that occurs within a session is very low. The session frequency (once per week) and programme duration (usually three weeks) are also insufficient. Whether it is possible to increase the session frequency and programme duration within the constraints of the service and patient length of stay requires consideration. However, physiotherapists can make better use of the session time by increasing the amount

of practise time within that session and by setting/monitoring the task difficulty to ensure the patient is working hard enough.

6. Consider incorporating educational or motivation sessions to support the CCT programme as described in the CCT literature.

5.5 LIMITATIONS OF THE RESEARCH

There were several limitations to the methods employed in this critical review. First, only a single physiotherapist user (the student researcher) participated in the usability testing. A larger user sample of physiotherapists, therapy assistant and stroke patients from JCH in Singapore would have been beneficial to gain a collective understanding of the user requirements and context of use. Recommendations from the usability literature suggest five users per usability testing session (Nielsen & Landauer, 1993). However, this would have required ethical approval and was outside the scope of this practice project but should be considered as an important next step in the research process to maximise the potential for successful implementation and sustained use of the device at JCH in Singapore.

Second, there is no standard method or established framework for the evaluation of exercise rehabilitation mobile applications. Therefore as proposed by Jake-Schoffman et al. (2017) comparator methods were employed to assess the apps content against the relevant evidence base. Whilst a substantial body of literature has advocated the application of motor learning and TRT principles in stroke rehabilitation a universal framework or guideline for their implementation does not exist. Whilst, the McLoughlin 2020 article was perceived to be the most feasible option, it lacked a specific focus on the underlying motor learning and TRT principles which influenced the comparator evaluation of the apps content against such principles. For example, little consideration was given to the stage of learning, the amount and intensity of practise, and their impact on practise structure and feedback to optimise motor learning and TRT delivery.

The third is that research studies that examined the effectiveness of CCT locomotor-based interventions in people with stroke between May 2021 and August 2022 where not mapped against the TRT app content. As a result, it is unclear whether the app's content reflects the most recent research, and tasks and related progressions might be absent. Although this time window only includes a small number of pertinent publications, it would be important

to re-run the search strategy closer to commercialisation to make sure it is as current as possible in order to maximise the app's credibility.

5.6 CONCLUSION

Preliminary user testing and thorough evidence-based evaluations show that the TRT app has the potential to support the delivery of the inpatient locomotor CCT programme for people with stroke at Jurong Health Campus (JCH), National University Health System in Singapore. Critiquing the apps' content revealed that the CCT programme at JCH has likely placed a greater emphasis on the use of technology and somewhat overlooked the rehabilitation principles that support the effectiveness of CCT on locomotor-related outcomes for people with stroke. Future directions should see designers of rehabilitation technology consider the recommendations outlined in this review and conduct future iterative user testing with physiotherapists, therapy associates and people with stroke in Singapore. Near-live encounters with the device over extended periods of time in the CCT context would also be important. Future research should also look at validating the device efficacy for delivering locomotor CCT programmes in people with stroke.

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Appendices

APPENDIX SECTION 1: Stage 1 Physiotherapy wireframes updated based on usability testing

APPENDIX SECTION 2: Stage 1 Patient wireframes updated based on usability testing

SECTION 3: Stage 2 Comparator Evaluation of the TRT app prototype with TRT and Motor Learning Evidence in people with stroke.

This section includes only Therapist and Patient wireframes that have been updated from Stage 1 based on this comparator evaluation process.

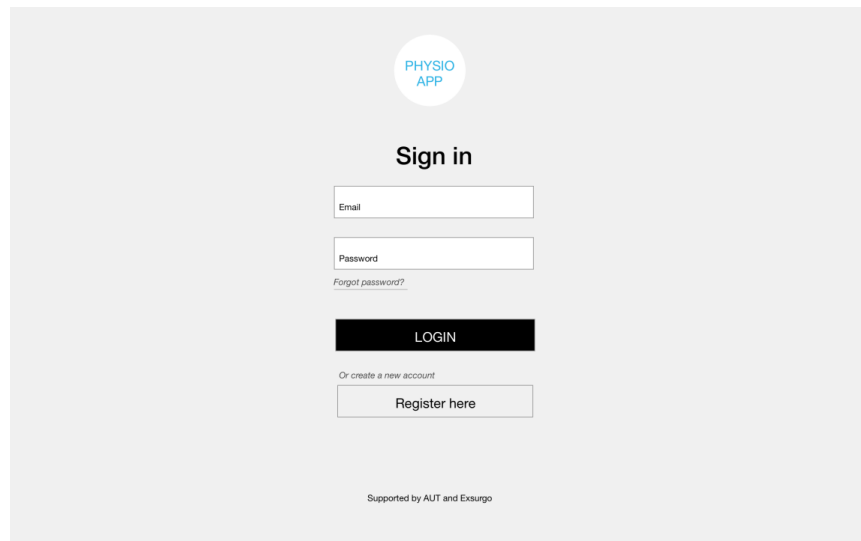
SECTION 4: Stage 3 Comparator Evaluation of the TRT app prototype with Locomotor CCT Evidence in people with stroke

This section includes only Therapist and Patient wireframes that have been updated from Stage 1 and 2 based on this comparator evaluation process.

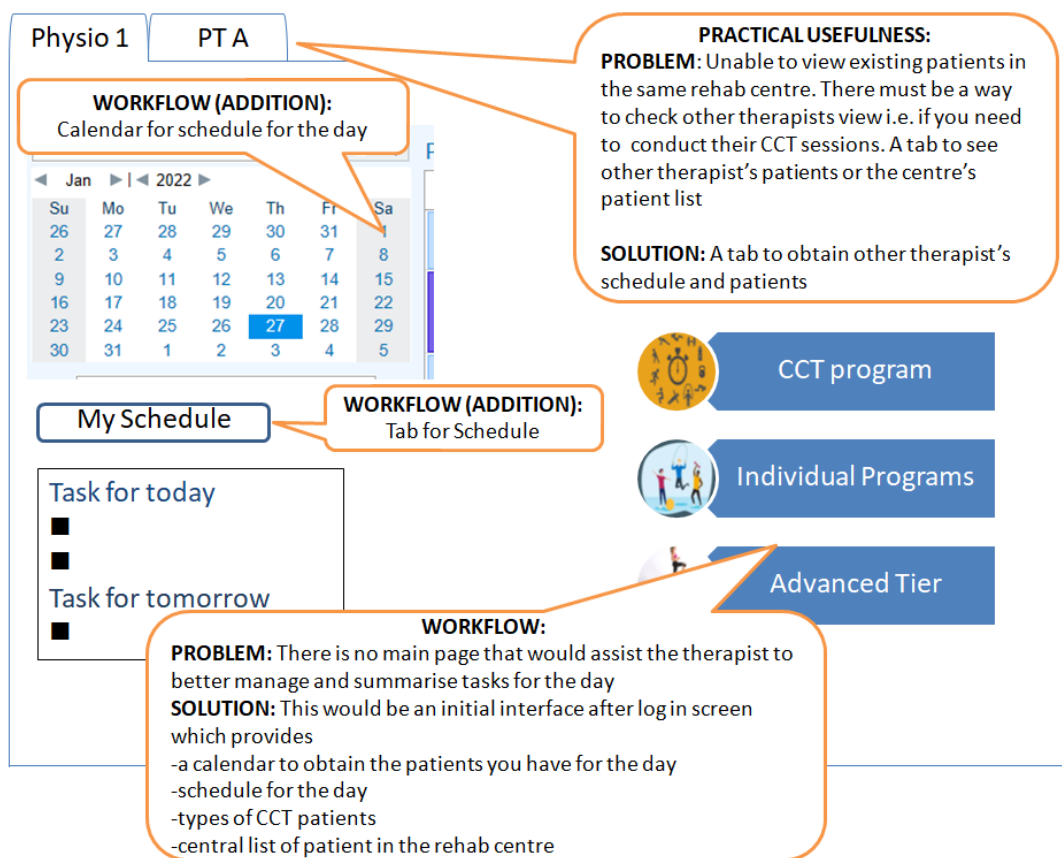
SECTION 5: Stage 3 Comparator Evaluation of the TRT app prototype with Locomotor CCT Evidence in people with stroke

APPENDIX SECTION 1: Stage 1 Physiotherapy wireframes updated based on usability testing

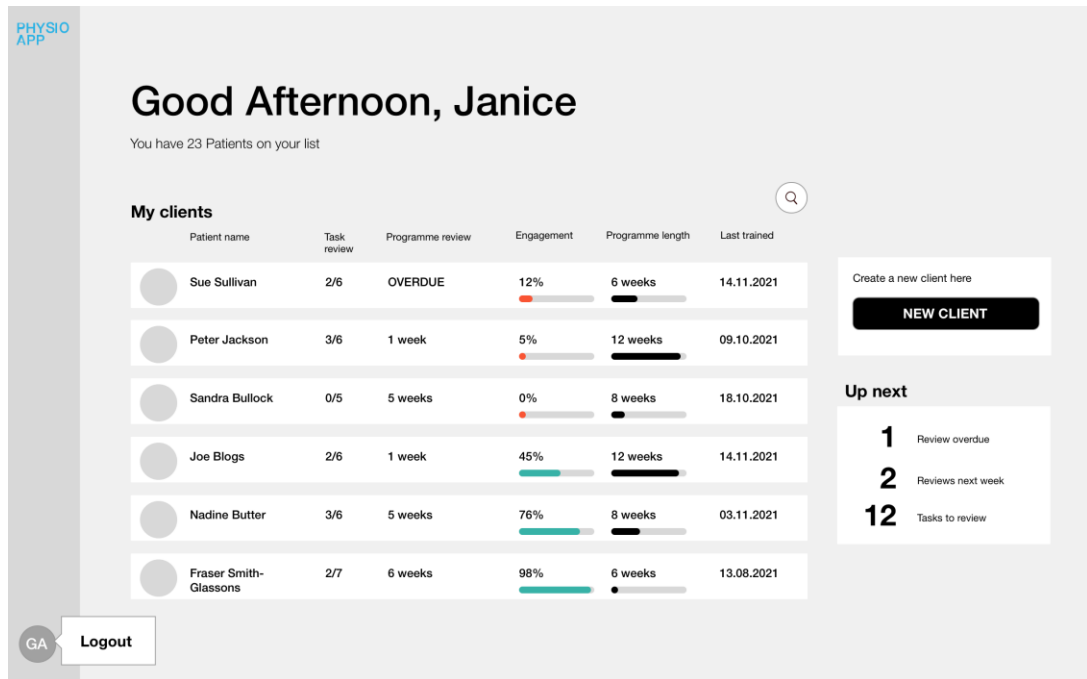
Screen 1.1



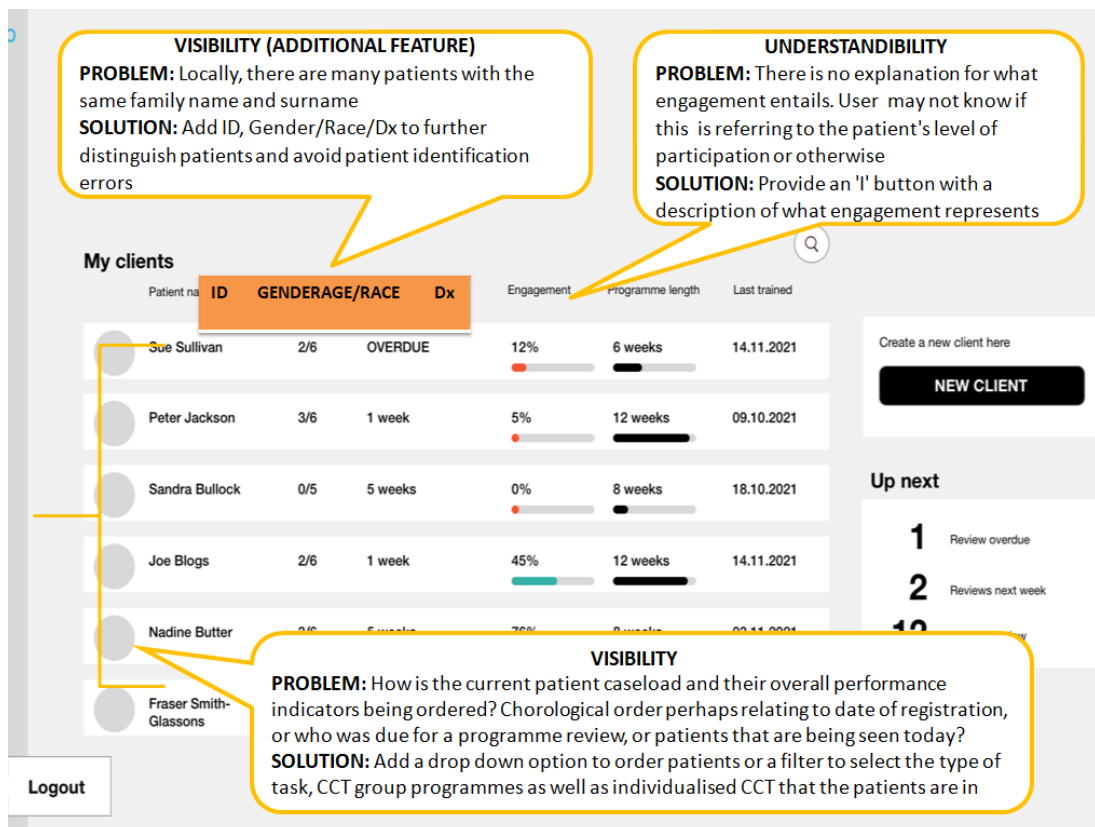
Wireframe 1.1



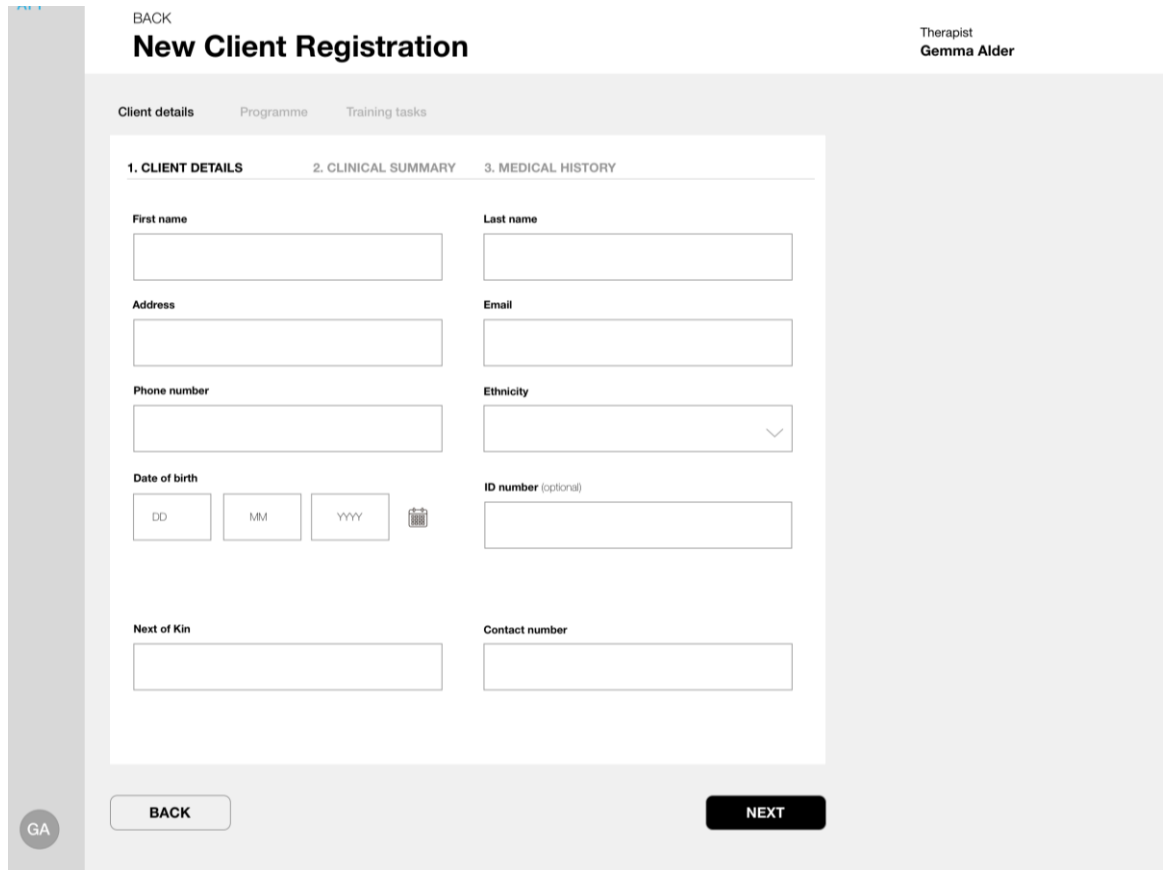
Screen 1.2



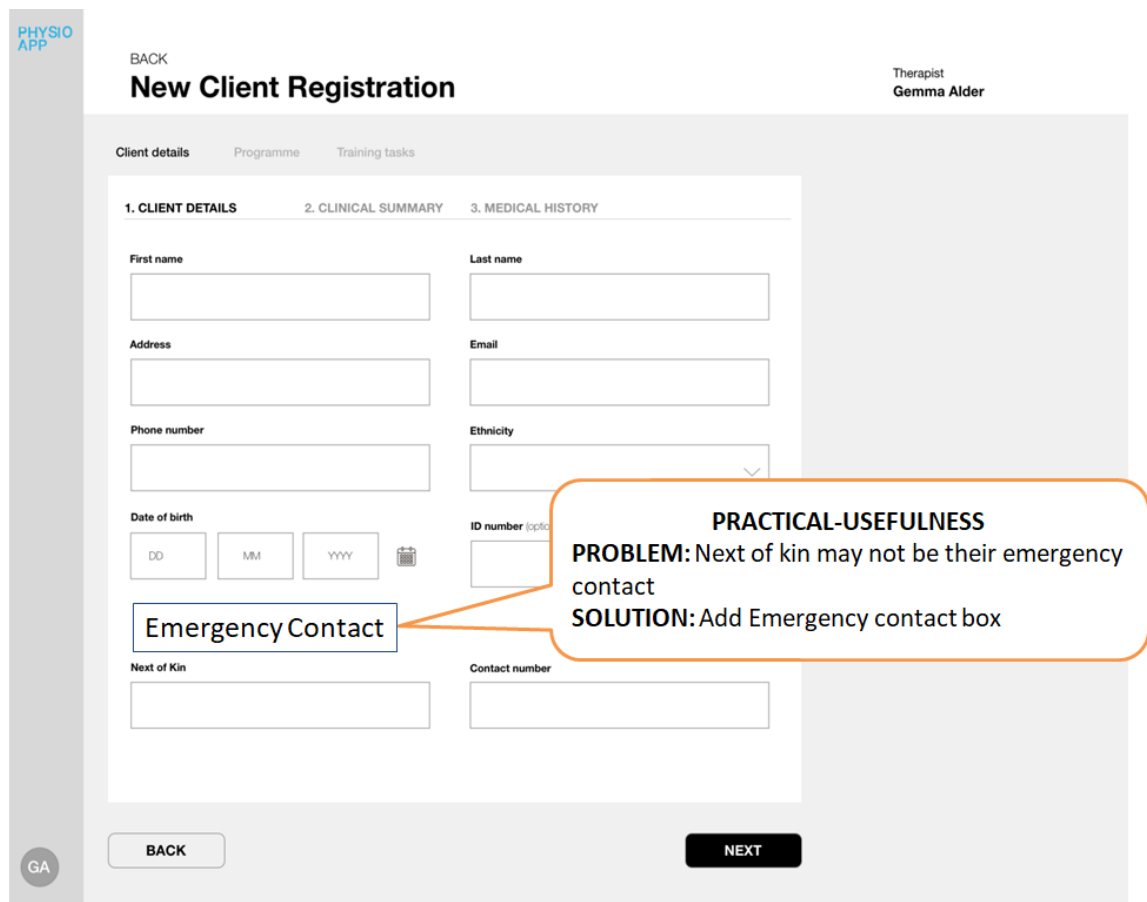
Wireframe 1.2



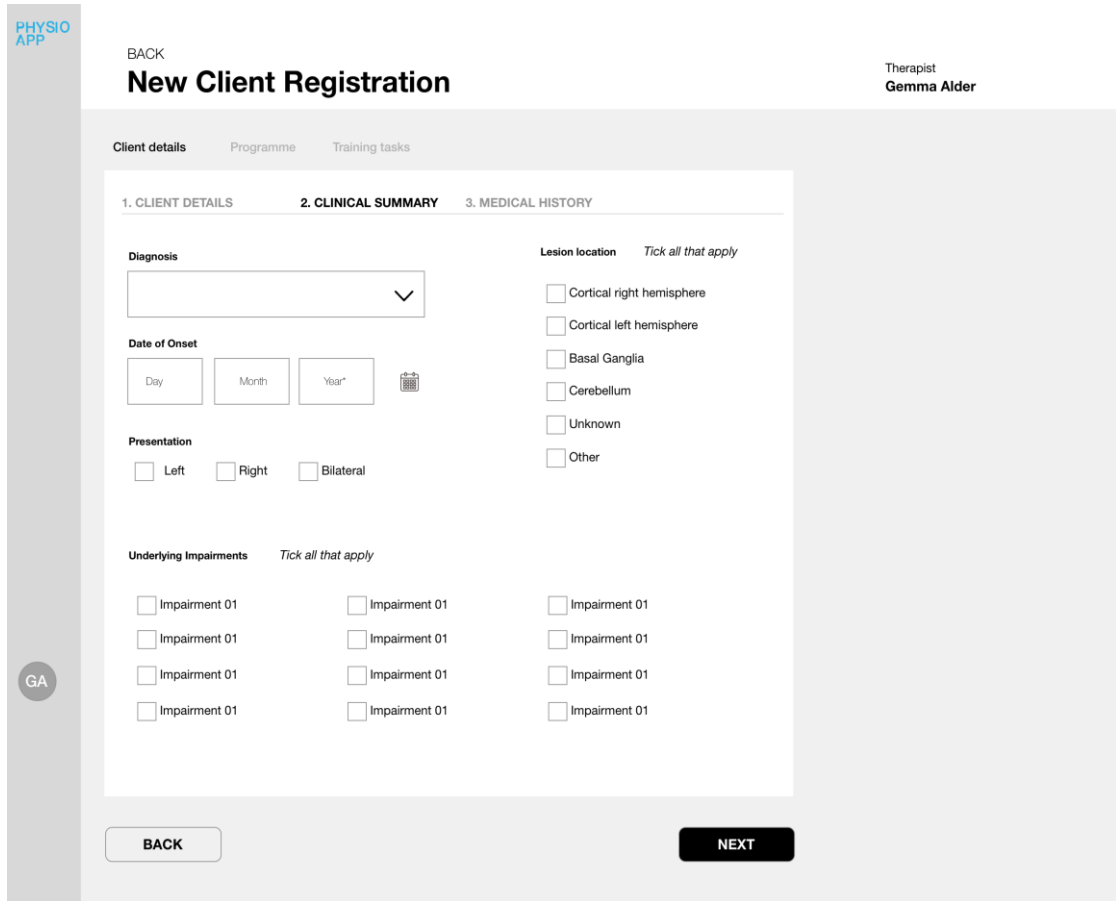
Screen 1.3



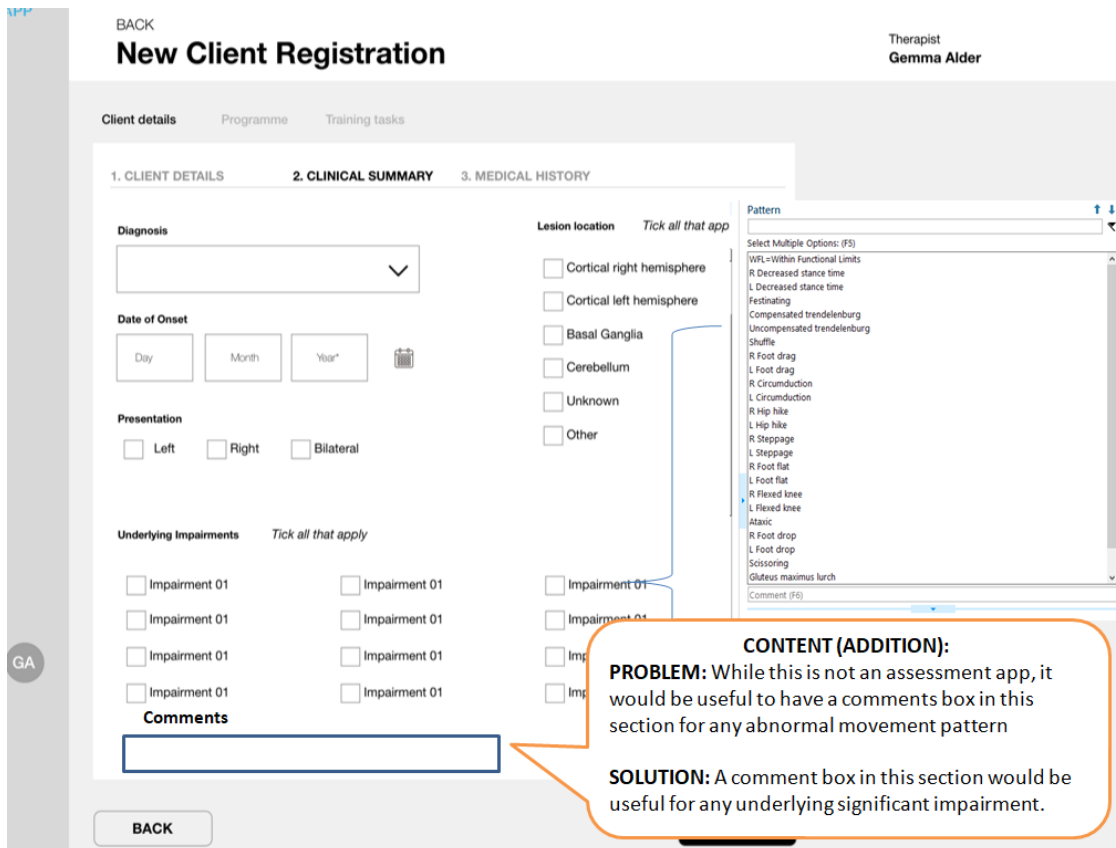
Wireframe 1.3



Screen 1.4



Wireframe 1.4



Screen 1.5

PHYSIO APP

BACK

Therapist
Gemma Alder

Client details Programme Training tasks

1. CLIENT DETAILS 2. CLINICAL SUMMARY 3. MEDICAL HISTORY

Relevant medical history Also refer to medical record

Please enter relevant medical history

Sociocultural History Also refer to medical record

Please enter relevant social history

Precautions and Contraindications ⓘ

Please enter relevant precautions and contraindications to exercise and rehabilitation

GA BACK SAVE

Wireframe 1.5

PHYSIO APP

BACK

Therapist
Gemma Alder

Client details Programme Training tasks

1. CLIENT DETAILS 2. CLINICAL SUMMARY 3. MEDICAL HISTORY

Relevant medical history

Please enter relevant medical history

Sociocultural History

Please enter relevant social history

Precautions and Contraindications ⓘ

Please enter relevant precautions and contraindications to exercise and rehabilitation

Work history Or Comments Box

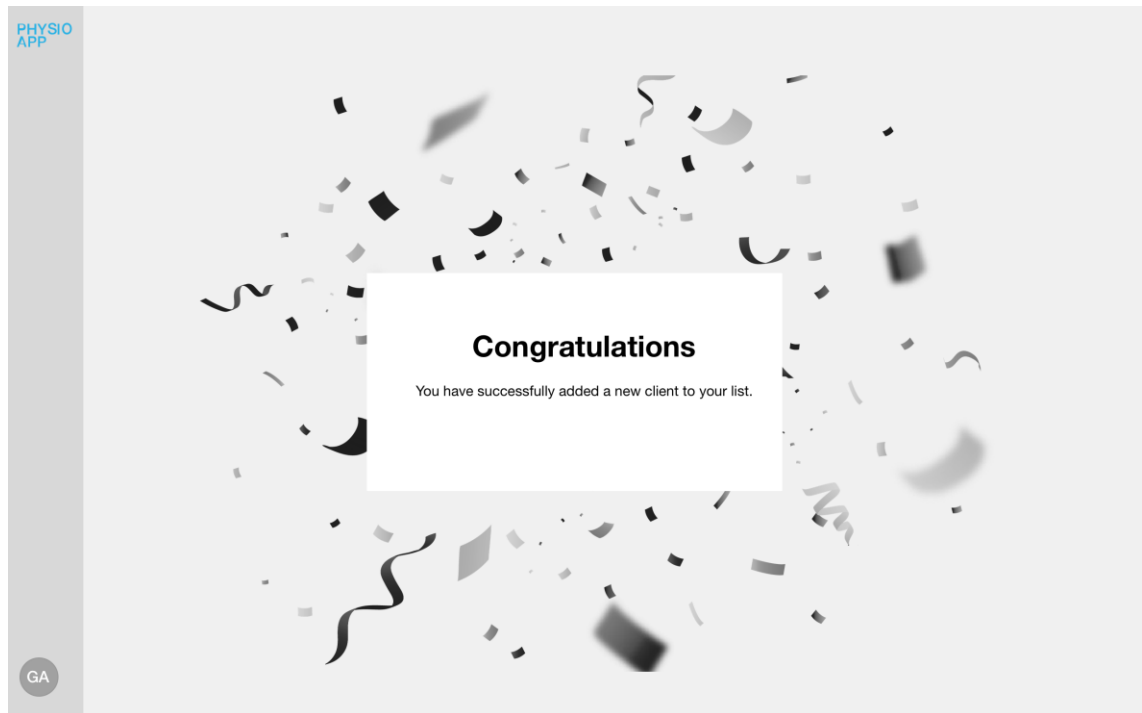
GA BACK SAVE

CONTENT

PROBLEM: There may be pertinent information in the conversation that you have with your patient which may not be penned in medical records. Its a good way to delve into social support. There should be a box for work history as it is interpreted differently, locally. It is different from sociocultural history.

SOLUTION: To provide a box for therapist to input any pertinent information about patient

Screen 1.6



Screen 1.7

PHYSIO APP

My Patients **Sue Sullivan** DoB 26.03.1945 Date of Onset 14.08.2021 Diagnosis **Bleed** Presentation **Left** Lesion Location **Cortial Right Hemisphere**

Client details **Programme** Training tasks

1. PROGRAMME GOALS 2. TRAINING FOCUS 3. PROGRAMME SETTING

Define your client aspiration

To go to my grand daughters wedding in summer

I am writing something

183 characters left

Define up to 3 measurable programme goals

1. To

Enter measurable goal

measured by

Enter measurement

by

DD/MM/YYYY

2. To

Enter measurable goal

measured by

Enter measurement

by

DD/MM/YYYY

3. To

Enter measurable goal

measured by

Enter measurement

by

DD/MM/YYYY

GA

BACK NEXT

Wireframe 1.7

My Patients

Sue Sullivan

DoB
26.03.1945

Date of Onset
14.08.2021

Diagnosis
Bleed

Presentation
Left

Lesion Location
Cortial Right Hemisphere

Client details
Programme
Training tasks

1. PROGRAMME GOALS
2. TRAINING FOCUS
3. P...

Define your client aspiration

To go to my grand daughters wedding in summer

I am writing something

183 characters left

Define up to 3 measurable programme goals

1. To

Alarm

measured by

by

2. To

Alarm

measured by

by

3. To

Alarm

measured by

by

BACK

NEXT

GA

NAVIGATION:

PROBLEM: Having up to three quantifiable goals, each with a deadline, offers a patient a sense of accomplishment. However, having a date in its timeline requires a trigger to alert the therapist– the user needs to know how will it show up in app. This is to ease navigation rather than the therapist having to sieve through the screens to look at the target date

SOLUTION: Alarm button to trigger on therapist dashboard

Screen 1.8

My Patients

Sue Sullivan

DoB
26.03.1945

Date of Onset
14.08.2021

Diagnosis
Bleed

Presentation
Left

Lesion Location
Cortial Right Hemisphere

Client details
Programme
Training tasks

1. PROGRAMME GOALS
2. TRAINING FOCUS
3. PROGRAMME SETTING

Select the Training focus for your client

Tick all that apply

Bed mobility and sitting balance

Sit to Stand and Transfers

Standing balance

Walking

BACK

NEXT

GA

Wireframe 1.8

PHYSIO APP

My Patients
Sue Sullivan

DoB: 26.03.1945 | Date of Onset: 14.08.2021 | Diagnosis: Bleed | Presentation: Left | Lesion Location: Cortial Right Hemisphere

Client details | Programme | Training tasks

1. PROGRAMME GOALS | **2. TRAINING FOCUS** | 3. PROGRAMME SETTING

Select the Training focus for your client

Tick all that apply

- Bed mobility and sitting balance
- Sit to Stand and Transfers
- Standing balance
- Walking

NAVIGATION

PROBLEM: There can be up to 3 measurable goals. There is a need to know how the therapist ensure all goals are being tailored to the training focus

SOLUTION: A header/footer to iterate the aim in order to better aid physiotherapists in selecting training focus planning

For Goal 1 of 3 :

BACK NEXT

Screen 1.9

PHYSIO APP

My Patients
Sue Sullivan

DoB: 26.03.1945 | Date of Onset: 14.08.2021 | Diagnosis: Bleed | Presentation: Left | Lesion Location: Cortial Right Hemisphere

Client details | Programme | Training tasks

1. PROGRAMME GOALS | 2. TRAINING FOCUS | **3. PROGRAMME SETTING**

Define programme parameters

Start Date:

Supervision:

- Therapist
- Therapy Assistant
- Family/Whanau
- Independent
- Remotely Supervised
- Group Exercise Class

Programme duration (weeks): 12 | Review in (weeks): 4

Sessions per week: 3 | Session duration (mins): 45

Define the bandwidth for task difficulty and confidence

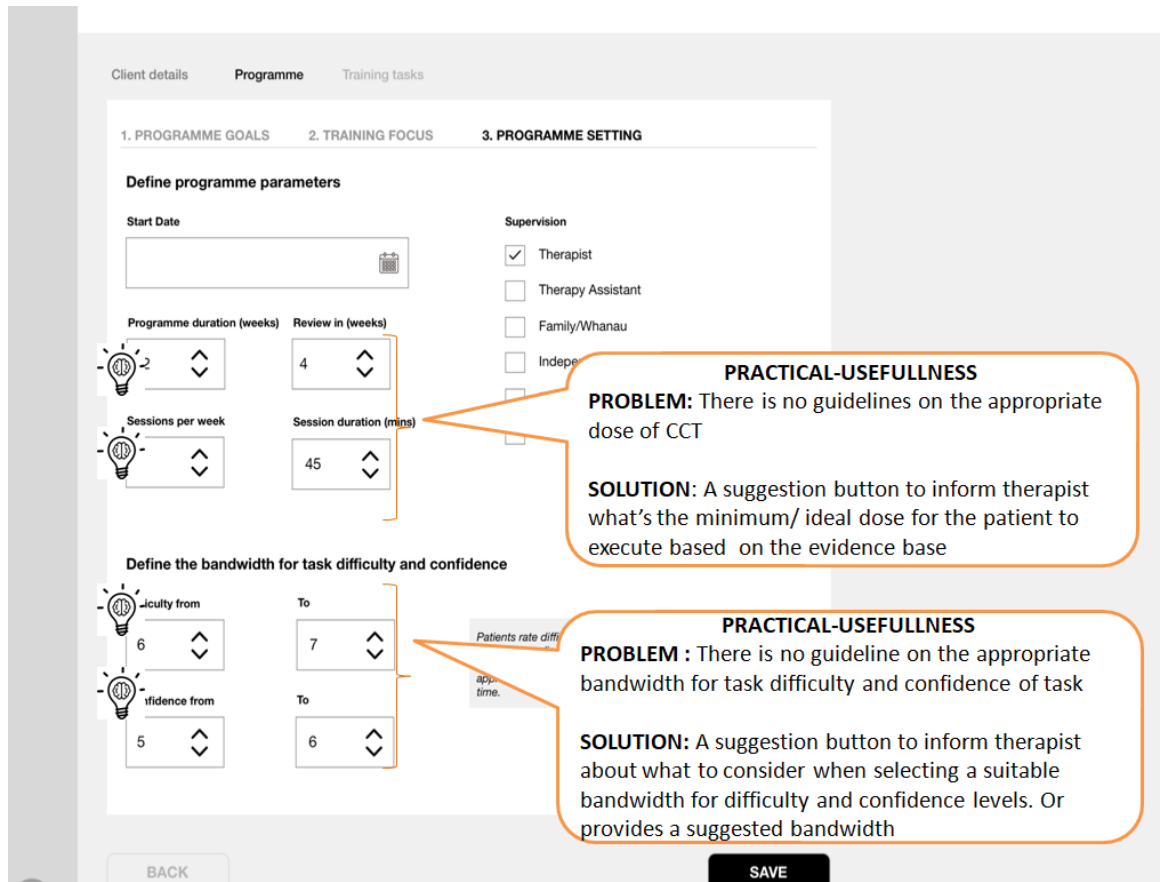
Difficulty from: 6 | To: 7

Confidence from: 5 | To: 6

Patients rate difficulty and confidence after every set of each task. Responding to the patients rating of difficulty and confidence ensures that the intensity of training is appropriate. You can review and edit the bandwidth at any time.

BACK SAVE

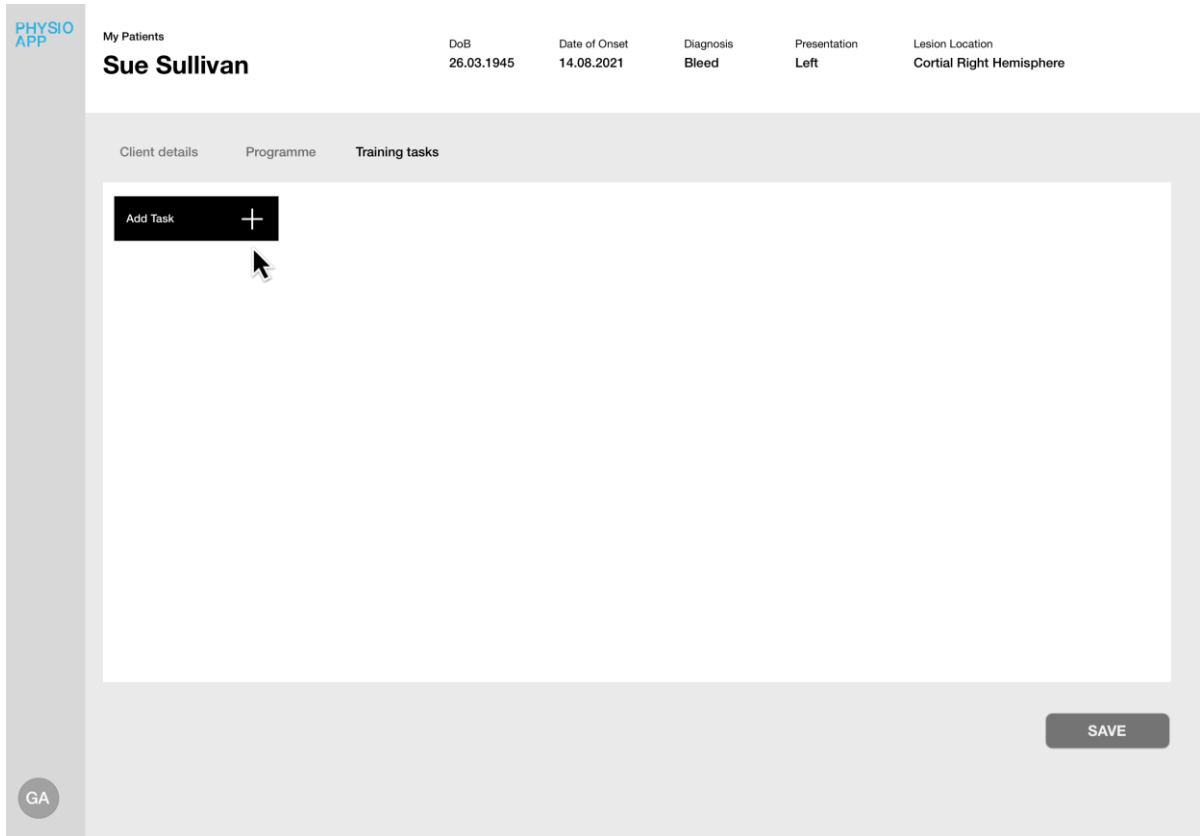
Wireframe 1.9



Screen 1.10



Screen 1.11



Screen 1.12



Screen 1.13

PHYSIO APP

My Patients


Sue Sullivan

DoB: 26.03.1945 | Date of Onset: 14.08.2021 | Diagnosis: Bleed | Presentation: Left | Lesion Location: Cortical Right Hemisphere

Client details

Task title Standing balance EDIT

Task description
Task description goes here. 200 characters max. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Donec efficitur at nulla et tincidunt. Donec non sapien risus. Nunc tincidunt lectus sit amet orci hendrerit molestie.

Task video

 Hide video in patient view

Reps/Set/Rest

Reps	Sets	Rest between sets (sec)
<input type="text" value="12"/>	<input type="text" value="5"/>	<input type="text" value="20"/>
Get ready (sec)	Active (sec)	
<input type="text" value="10"/>	<input type="text" value="60"/>	

Set up

Starting Position	Assistance
<input type="text" value="Not specified"/>	<input type="text" value="Independent"/>
Physical Support	Environment
<input type="text" value="No support"/>	<input type="text" value="Not specified"/>

Movement parameters

Movement Size	Movement Speed
<input type="text" value="Stationary"/>	<input type="text" value="Comfortable"/>
Movement direction	Movement accuracy
<input type="text" value="Forwards"/>	<input type="text" value="No target"/>

Feedback + Dual Tasks

Somatosensory Feedback	Visual / Vestibular Feedback
<input type="text" value="No manipulation"/>	<input type="text"/>
Motor Dual Task	Cognitive Dual Task
<input type="text"/>	<input type="text"/>

Remember to...

Add up to 3 comments for your patient

i.e. "focus on your hand movement"

SAVE TASK **DUPLICATE** **DELETE**

Wireframe 1.13

PHYSIO APP My Patients **Sue Sullivan** DoB 26.03.1945 Date of Onset 14.08.2021 Diagnosis Bleed Presentation Left Lesion Location Cortial Right Hemisphere

Client details

Task title **Standing balance** EDIT

Task description
Task description goes here. 200 characters max. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Donec efficitur at nulla et tristique. Donec non sapien risus. Nunc tristique lectus sit amet orci hendrerit molestie.

Task video
 Hide video in patient view

Reps/Set/Rest

Reps: 12 Sets: 5 Rest between sets (sec): 20

Get ready (sec): 10 Active (sec): 60

Set up

Starting Position: Not specified Assistance: Independent

Physical Support: No support Environment: Not specified

Movement parameters

Movement Size: Stationary Movement Speed: Comfortable

Movement direction: Forwards Movement accuracy: No target

Feedback + Dual Tasks

Somatosensory Feedback: No manipulation Visual / Vestibular Feedback: []

Motor Dual Task: [] Cognitive Dual Task: []

Remember to...

Add up to 3 comments for your patient

I.e. "focus on your hand movement"

SAVE TASK **DUPLICATE** **DELETE**

CONTENT

PROBLEM: For task progressions there is no video on for these variations this would likely help patients to visualise the changes made to the task

SOLUTION:

Add (+) Upload videos that can show variations of the task and video feedback from therapist

CONTENT (Addition)

The option of recording patient whilst performing a task would be desirable. Future addition could be a function to upload video of patient. The app starts recording patient when they are performing the task so that therapist can feedback

Screen 1.14

PHYSIO APP My Patients **Sue Sullivan** DoB 26.03.1945 Date of Onset 14.08.2021 Diagnosis Bleed Presentation Left Lesion Location Cortial Right Hemisphere

Client details Programme **Training tasks**

Add Task +

Standing balance ...

Reps/Sets/Rest

Reps: 12 Sets: 5

Rest between sets: 20 sec

Active time: 60 secs

Get ready time: 10 secs

Set up +

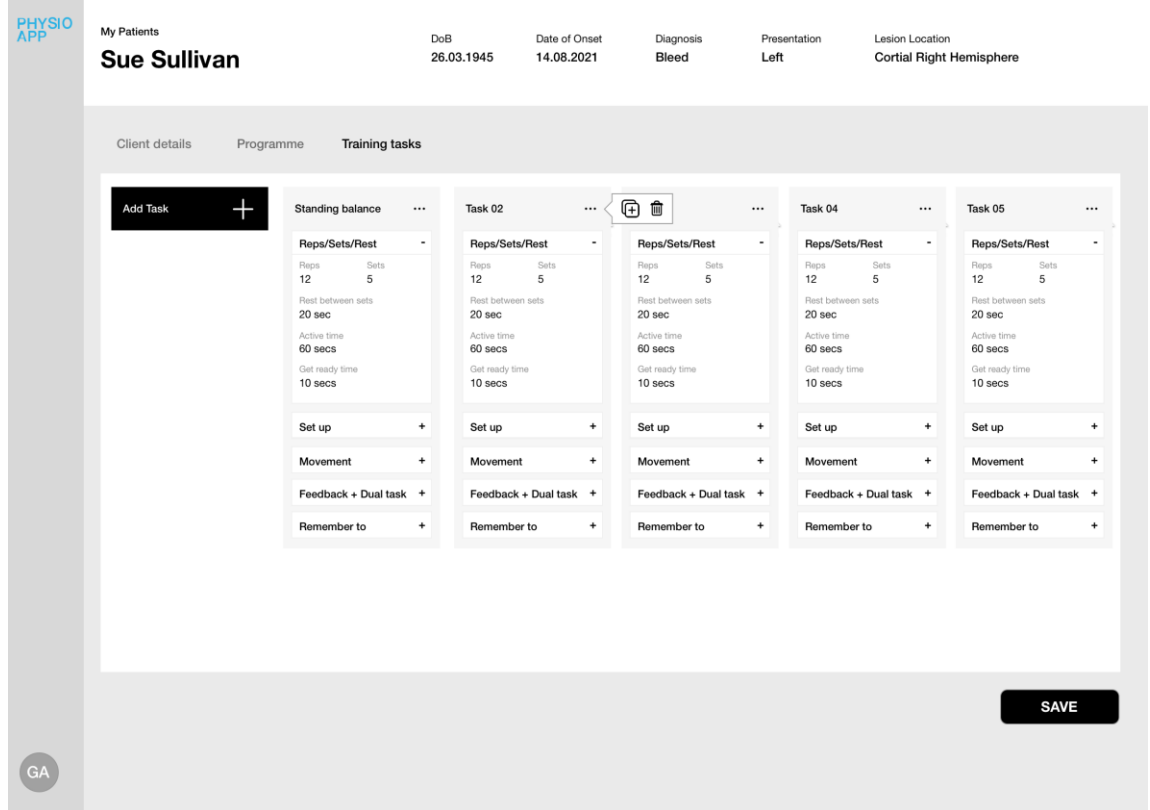
Movement +

Feedback + Dual task +

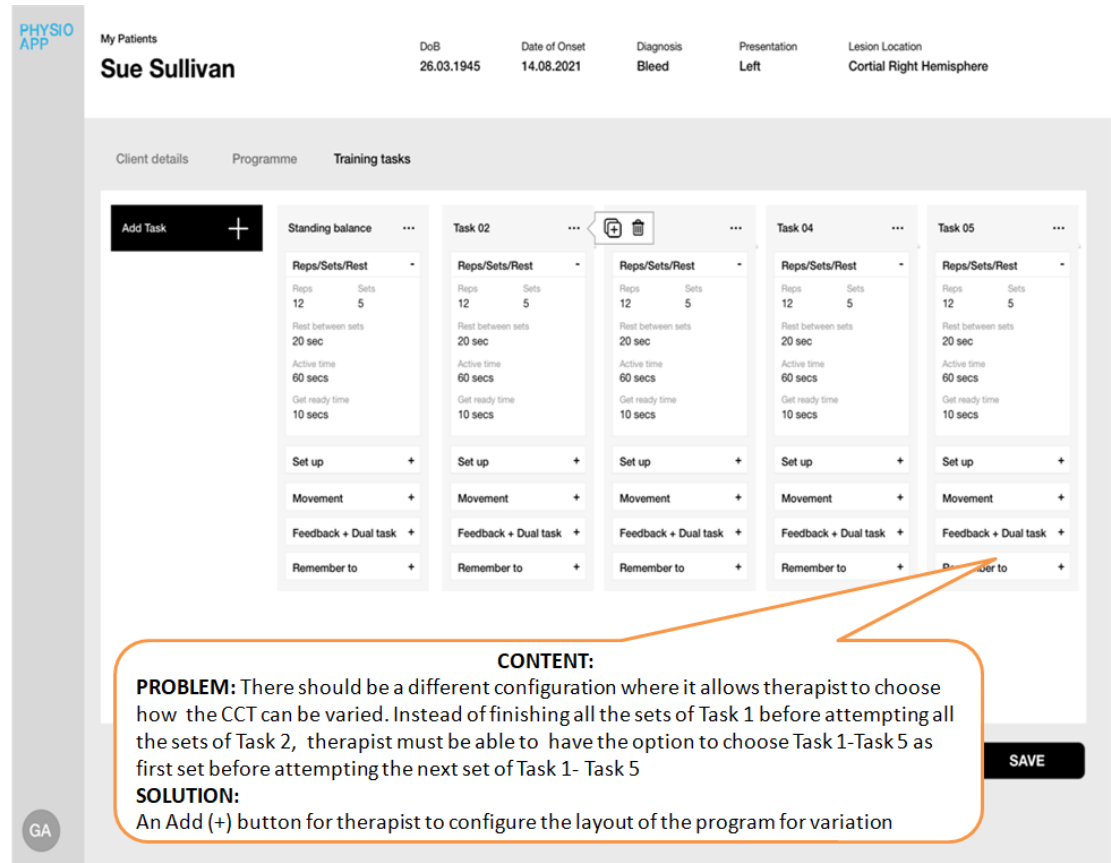
Remember to +

SAVE

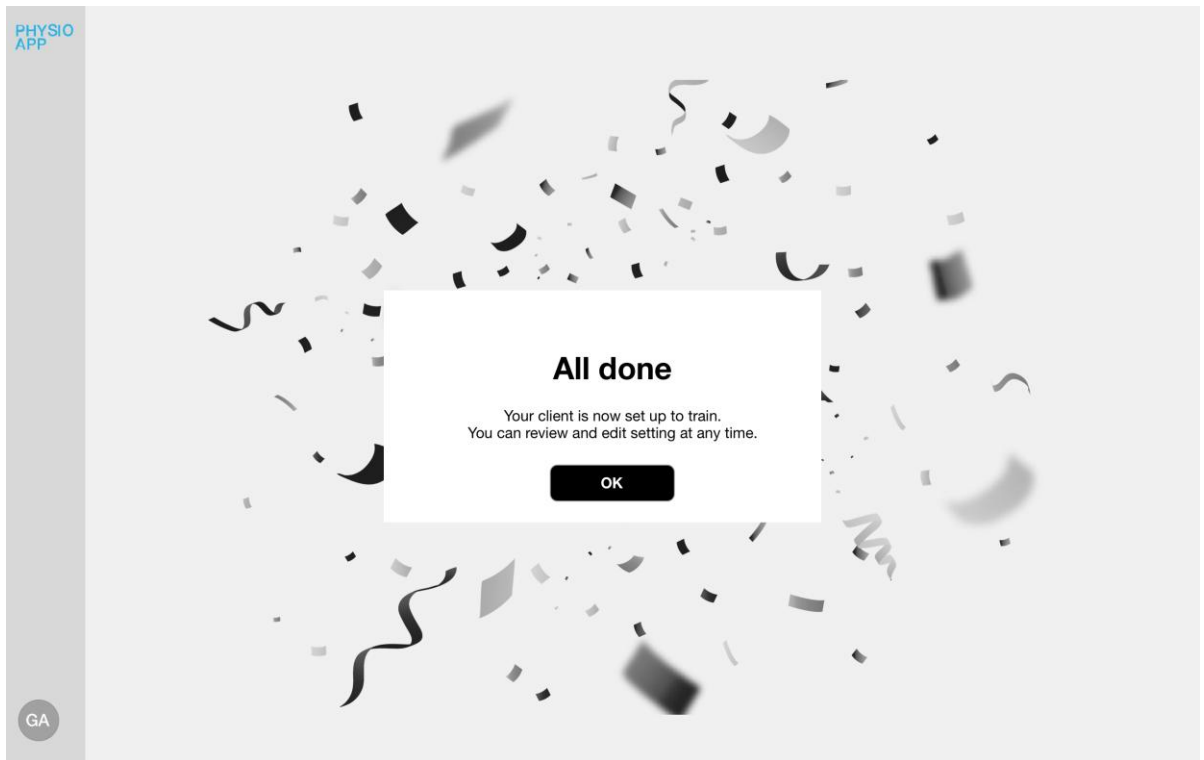
Screen 1.15



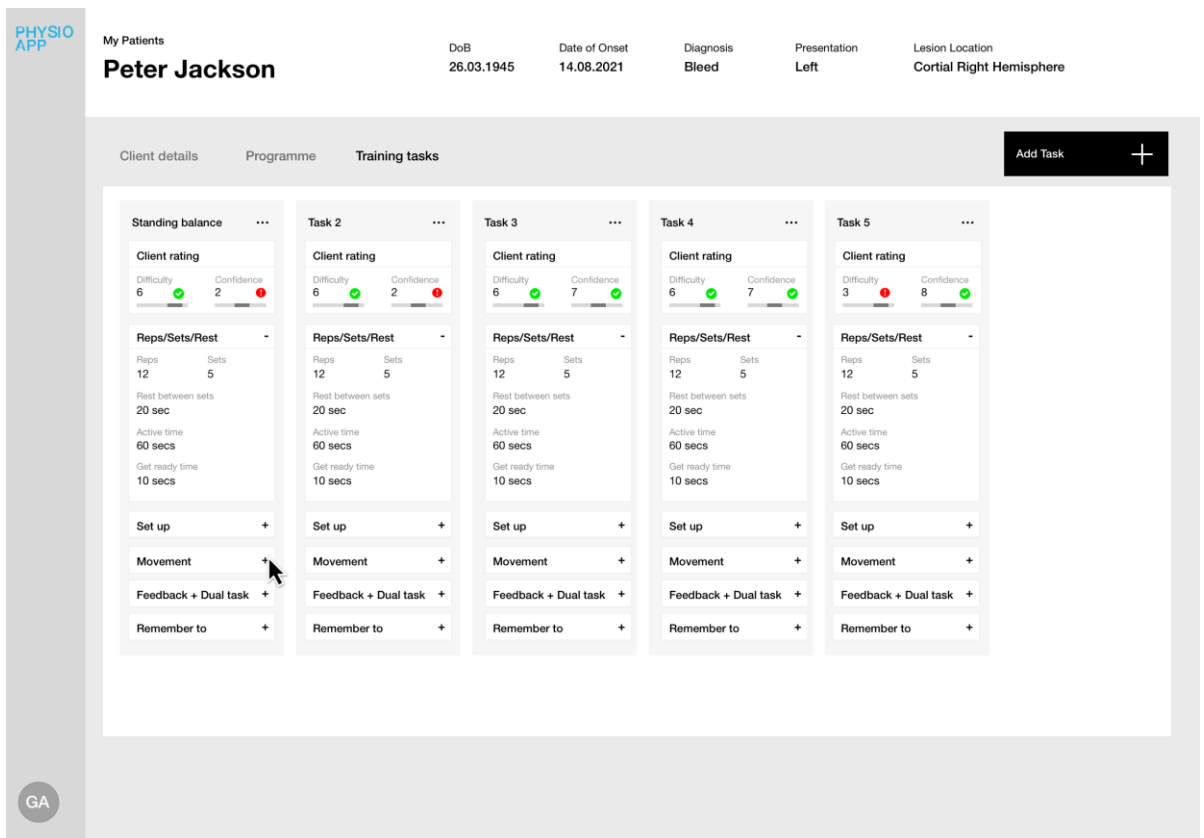
Wireframe 1.15



Screen 1.16



Screen 1.17

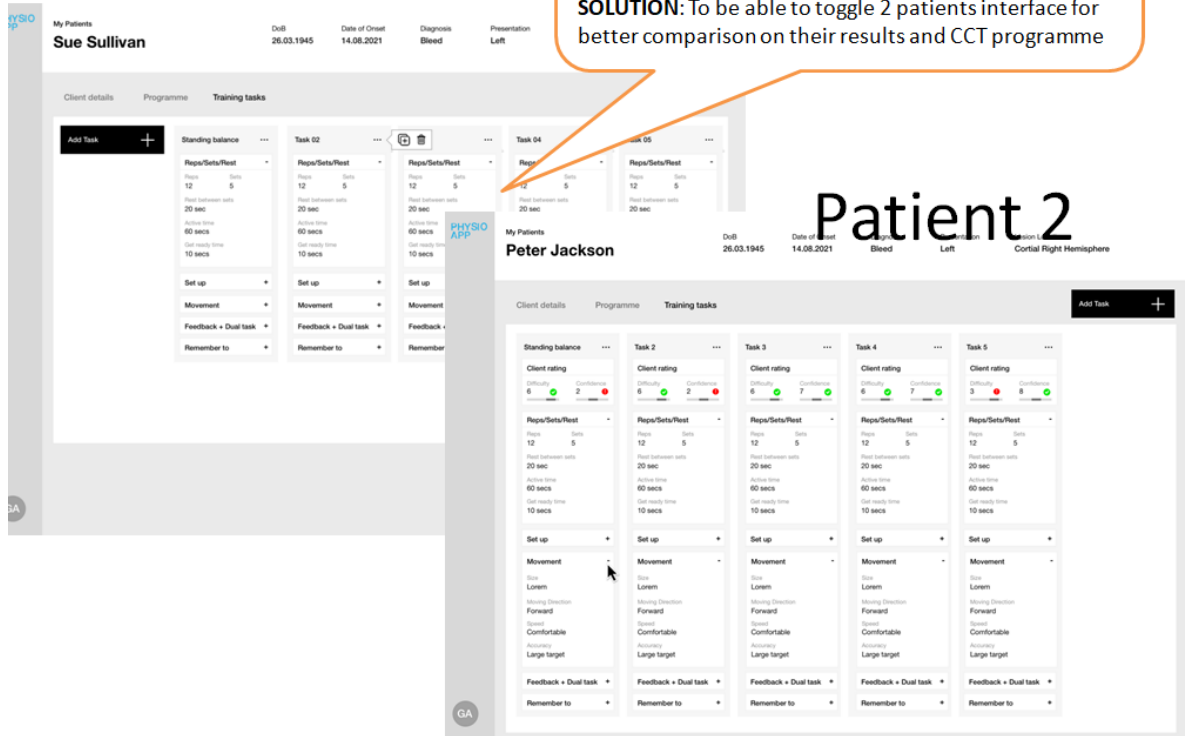


Patient 1

PRACTICAL USEFULNESS (ADDITION)

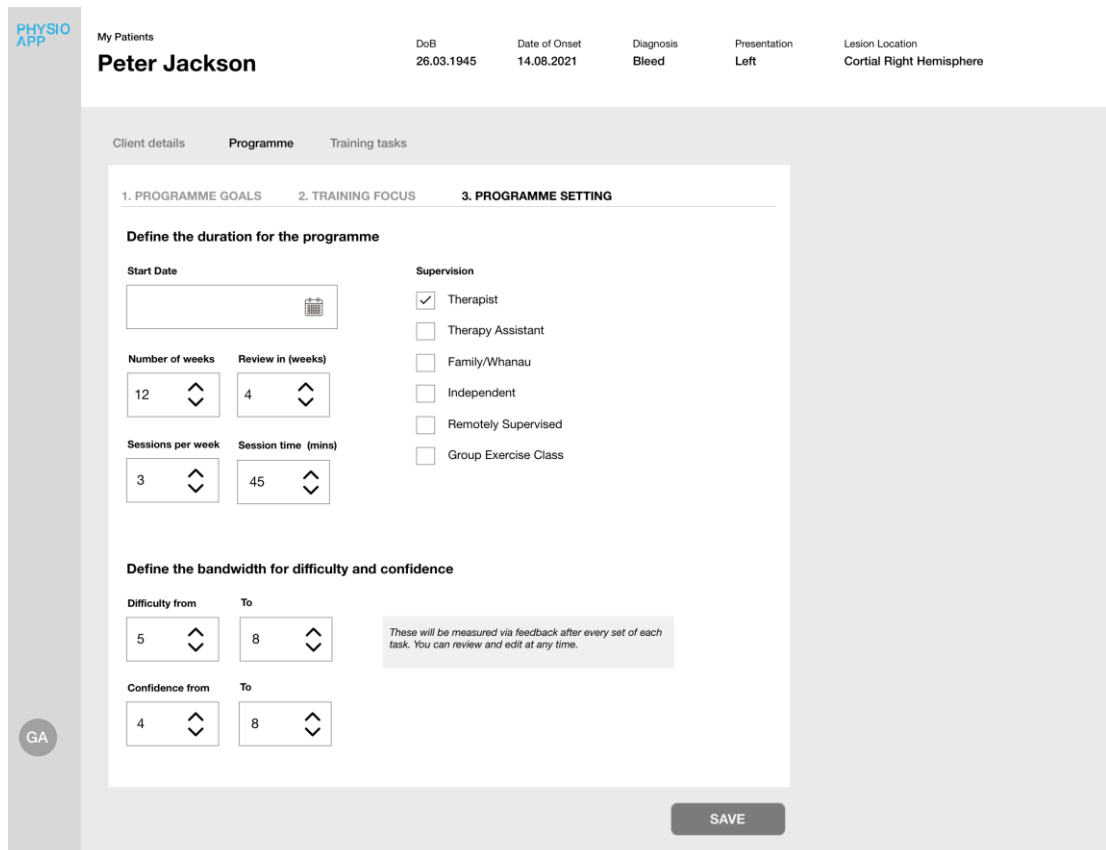
PROBLEM: Not able to compare the CCT programme parameters and overall performance of patients in the same group

SOLUTION: To be able to toggle 2 patients interface for better comparison on their results and CCT programme



Patient 2

Screen 1.18



Screen 1.19

PHYSIO APP My Patients **Peter Jackson** DoB 26.03.1945 Date of Onset 14.08.2021 Diagnosis Bleed Presentation Left Lesion Location Cortial Right Hemisphere

Client details Programme Training tasks

1. CLIENT DETAILS 2. CIINICAL SUMMARY 3. MEDICAL HISTORY

First name: Peter Last name: Jackson

Address: Lorem ipsum Email: Lorem ipsum

Phone number: 1234567890 Ethnicity: Lorem ipsum

Date of birth: 12 07 1945 ID number (optional): 1234567890

Next of Kin: Lorem ipsum Contact number: 1234567890

GA SAVE

Screen 1.20

PHYSIO APP My Patients **Peter Jackson** DoB 26.03.1945 Date of Onset 14.08.2021 Diagnosis Bleed Presentation Left Lesion Location Cortial Right Hemisphere

Client details Programme Training tasks Add Task +

Standing balance ... Task 2 ... Task 3 ... Task 4 ... Task 5 ...

Client rating: Difficulty 6 Confidence 2 (Task 2), Difficulty 6 Confidence 7 (Task 3), Difficulty 3 Confidence 8 (Task 5)

Reps/Sets/Rest: 12 Reps, 5 Sets, 20 sec Rest between sets, 60 secs Active time, 10 secs Get ready time

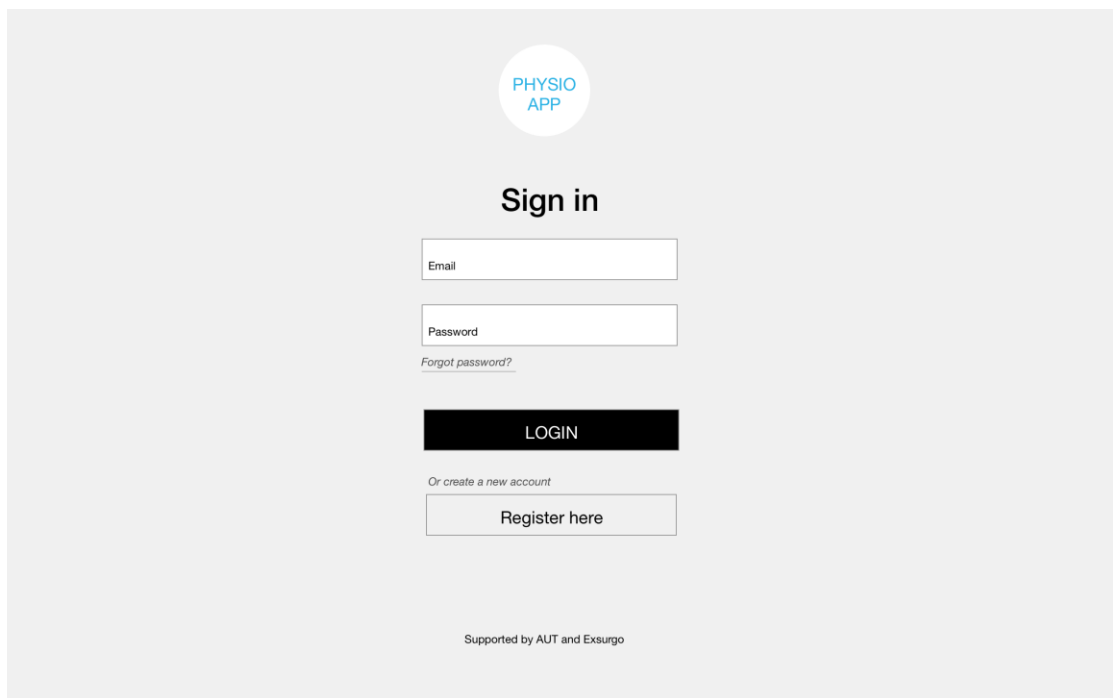
Set up + Movement - Size: Lorem, Moving Direction: Forward, Speed: Comfortable, Accuracy: Large target

Feedback + Dual task + Remember to +

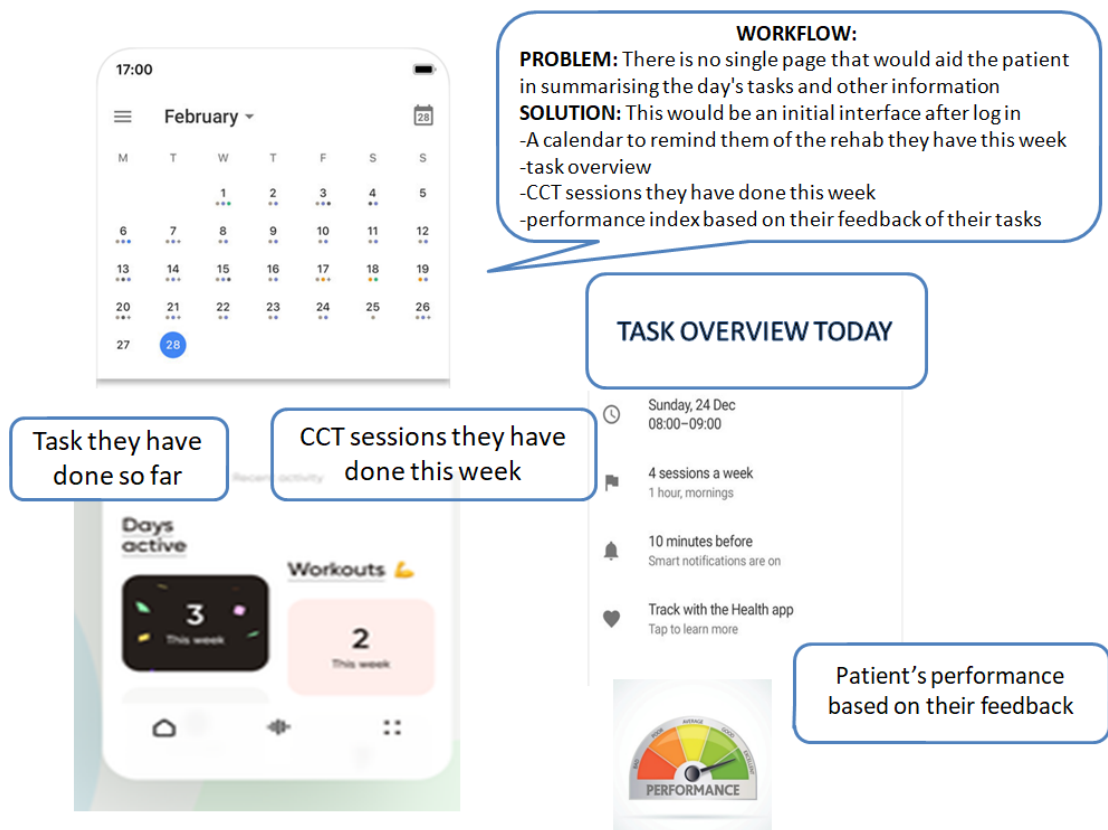
GA

SECTION 2: Stage 1 Patient wireframes updated based on usability testing

Screen 2.1



Wireframe 2.1





Screen 2.2

PHYSIO APP


Hello Sue

Training tasks

- 1 Standing tree
- 2 Step it up 
- 3 Standing flamingo
- 4 Walk the talk
- 5 Walk the talk ++ 

You will need

- Foam
- A wall
- A heavy object
- One other person

START 

My goals

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Donec ut ultrices sem, non pellentesque lorem.

Morbi turpis leo, faucibus interdum urna nec, pulvinar placerat turpis. Sed vitae turpis non.

Donec ut ultrices sem, non pellentesque lorem.

My gains

1 Session this week
1 of 3 sessions trained

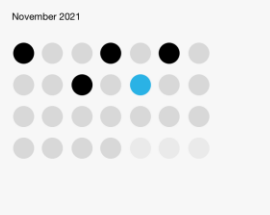
4 Progress
4 of 6 weeks trained

1 Challenge
1 of 6 tasks is difficult

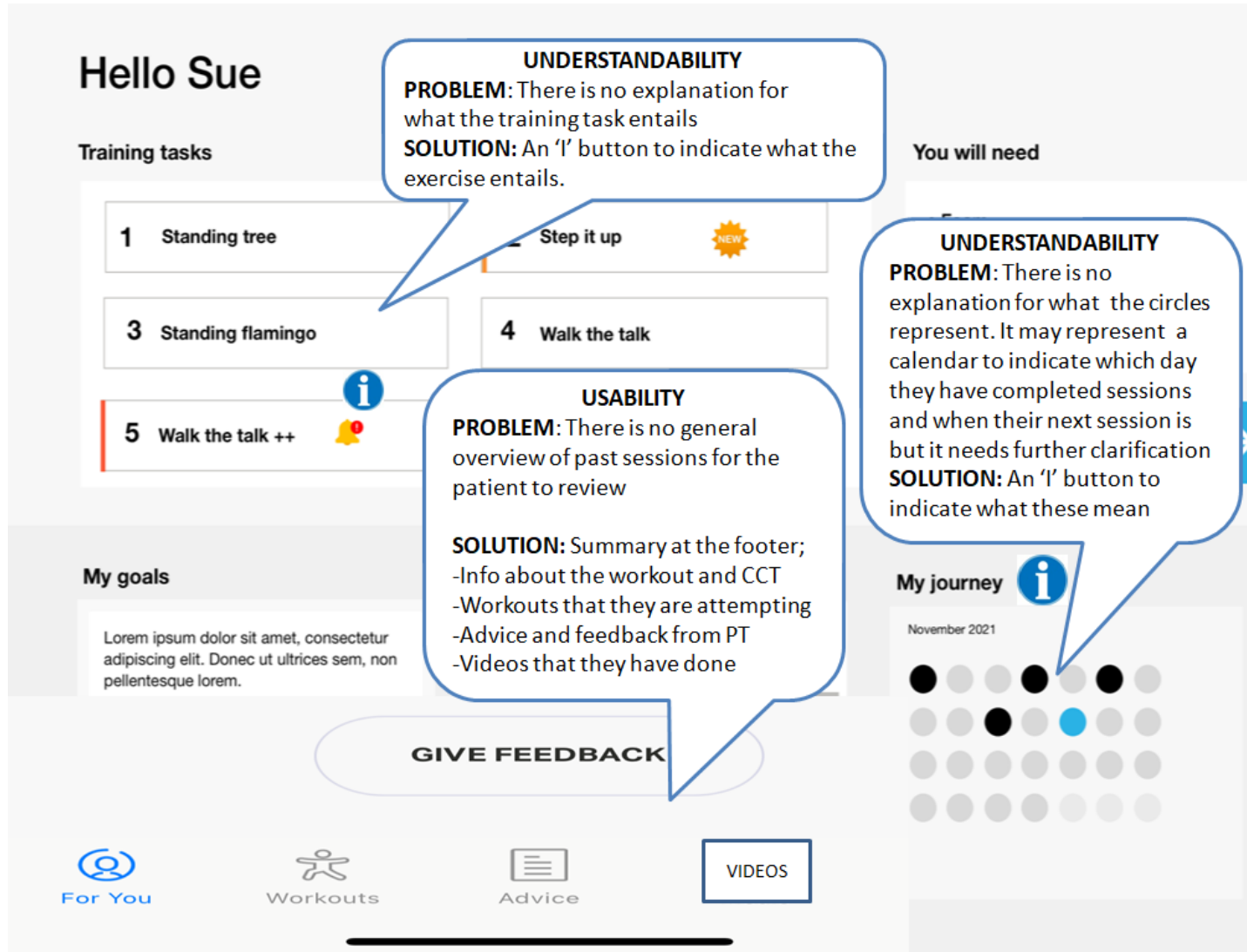
5 Confidence
5 of 6 tasks are easier

My journey

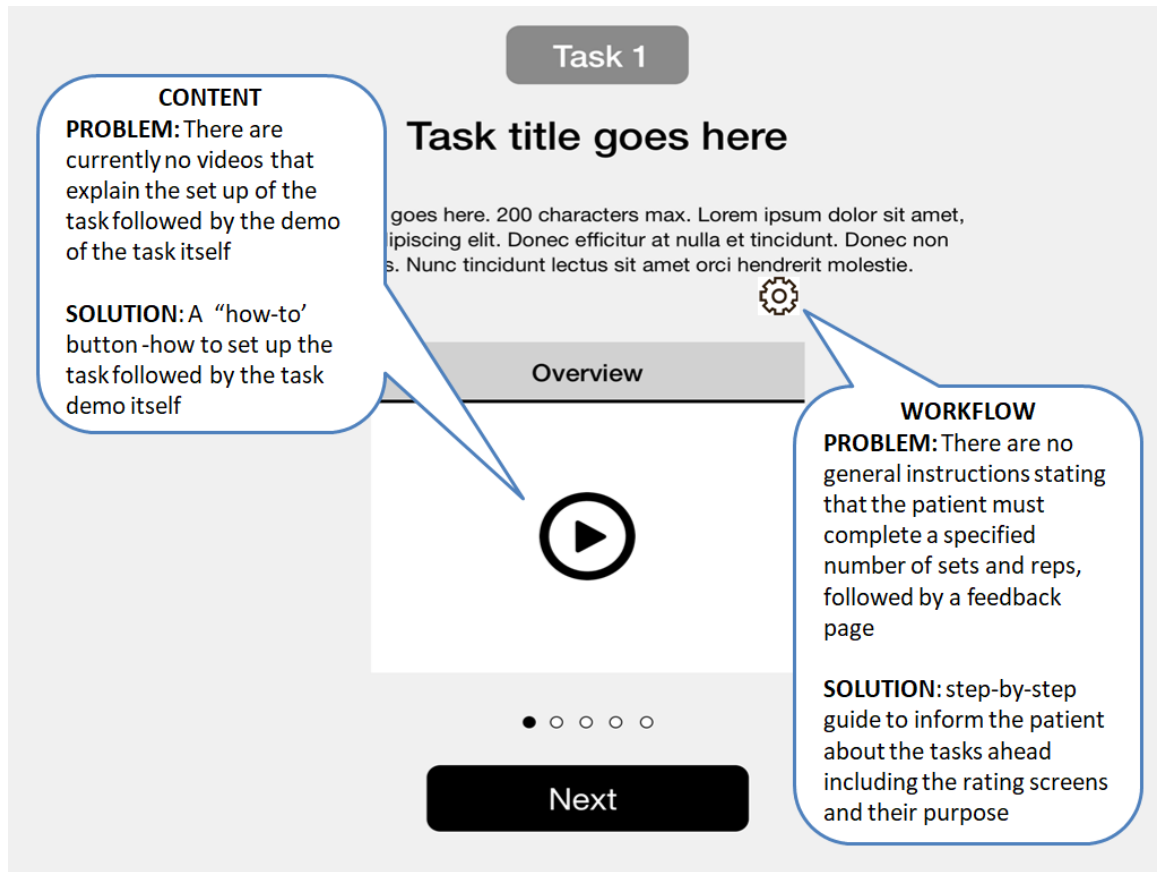
November 2021



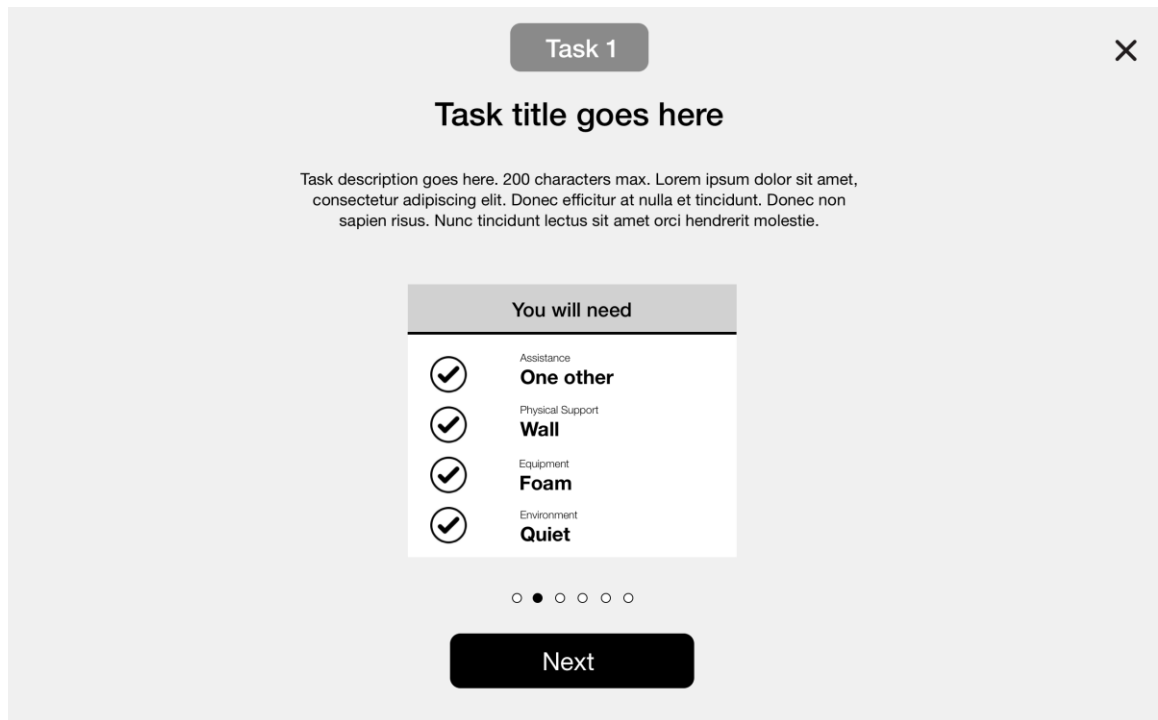
JS



Wireframe 2.4



Screen 2.5



Screen 2.6

Task 1

Task title goes here

Get on the floor on all fours, positioning your hands slightly wider than your shoulders. Don't lock out the elbows; keep them slightly bent. Extend your legs back so you are balanced on your hands and toes, your feet hip-width apart.

How to do it

- ✓ Start standing
- ✓ Reach forward
- ✓ With high speed
- ✓ Hit a small target

○ ○ ● ○ ○

Next

Screen 2.7

Task 1

Task title goes here

Get on the floor on all fours, positioning your hands slightly wider than your shoulders. Don't lock out the elbows; keep them slightly bent. Extend your legs back so you are balanced on your hands and toes, your feet hip-width apart.

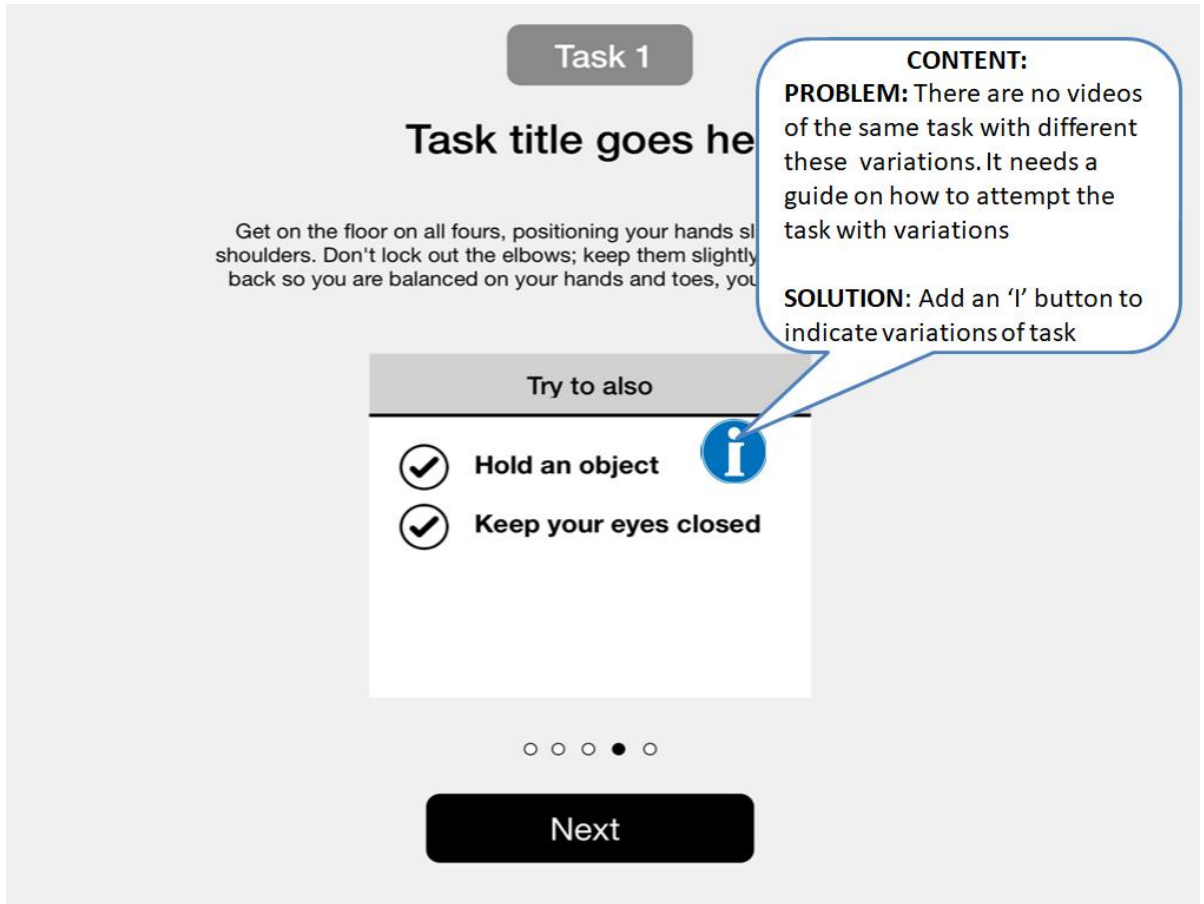
Try to also

- ✓ Hold an object
- ✓ Keep your eyes closed

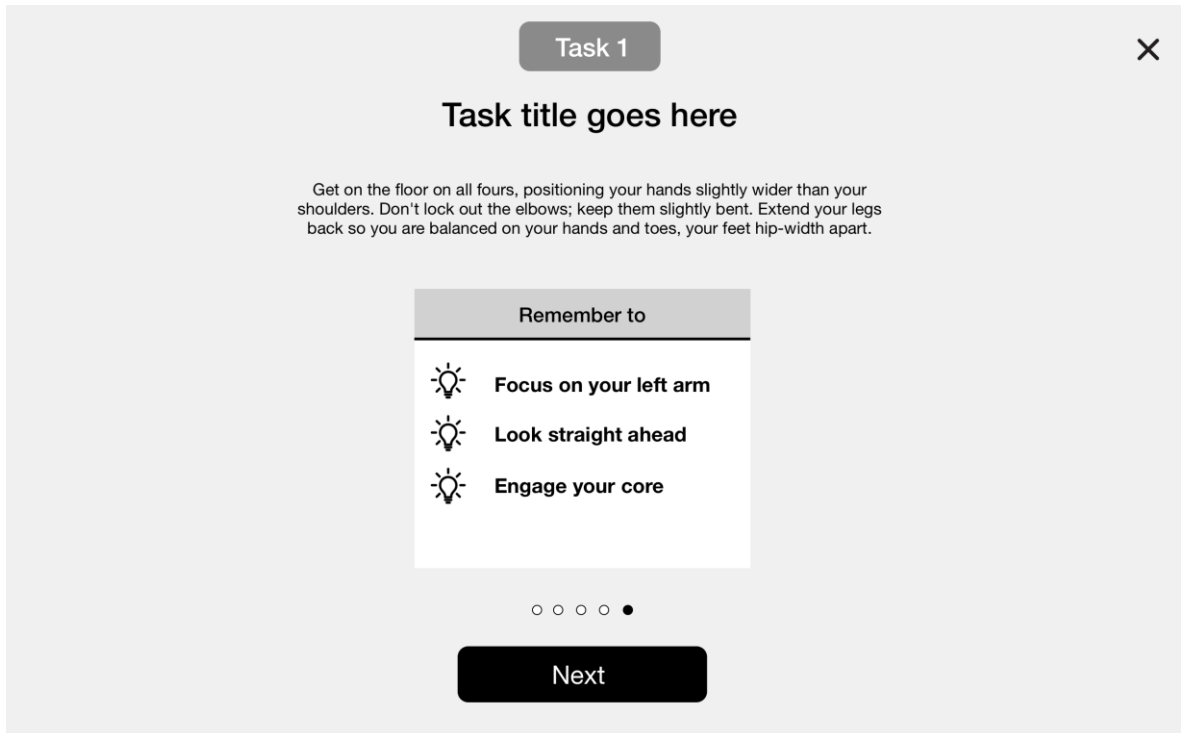
○ ○ ○ ● ○

Next

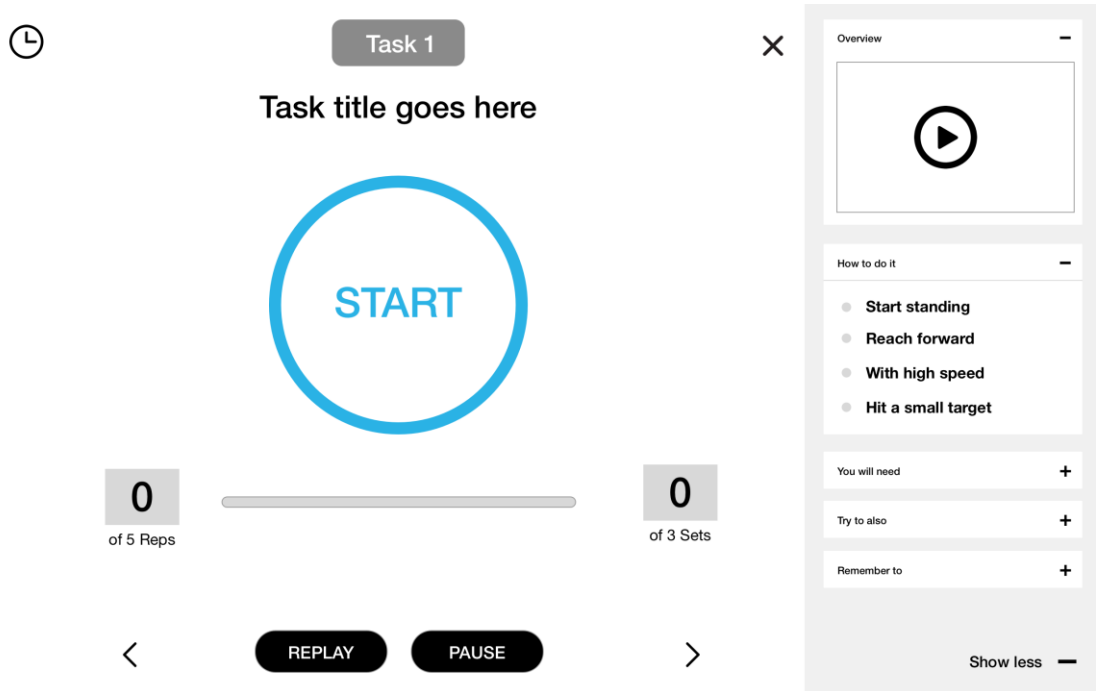
Wireframes 2.7



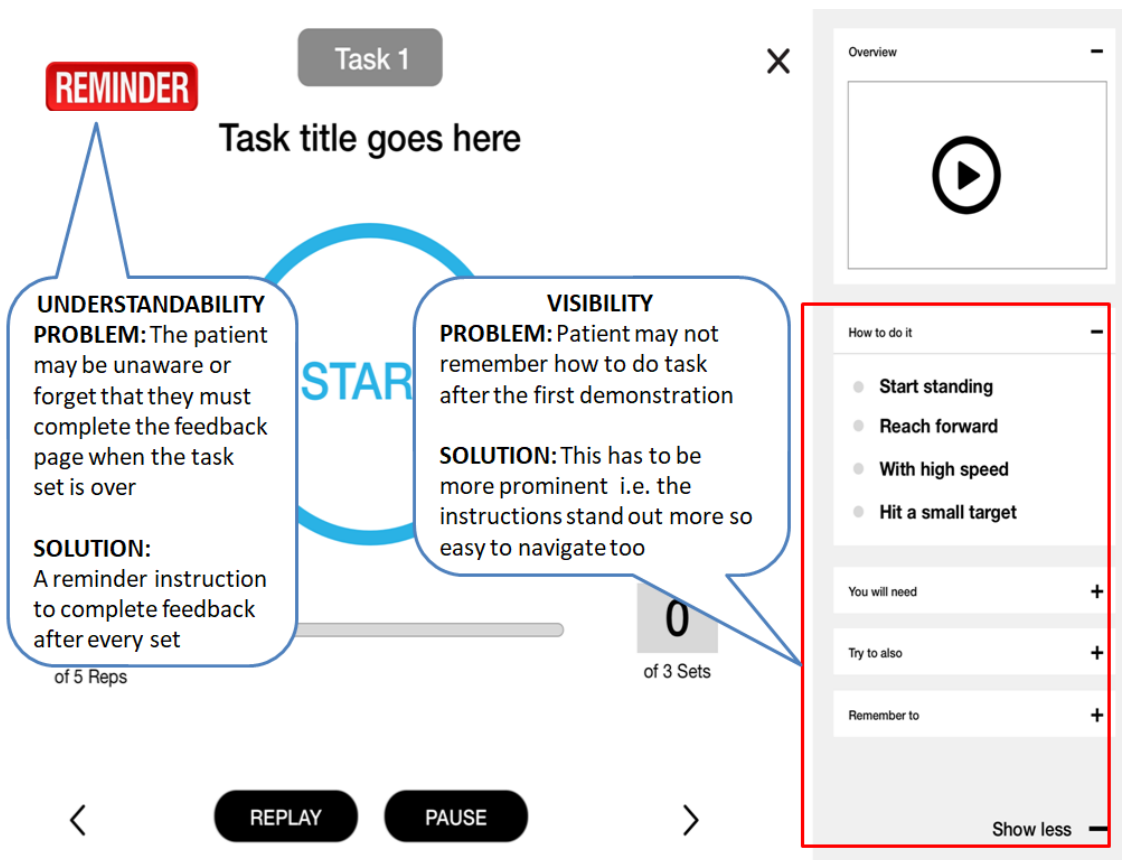
Screen 2.8



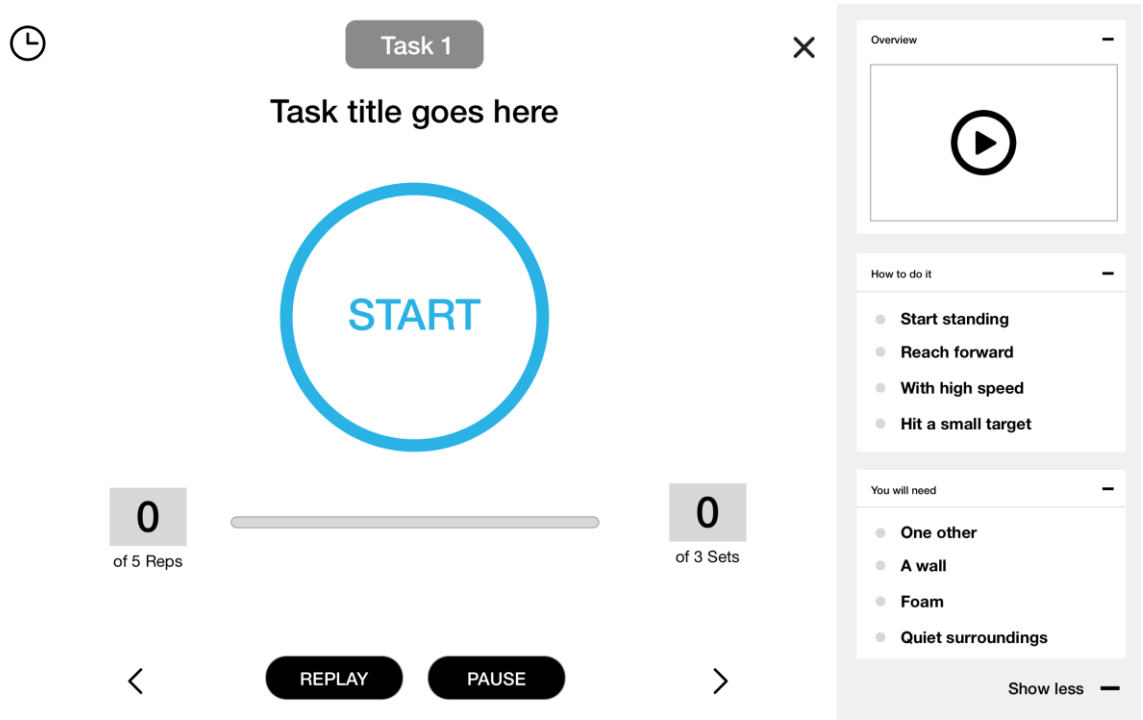
Screen 2.9



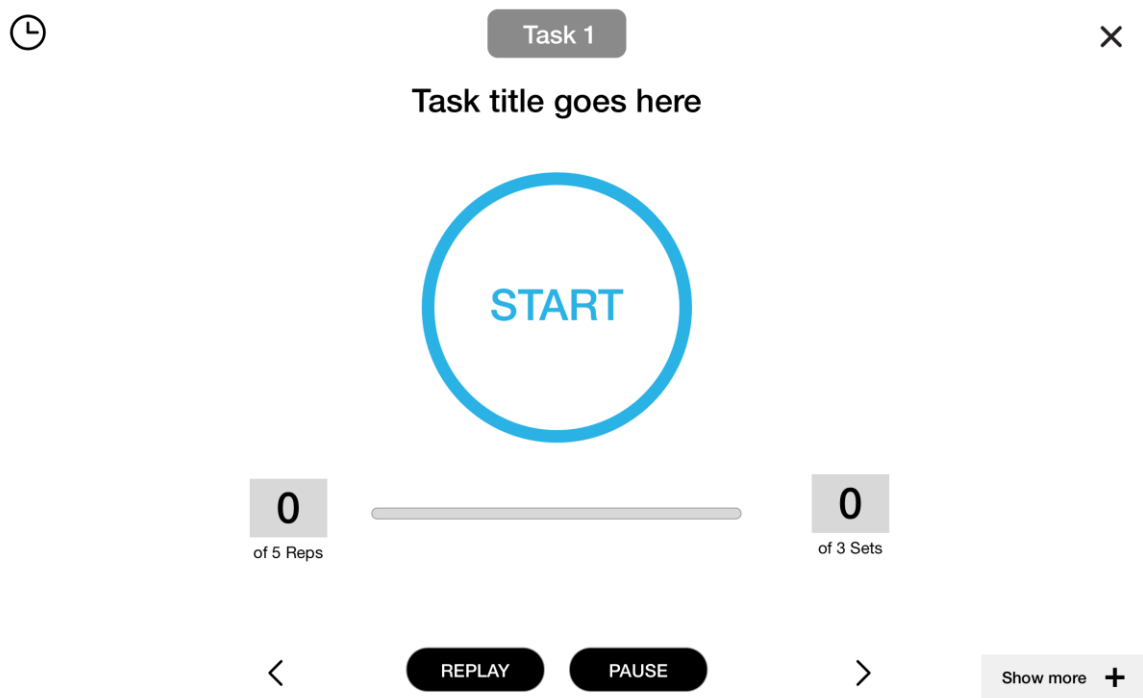
Wireframe 2.9



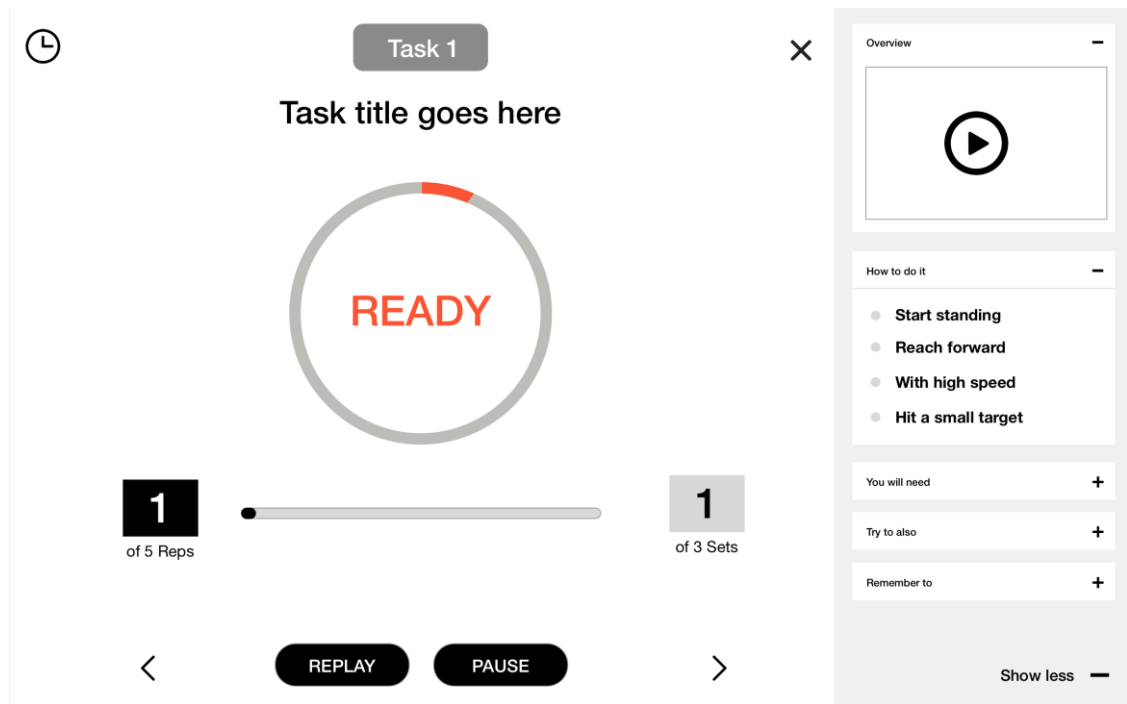
Screen 2.10



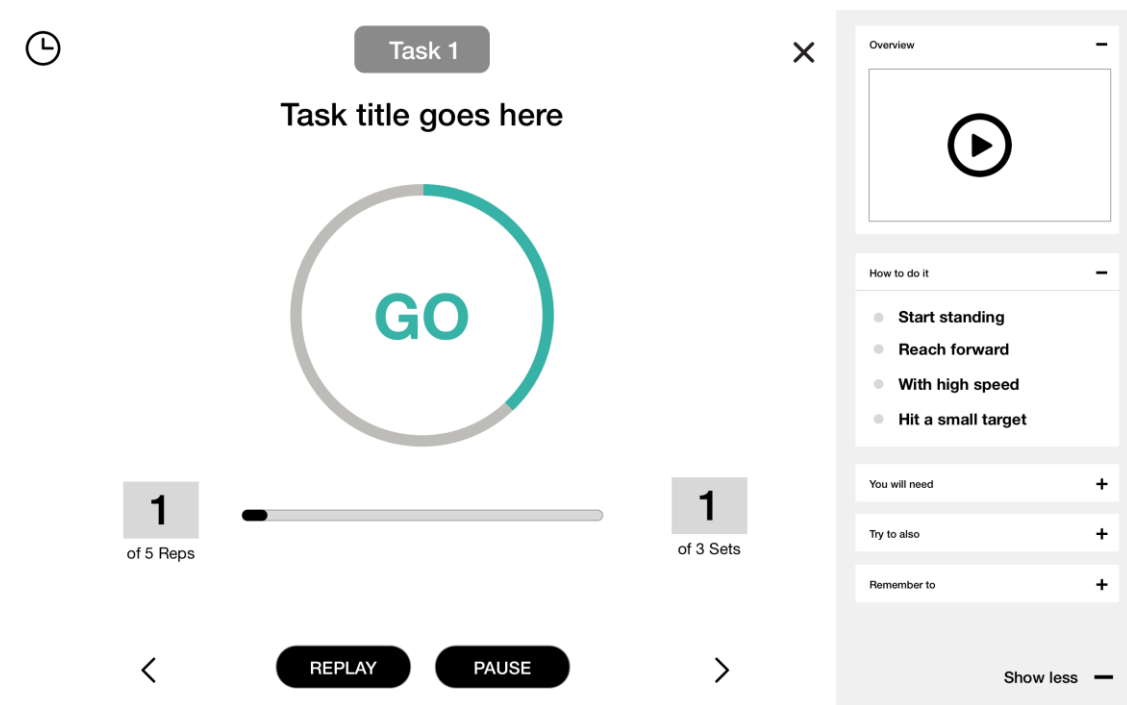
Screen 2.11



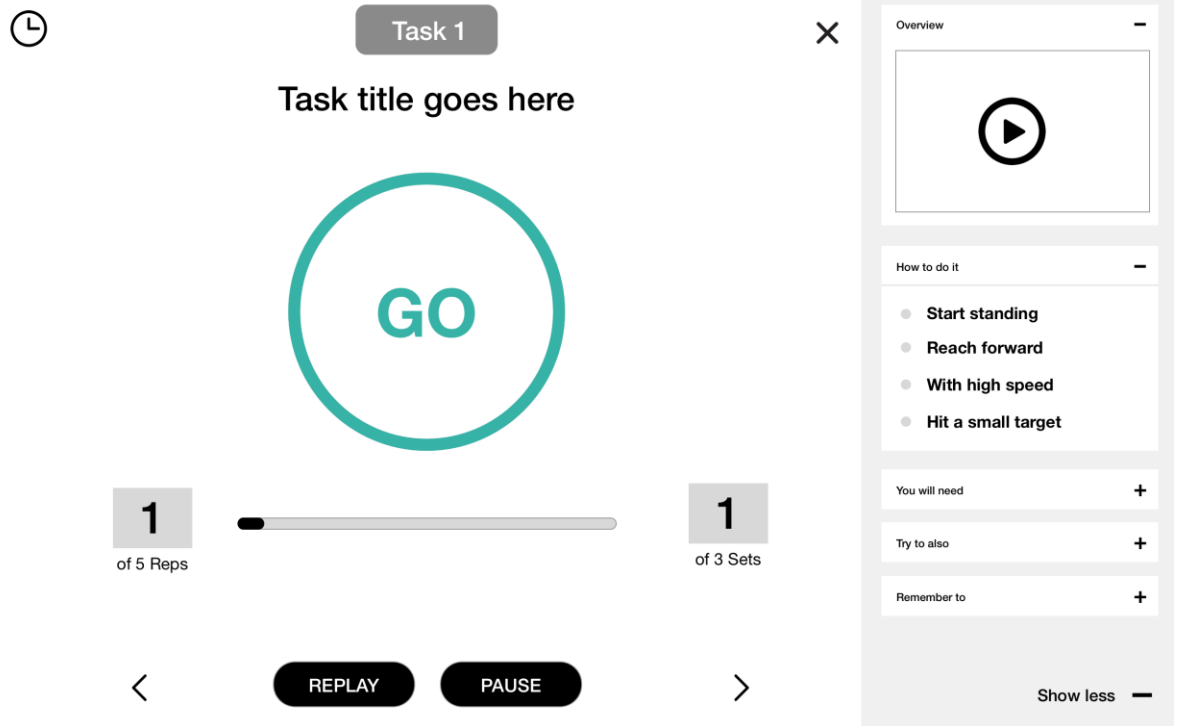
Screen 2.12



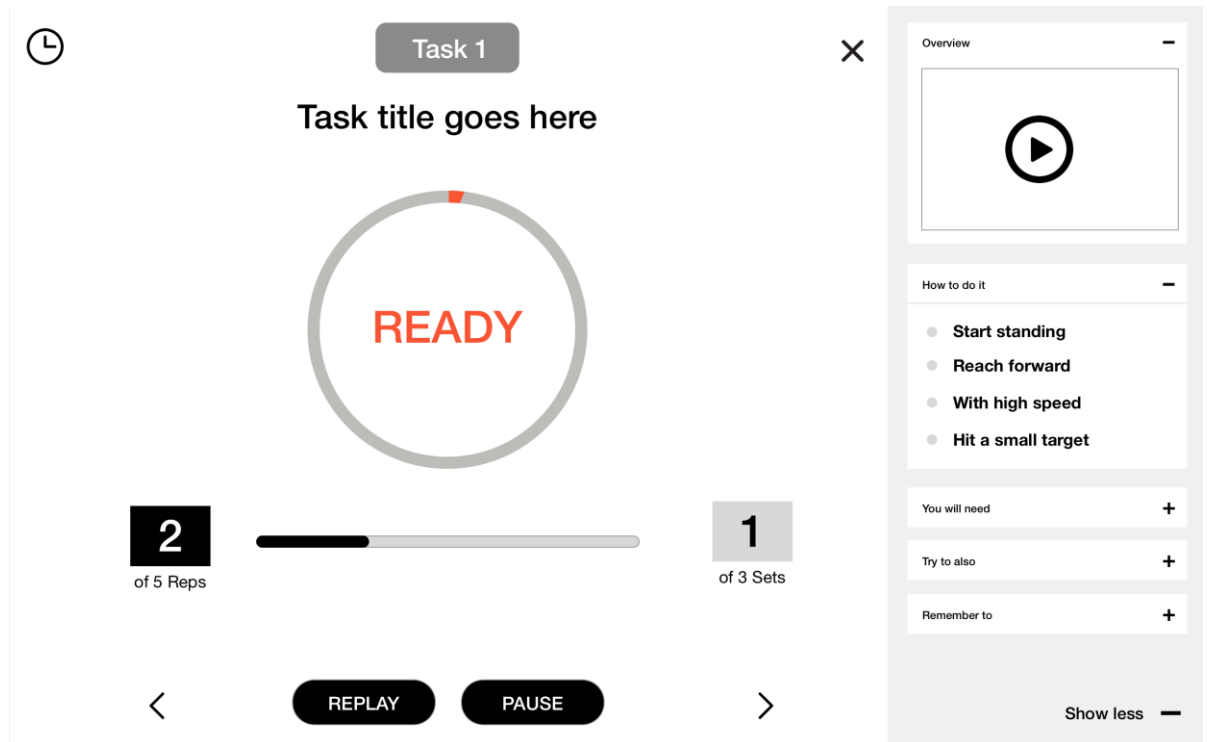
Screen 2.13



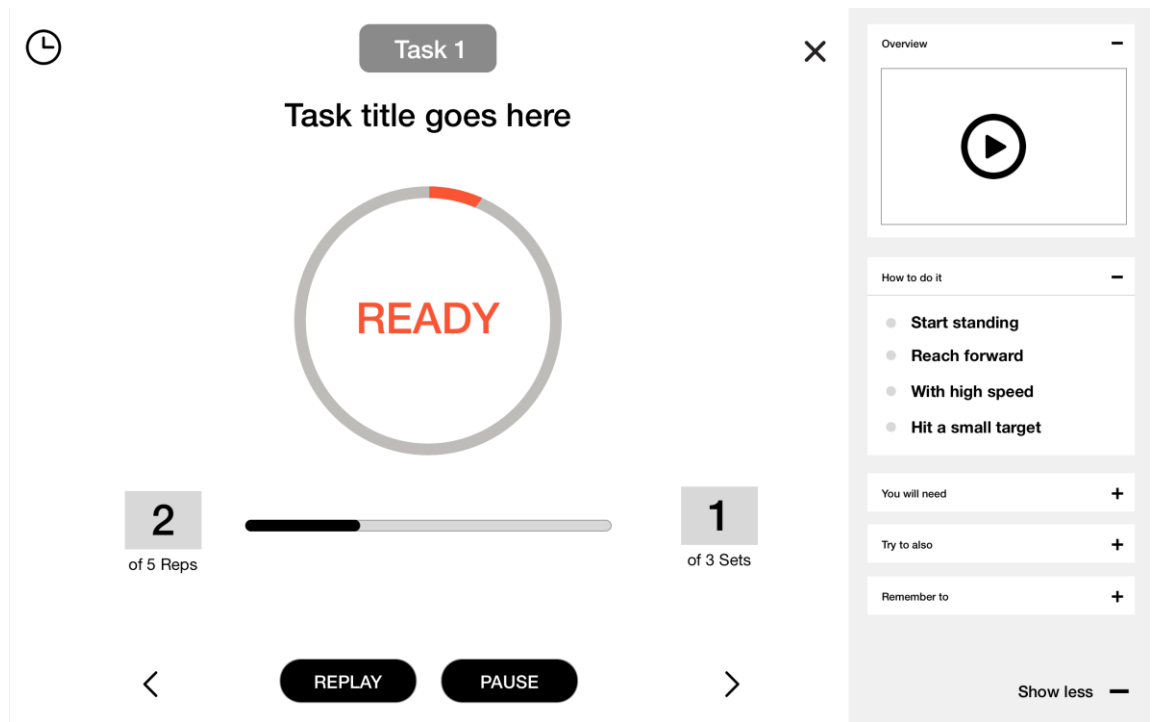
Screen 2.14



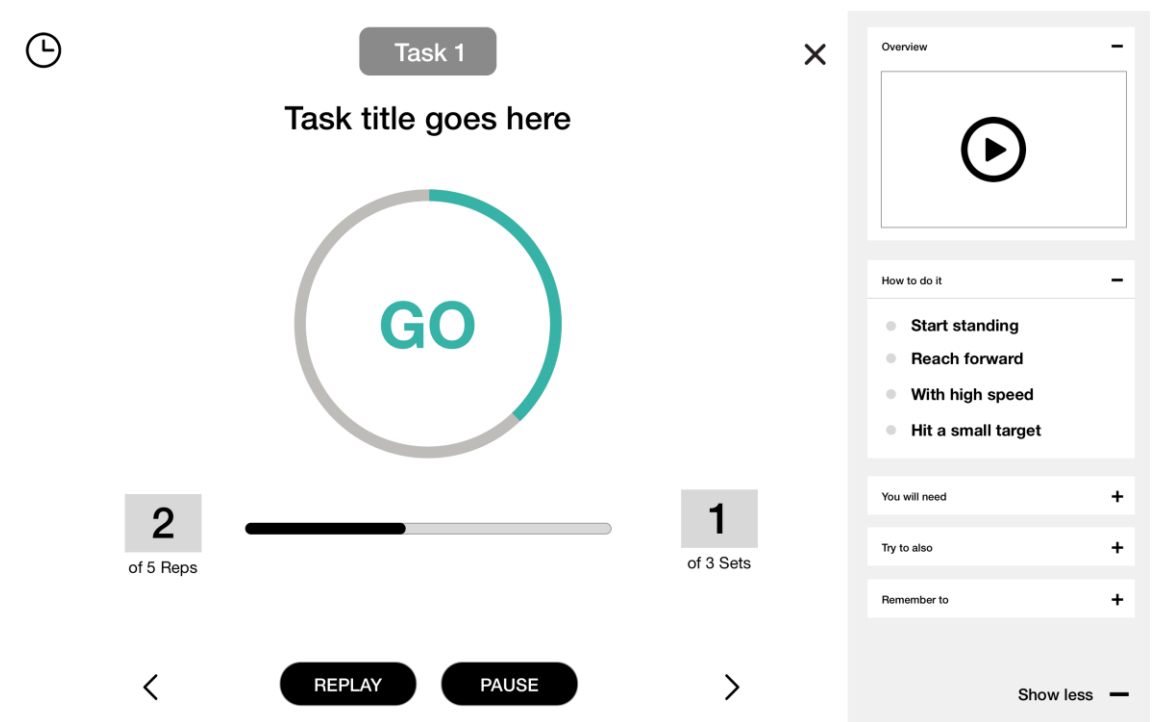
Screen 2.15



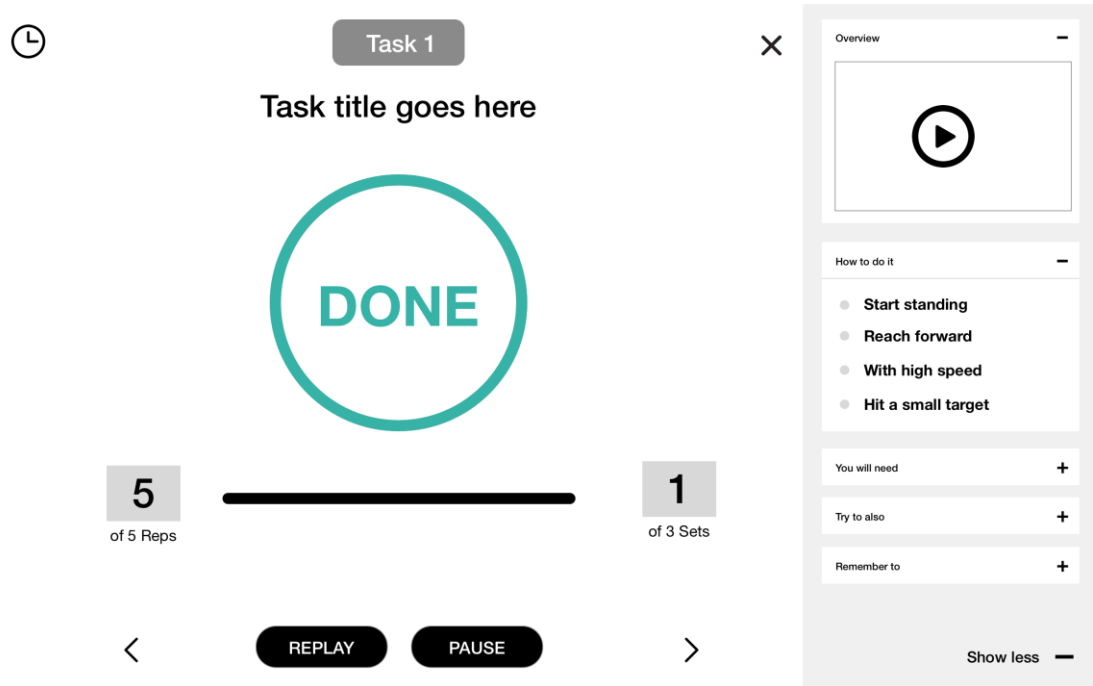
Screen 2.16



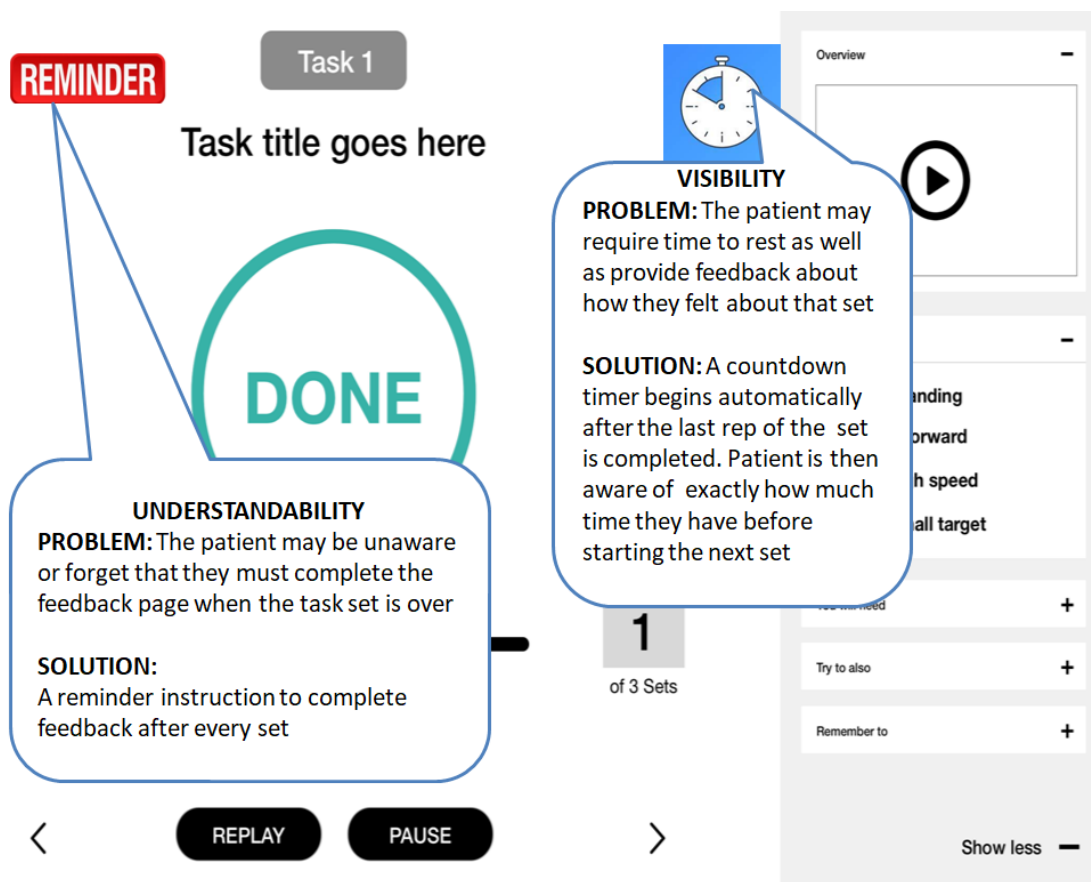
Screen 2.17



Screen 2.18



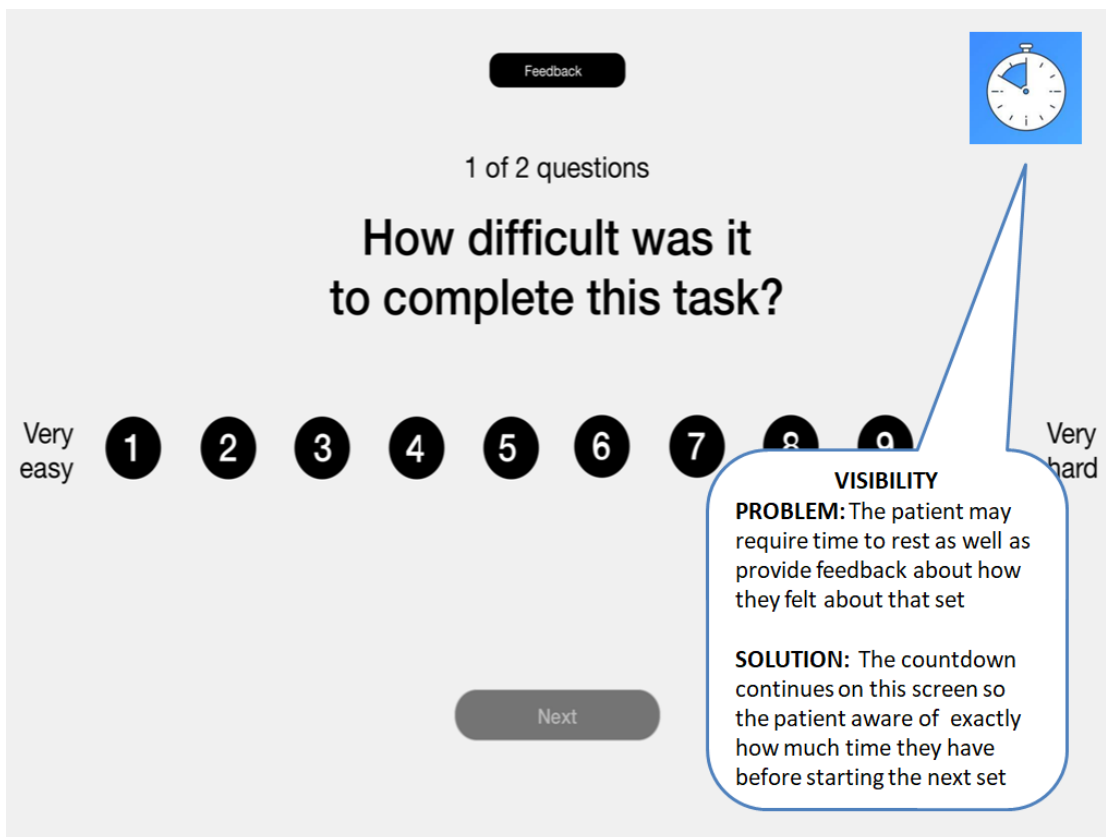
Wireframe 2.18



Screen 2.19



Wireframe 2.19



Screen 2.20

Feedback

1 of 2 questions

How difficult was it to complete this task?

Very easy 1 2 3 4 5 6 7 8 9 10 Very hard

Next

The screenshot shows a survey question on a light gray background. At the top, there is a dark gray rounded rectangle with the word "Feedback" in white. Below it, the text "1 of 2 questions" is centered. The main question is "How difficult was it to complete this task?" in a large, bold, black font. Below the question is a horizontal scale of ten circular buttons, numbered 1 to 10. The buttons are dark gray with white numbers. The button for "5" is highlighted with a blue background and white text. To the left of the scale is the text "Very easy" and to the right is "Very hard". At the bottom center, there is a dark gray rounded rectangle with the word "Next" in white.

Screen 2.21

Feedback

2 of 2 questions

How confident were you in completing this task?

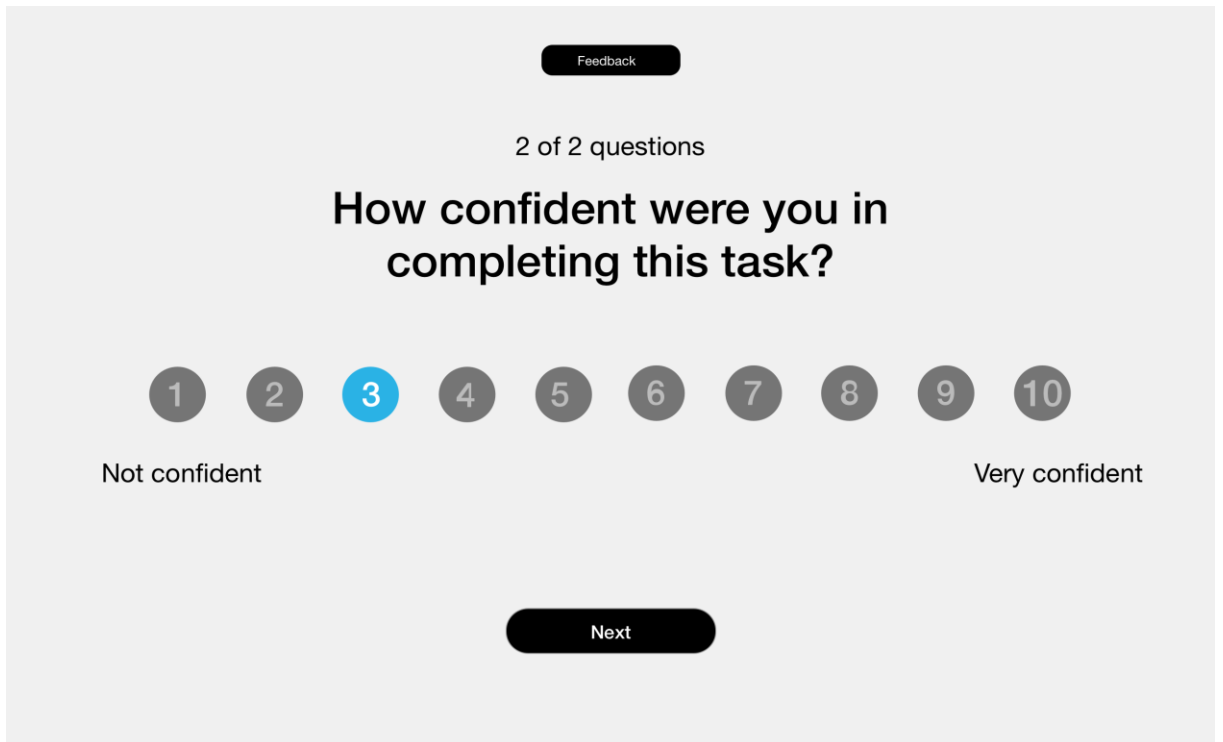
1 2 3 4 5 6 7 8 9 10

Not confident Very confident

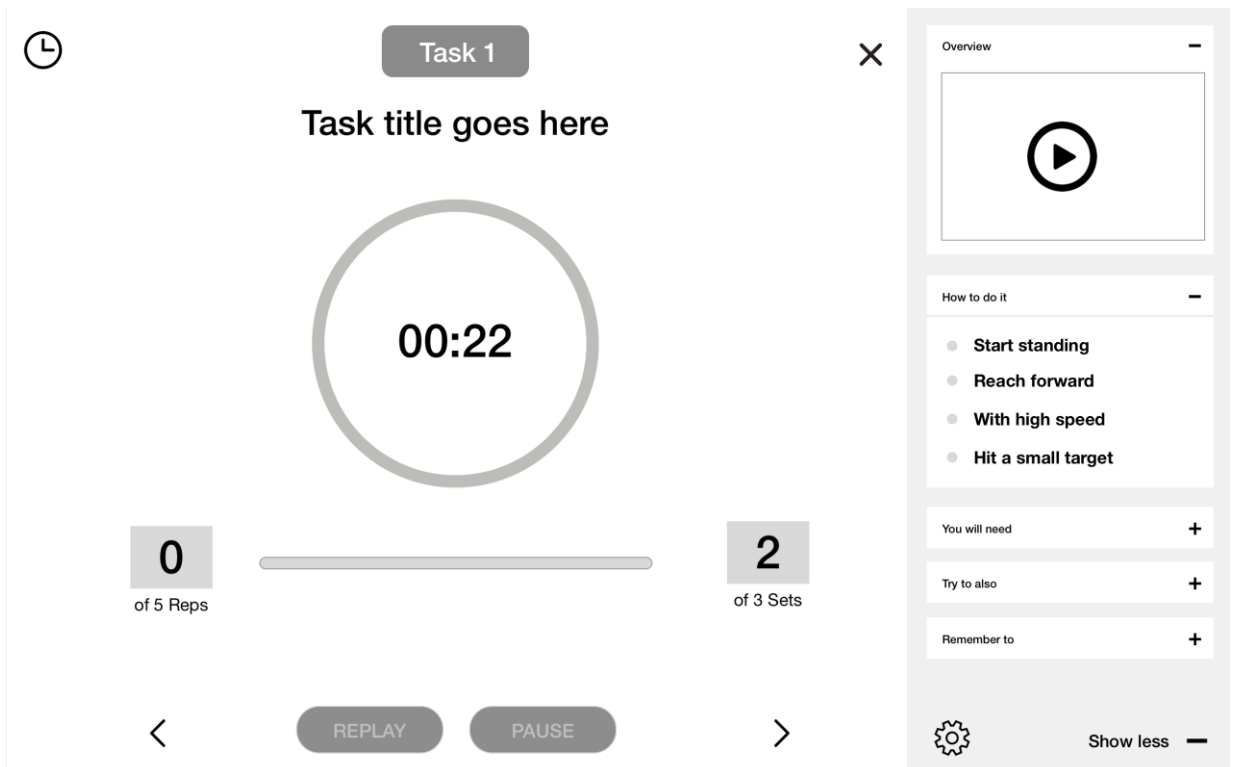
Next

The screenshot shows a survey question on a light gray background. At the top, there is a dark gray rounded rectangle with the word "Feedback" in white. Below it, the text "2 of 2 questions" is centered. The main question is "How confident were you in completing this task?" in a large, bold, black font. Below the question is a horizontal scale of ten circular buttons, numbered 1 to 10. The buttons are dark gray with white numbers. The button for "10" is highlighted with a white background and black text. To the left of the scale is the text "Not confident" and to the right is "Very confident". At the bottom center, there is a dark gray rounded rectangle with the word "Next" in white.

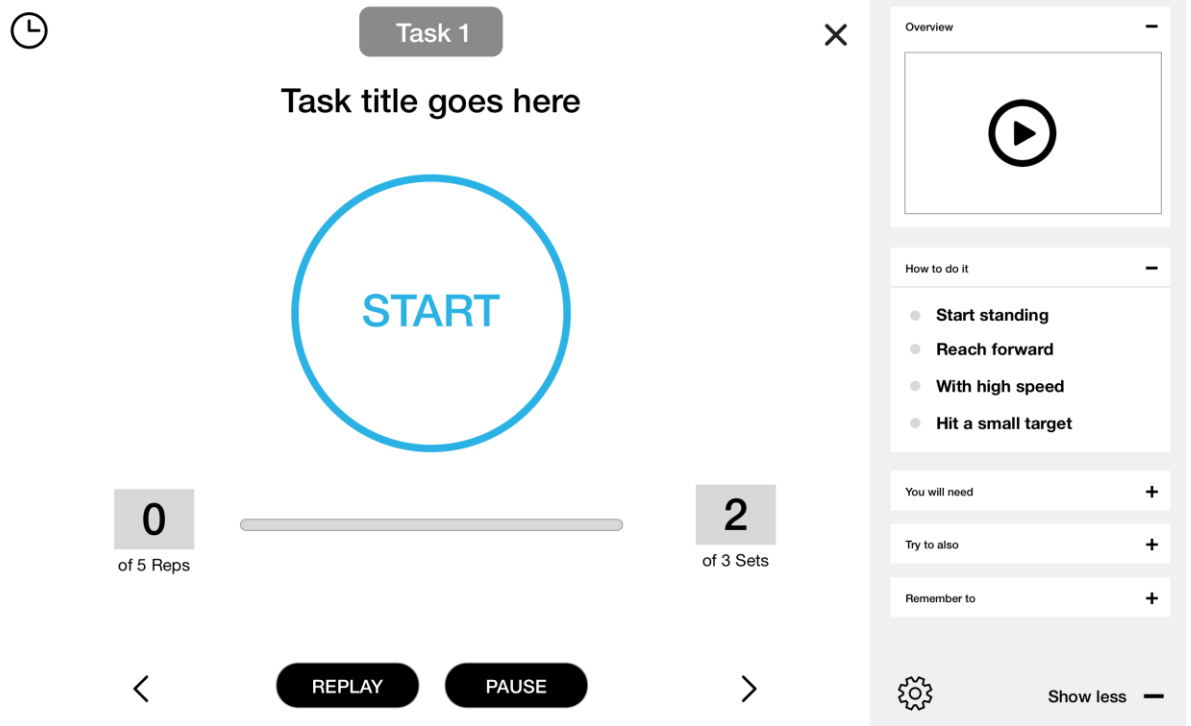
Screen 2.22



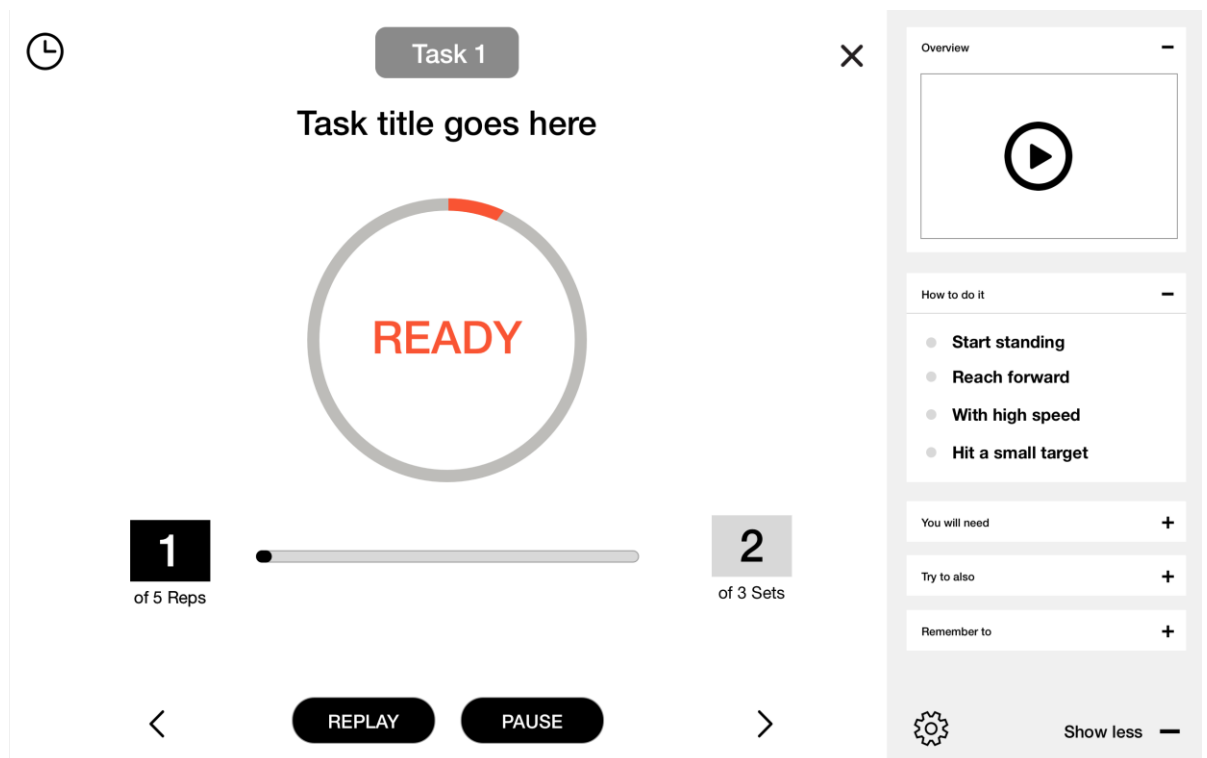
Screen 2.23



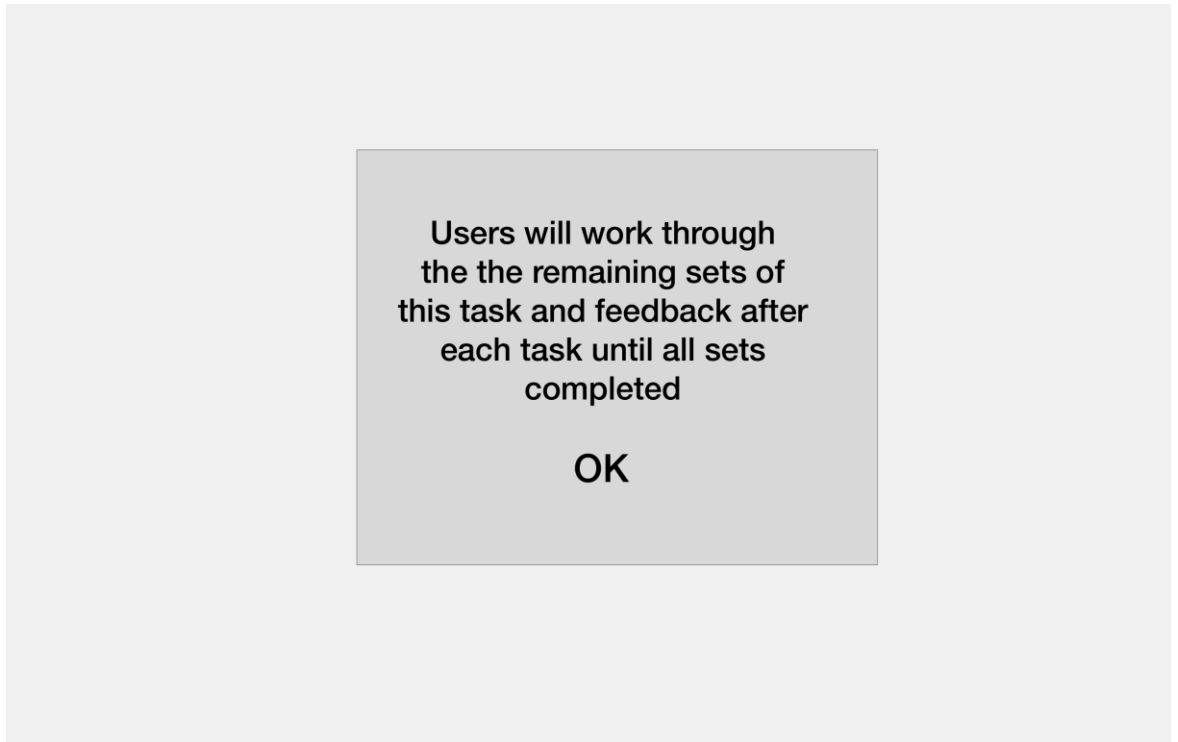
Screen 2.24



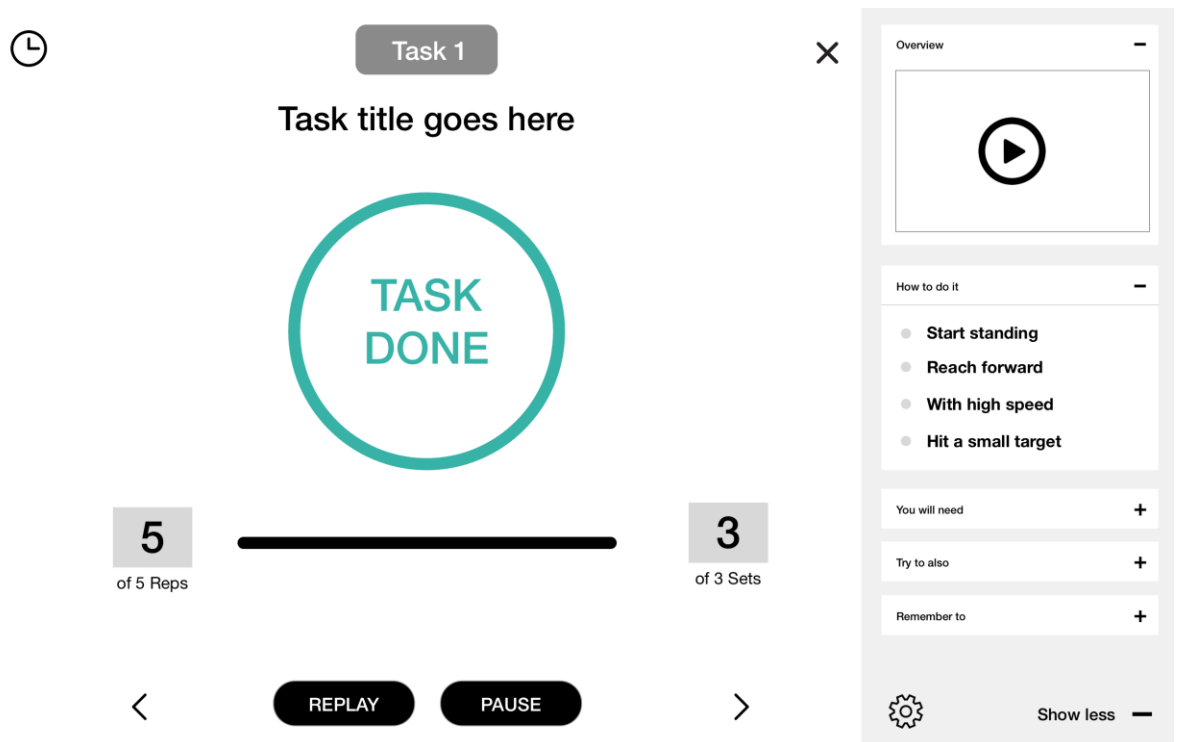
Screen 2.25



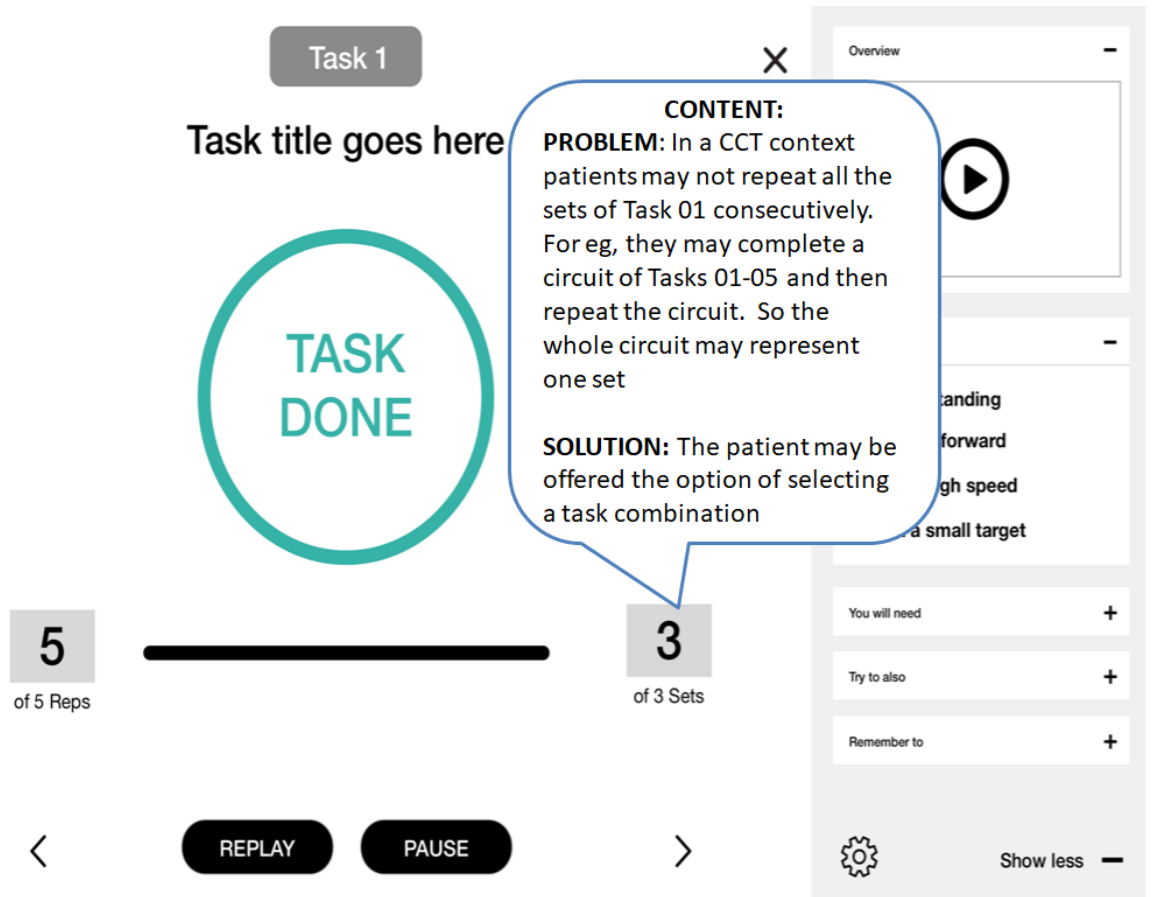
Screen 2.26



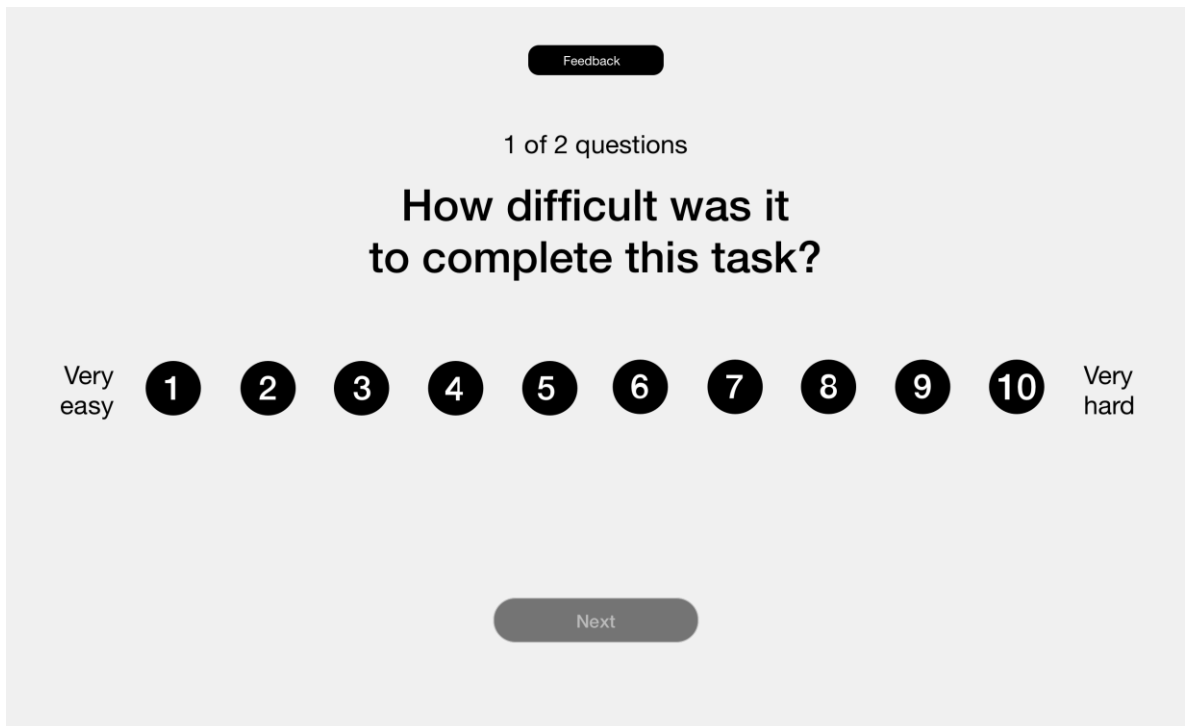
Screen 2.27



Wireframes for 2.27



Screen 2.28



Screen 2.29

Feedback

1 of 2 questions

How difficult was it to complete this task?

Very easy 1 2 3 4 5 6 7 8 9 10 Very hard

Next

Screen 2.30

Feedback

2 of 2 questions

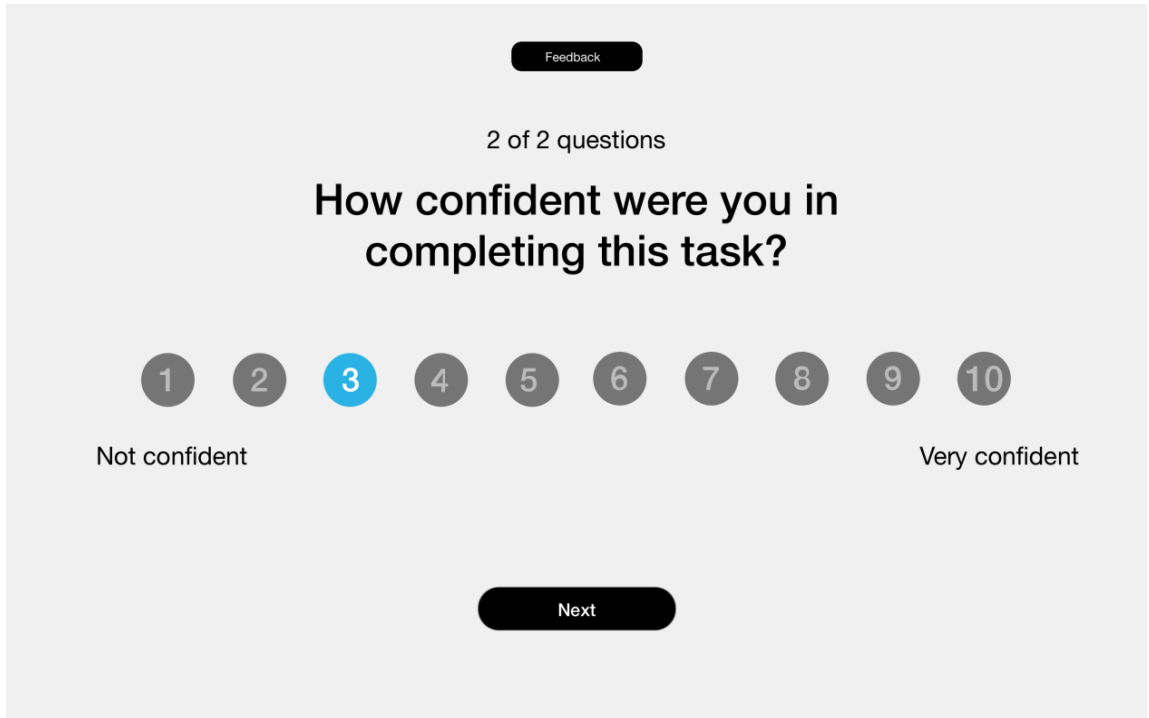
How confident were you in completing this task?

1 2 3 4 5 6 7 8 9 10

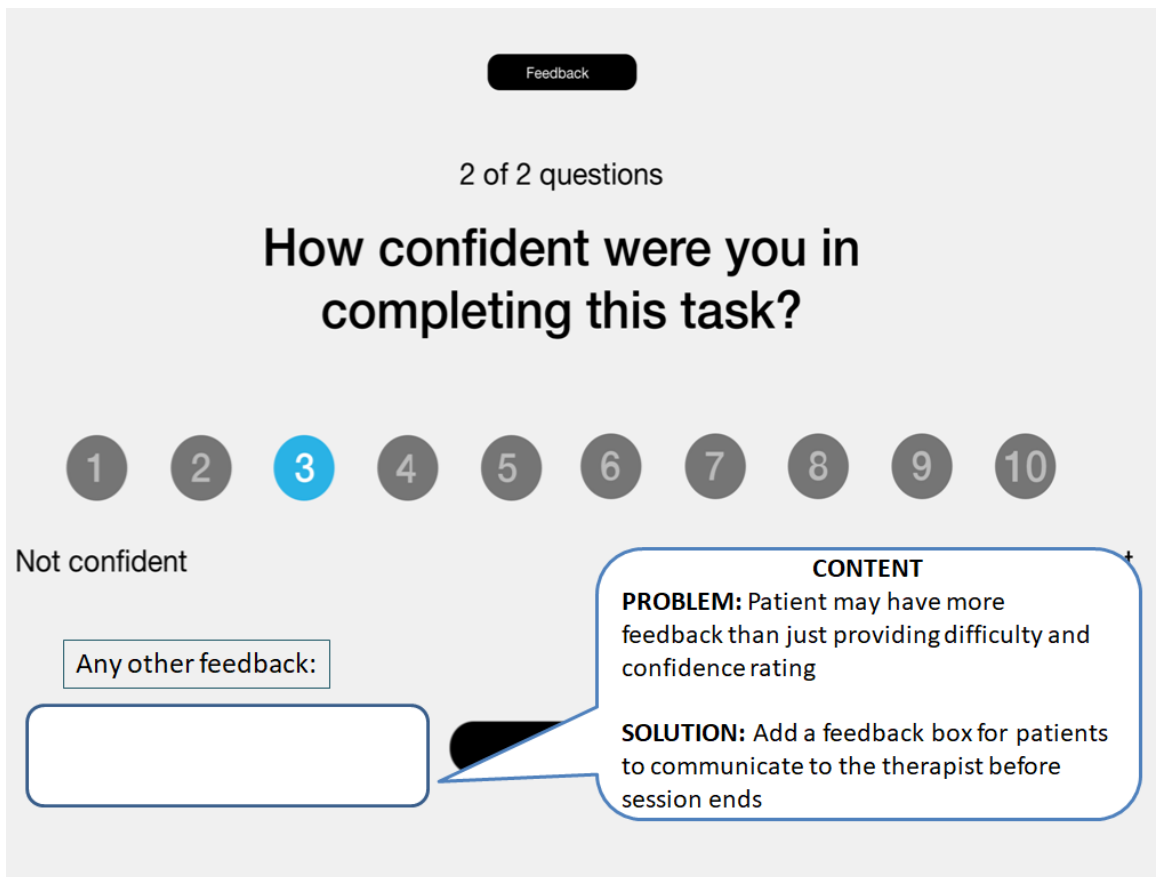
Not confident Very confident

Next

Screen 2.31



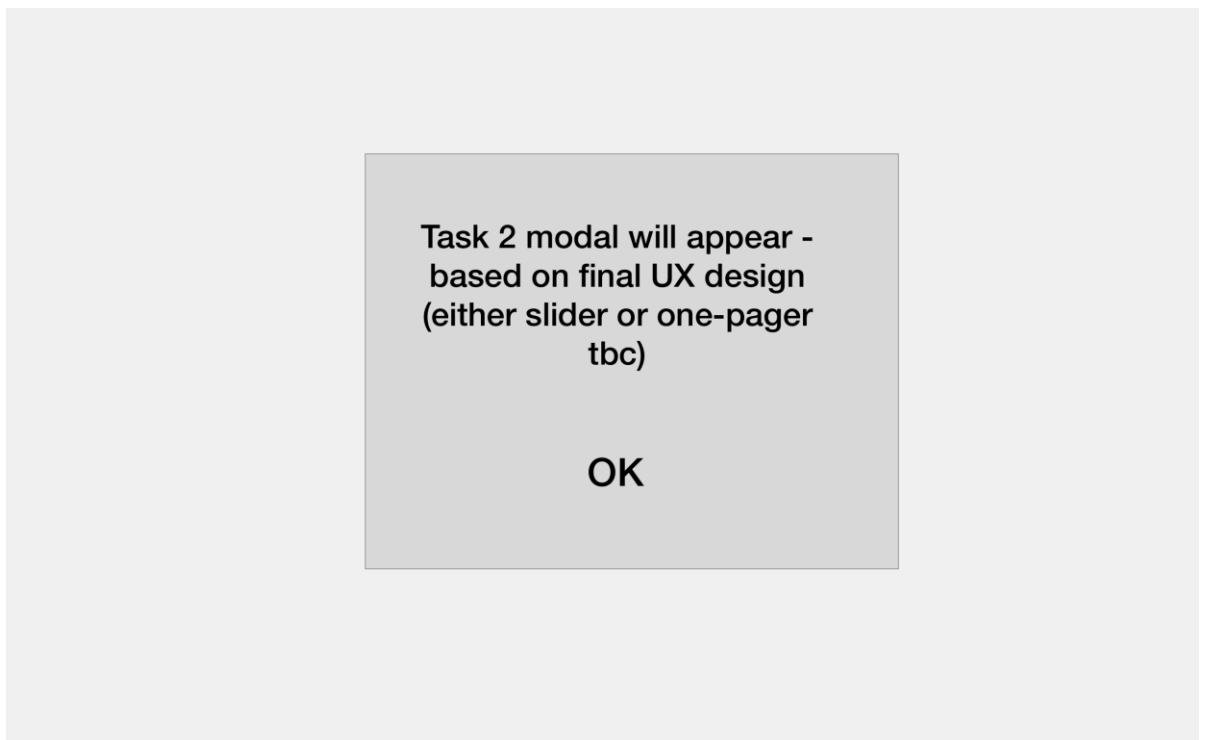
Wireframes 2.31



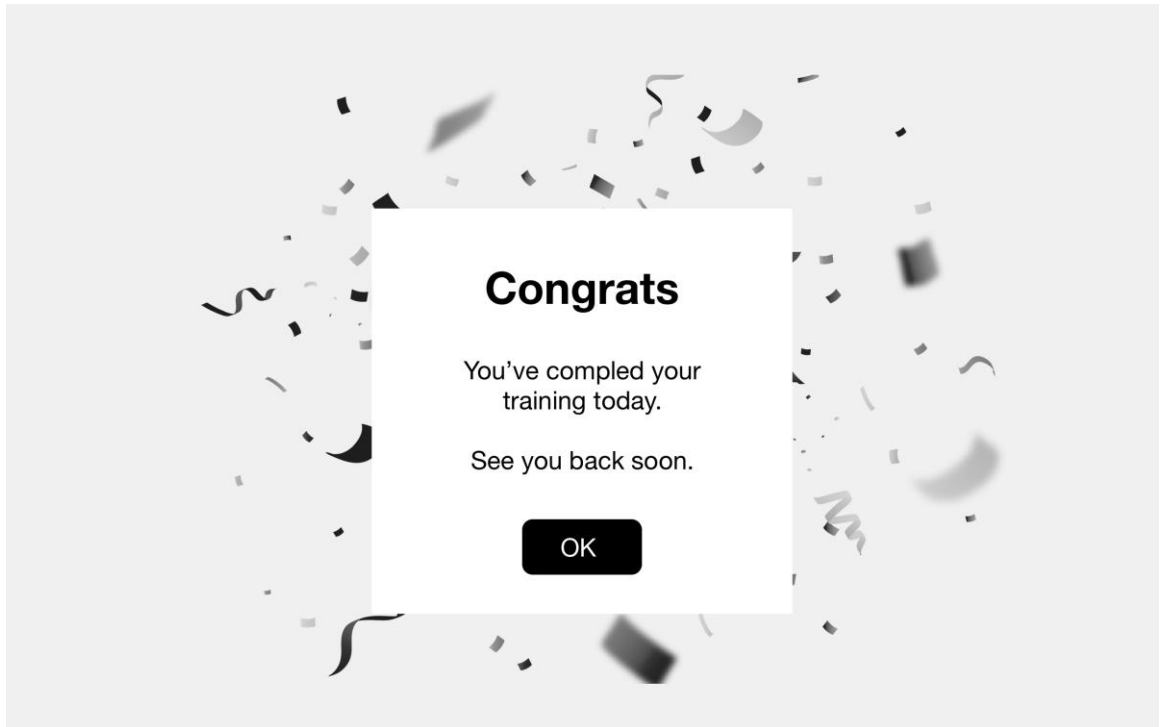
Screen 2.32



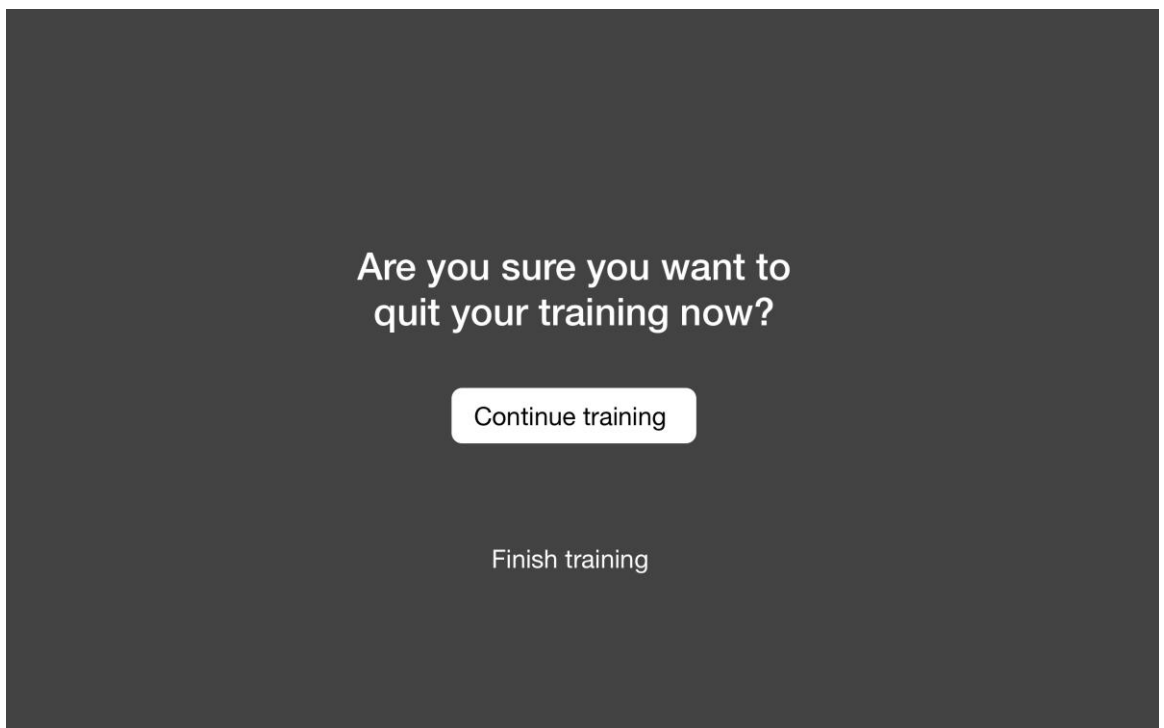
Screen 2.33



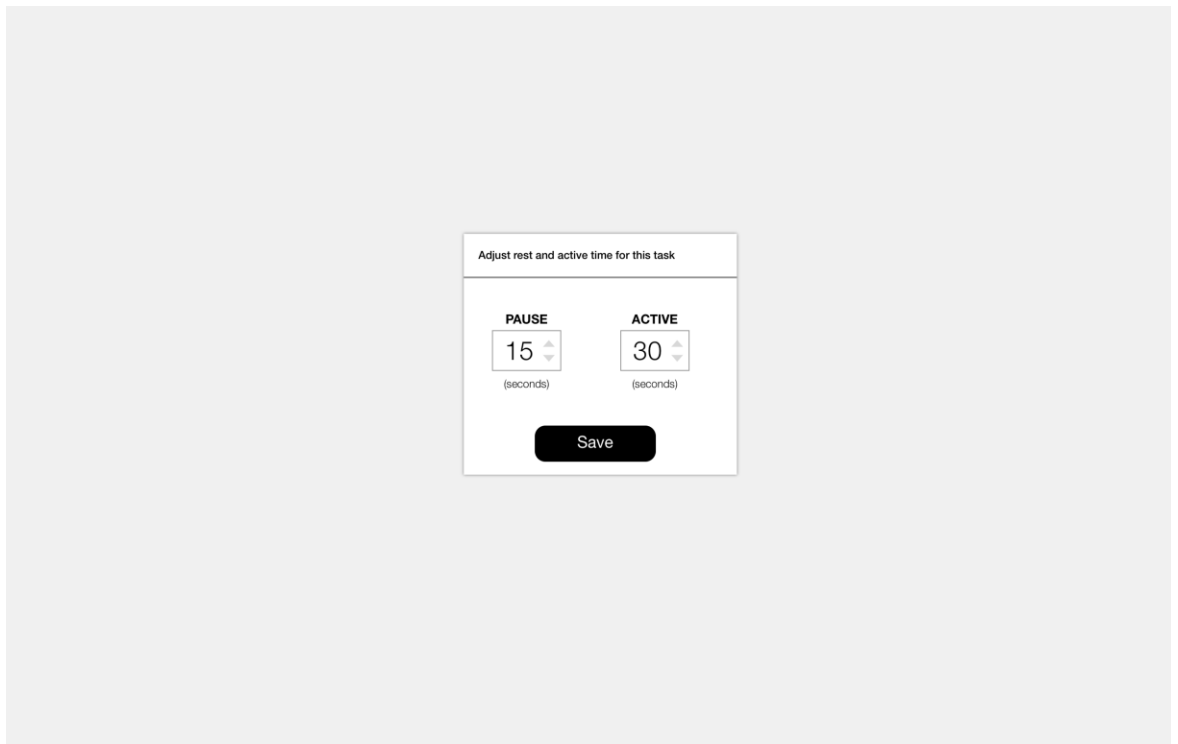
Screen 2.34



Screen 2.35



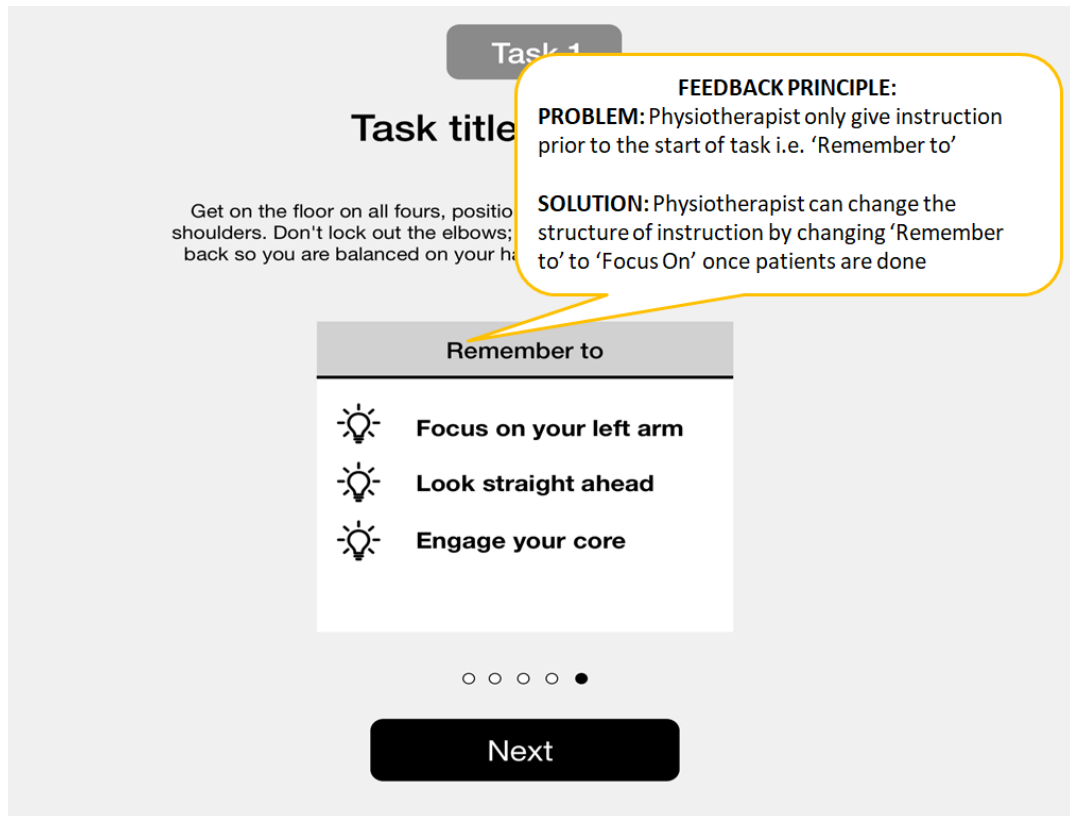
Screen 2.36



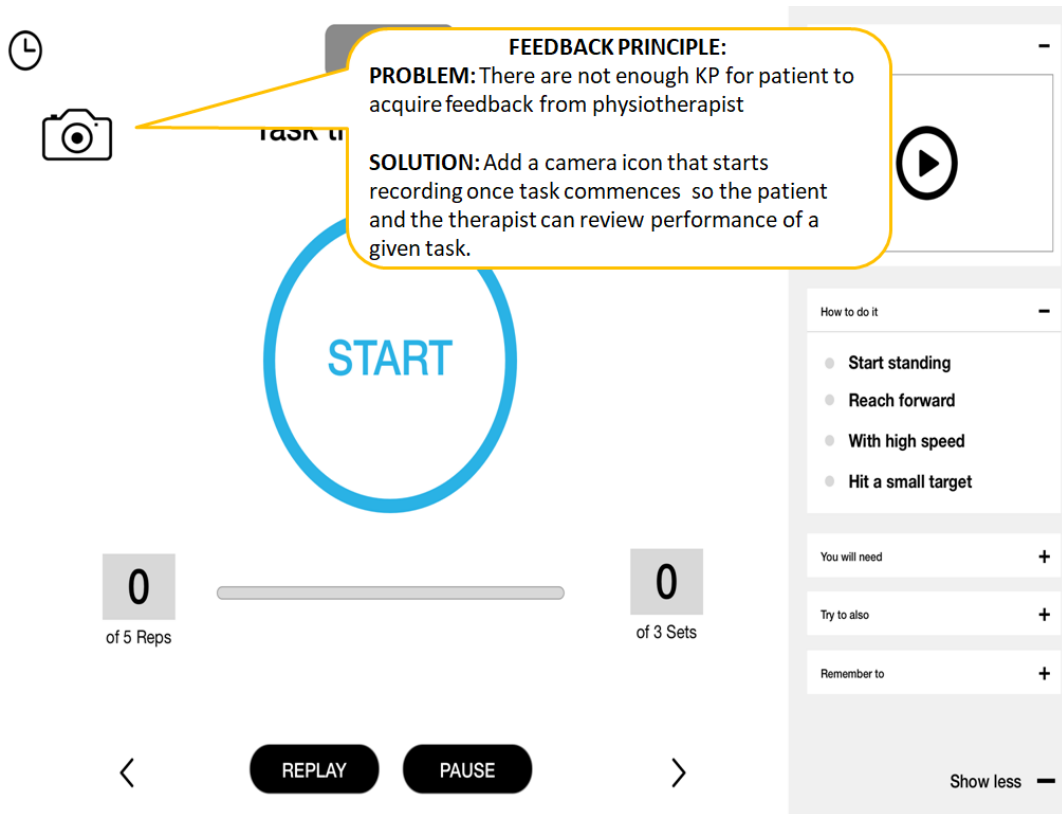
SECTION 3: Stage 2 Comparator Evaluation of the TRT app prototype with TRT and Motor Learning Evidence in people with stroke.

This section includes only Therapist and Patient wireframes that have been updated from Stage 1 based on this comparator evaluation process.

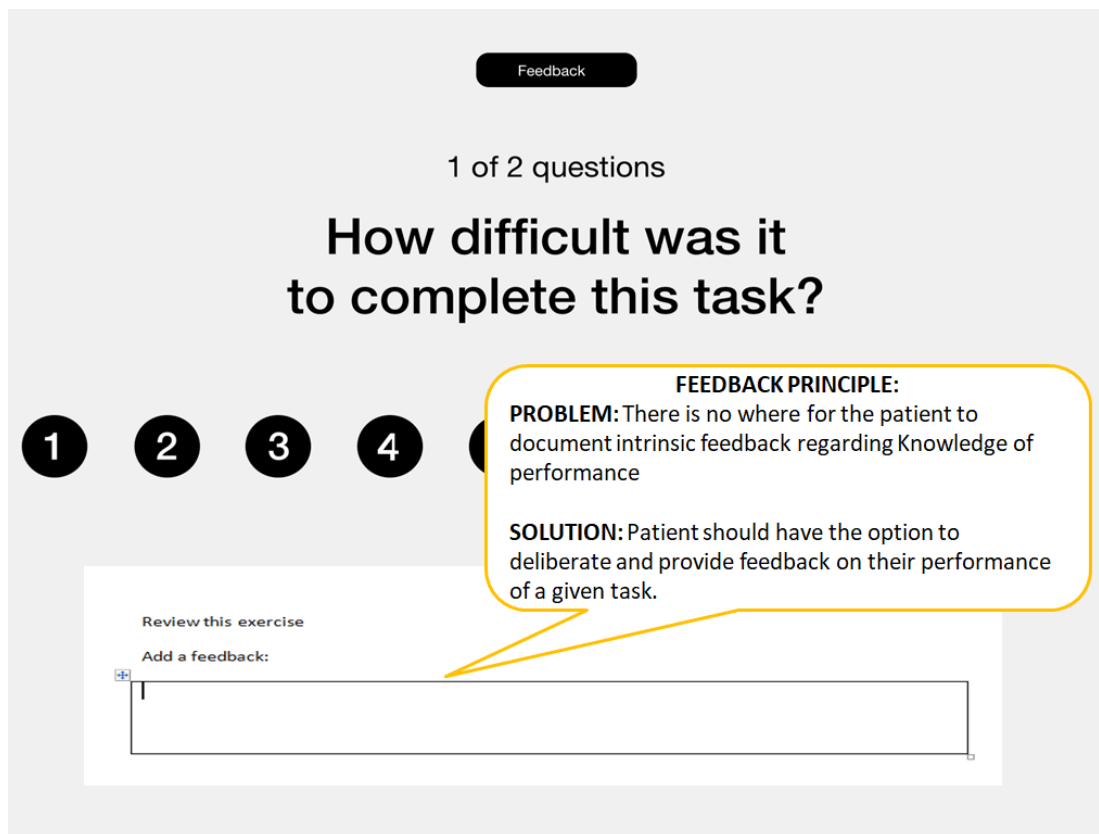
Feedback Principle: Patient Wireframe 1



Feedback Principle : Patient Wireframe 2



Feedback Principle: Patient Wireframe 3



Feedback Principle: Physiotherapist Wireframe 4

PHYSIO APP My Patients
Peter Jackson DoB: 26.03.1945 Date of Onset: 14.08.2021 Diagnosis: Bleed Presentation: Left Lesion Location: Cortial Right Hemisphere

Client details Programme Training tasks Add Task +

FEEDBACK PRINCIPLE:
PROBLEM: There is currently no way of recording knowledge of performance feedback regarding a task to the patient
SOLUTION: Explicit feedback about performance and coaching information about ways for eg, to optimising technique. This could be provided in written format or as an audio/video file recorded by the therapist in real time at the start in real time at the circuit station or and the end of the session

New Review [X]
 Upload

Error-Based Learning Principle: Physiotherapy Wireframe 1

PHYSIO APP My Patients
Sue Sullivan DoB: 26.03.1945 Date of Onset: 14.08.2021 Diagnosis: Bleed Presentation: Left Lesion Location: Cortial Right Hemisphere

Client details Programme Training tasks

1. PROGRAMME GOALS 2. TRAINING FOCUS 3. PROGRAMME SETTING

Select the Training focus for your client
 Tick all that apply

- Bed mobility and sitting balance
- Sit to Stand and Transfers
- Standing balance
- Walking
- : _____

ERROR-BASED LEARNING PRINCIPLE:
PROBLEM: Currently the error based learning has a variety of training focus for patient , however patient may have a selective focus that has higher dynamic activity
SOLUTION: An option to input the training focus such as playing golf, rock climbing etc

BACK NEXT

Reward-Based Learning Principle: Patient wireframe 1

Hello Sue

Training tasks

- 1 Standing tree
- 2
- 3 Standing flamingo
- 4
- 5 Walk the talk ++

REWARD BASED LEARNING PRINCIPLE
PROBLEM: There are no incorporation of rewards into movement training, which is likely to be important for movement selection.
SOLUTION: There could be a rewards chart or loading success images to show patient – how much they have achieved and how much more till they reach their goal

START →

Share via
 WhatsApp, Facebook, Telegram

My goals
 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Donec ut ultrices sem, non pellentesque lectus.

My gains
 4 Progress

My journey
 5/12

REWARD BASED LEARNING PRINCIPLE
PROBLEM: There are no links to share the patient's success
SOLUTION: When you have rated confidence X number of times and social rewards i.e sharing results with family and friends

Reward-Based Learning Principle: Patient wireframe 2

Hello Sue

Training tasks

- 1 Standing tree
- 2 Step it up NEW
- 3 Standing flamingo
- 4 Walk the talk
- 5 Walk the talk ++

You will need

- Foam
- A wall
- A heavy object
- One other person

START →

Calendar:

October	21	2009
November	22	2010
December	23	2011
January	24	2012
February	25	2013

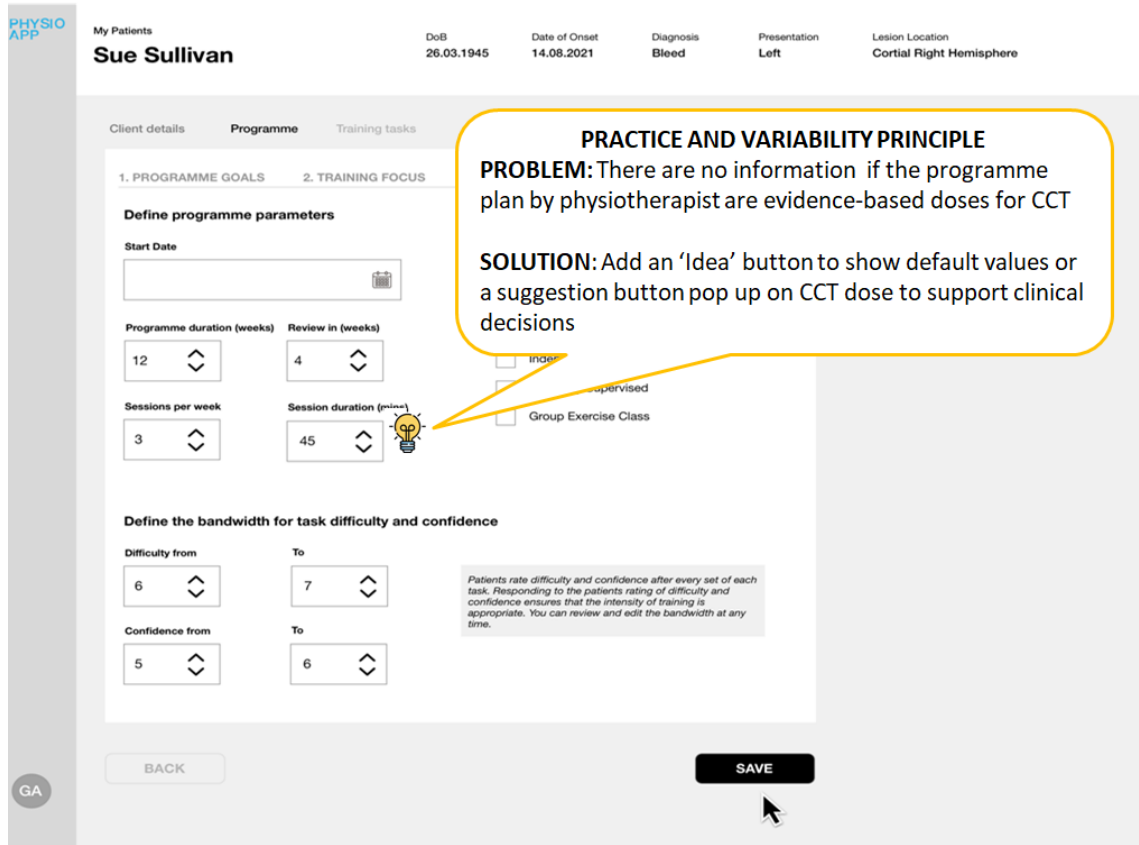
REWARD BASED LEARNING PRINCIPLE
PROBLEM: There are no visible dates by the selected training tasks that is highlighted or made visible so that patient would have a natural discourse to work towards it
SOLUTION: A date by each training task

My goals
 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Donec ut ultrices sem, non pellentesque lectus.

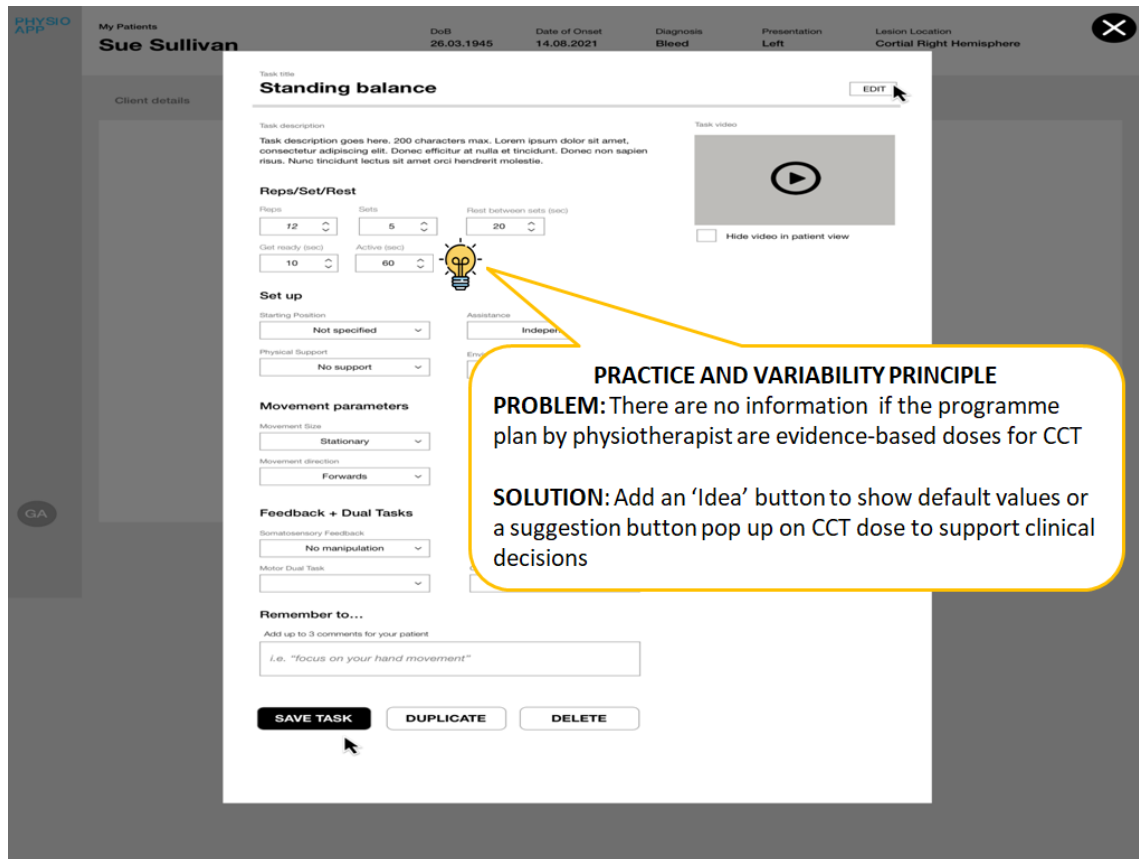
Challenge
 1 of 6 tasks is difficult

Confidence
 5 of 6 tasks are easier

Practice and Variability Principle: Physiotherapy Wireframe 1:



Practice and Variability Principle: Physiotherapy Wireframe 2:



Physical Capacity Principle: Physiotherapy Wireframe 1:

PHYSICAL CAPACITY PRINCIPLE
PROBLEM: There are no other forms of intensity other than the task difficulty that are displayed in this app
SOLUTION: Incorporating a display to monitor other forms of intensity other than the task difficulty scale within the app would be beneficial

The wireframe shows a patient profile for Peter Jackson with details like DoB (26.03.1945), Date of Onset (14.08.2021), Diagnosis (Bleed), Presentation (Left), and Lesion Location (Cortial Right Hemisphere). Below this is a 'Training tasks' section with five task cards. Each card displays 'Client rating' with 'Difficulty' and 'Confidence' scores, and 'Reps/Sets/Rest' information. A callout box highlights the lack of intensity monitoring beyond the difficulty scale and suggests a solution to include other intensity metrics.

Belief and Self-Efficacy Principle: Patient Wireframe 1:

BELIEFS AND SELF-EFFICACY PRINCIPLE
PROBLEM: It is the purpose of goal-oriented training programmes to increase performance and function, while simultaneously instilling confidence in one's skills
SOLUTION: To embed Participatory/Self-efficacy outcome measure

BELIEFS AND SELF-EFFICACY PRINCIPLE
PROBLEM: There is a need to justify progressions with outcome measures
SOLUTION: To include a nationally recognised quality metrics that pertains to stroke participatory or locomotor outcomes

The wireframe features a 'Hello Sue' greeting and a 'Training tasks' section with two tasks: '1 Standing tree' and '2 Step it up' (marked as 'NEW'). A 'You will need' section lists requirements: 'Foam', 'A wall', 'A heavy object', and 'One other person'. A prominent blue 'START' button is visible. Below the tasks are sections for 'My goals', 'My gains' (showing a '1' gain), and 'My journey' (a progress grid for November 2021). Callout boxes discuss the principle of belief and self-efficacy, highlighting the need for outcome measures to justify progressions and the inclusion of quality metrics.

SECTION 4: Stage 3 Comparator Evaluation of the TRT app prototype with Locomotor CCT Evidence in people with stroke

This section includes only Therapist and Patient wireframes that have been updated from Stage 1 and based on this comparator evaluation process.

Physiotherapy Wireframe 1

My Patients
Sue Sullivan

DOB: 26.03.1945 | Date of Onset: 14.08.2021 | Diagnosis: Blood | Presentation: Left | Lesion Location: Cortical Right Hemisphere

Task title: Standing balance

Task description:
Task description goes here. 200 characters max. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Donec efficitur at nulla et fructibus. Donec non sapien. Nunc fructibus lectus sit amet qui hendrerit molestia.

Reps/Set/Rest
Reps: 12 | Sets: 5 | Rest between sets (sec): 20
Set ready (sec): 10 | Actual (sec): 60

Set up
Starting Position: Not specified | Assistance: Independent
Physical Support: No support | Measurement: Not specified

Movement parameters
Movement Size: Stationary | Movement Speed: Comfortable
Movement direction: Forwards | Movement accuracy: No target

Feedback + Dual Tasks
Sensory Feedback: No manipulation | Visual / Vestibular Feedback: []
Motor Dual Task: [] | Cognitive Dual Task: []

Remember to...
Add up to 3 comments for your patient
e.g. "Focus on your hand movement"

SAVE TASK | **DUPLICATE** | **DELETE**

Stage 3 Comparator Evaluation:
PROBLEM: Reactive balance was not reported in the app and warrants further investigation for CCT programmes
SOLUTION: There can be another option to include reactive balance under standing balance or sitting balance

Physiotherapy Wireframe 2

PHYSIO APP My Patients **Sue Sullivan** DoB 26.03.1945 Date of Onset 14.08.2021 Diagnosis Bleed Presentation Left Lesion Location Cortial Right Hemisphere

Client details Programme Training tasks

1. PROGRAMME GOALS 2. TRAINING FOCUS 3.

Select the Training focus for your client

Tick all that apply

- Bed mobility and sitting balance
- Sit to Stand and Transfers
- Standing balance
- Walking

BACK NEXT

GA

Stage 3 Comparator Evaluation:

PROBLEM: The app does not currently include motor imagery-based tasks prior to actual task practice

SOLUTION: There can be another option for training focus that the app can add for mental imagery

Physiotherapy Wireframe 3

SIO My Patients **Peter Jackson** DoB 26.03.1945 Date of Onset 14.08.2021 Diagnosis Bleed Presentation Left Lesion Location Cortial Right Hemisphere

Client details Programme Training tasks Add Task +

Standing balance ...

Client rating

Difficulty 6 Confidence 2

Reps/Sets/Rest

Reps 12 Sets 5

Rest between sets 20 sec

Active time 60 secs

Get ready time 10 secs

Set up +

Movement -

Size Lorem

Moving Direction Forward

Speed Comfortable

Accuracy Large target

Feedback + Dual task +

Remember to +

Task 2 ...

Client rating

Difficulty 6 Confidence 2

Reps/Sets/Rest

Reps 12 Sets 5

Rest between sets 20 sec

Active time 60 secs

Get ready time 10 secs

Set up +

Movement -

Size Lorem

Moving Direction Forward

Speed Comfortable

Accuracy Large target

Feedback + Dual task +

Remember to +

Task 3 ...

Client rating

Difficulty 6 Confidence 7

Reps/Sets/Rest

Reps 12 Sets 5

Rest between sets 20 sec

Active time 60 secs

Get ready time 10 secs

Set up +

Movement -

Size Lorem

Moving Direction Forward

Speed Comfortable

Accuracy Large target

Feedback + Dual task +

Remember to +

Task 4 ...

Client rating

Difficulty 6 Confidence 7

Reps/Sets/Rest

Reps 12 Sets 5

Rest between sets 20 sec

Active time 60 secs

Get ready time 10 secs

Set up +

Movement -

Size Lorem

Moving Direction Forward

Speed Comfortable

Accuracy Large target

Feedback + Dual task +

Remember to +

Task 5 ...

Client rating

Difficulty 3 Confidence 8

Reps/Sets/Rest

Reps 12 Sets 5

Rest between sets 20 sec

Active time 60 secs

Get ready time 10 secs

Set up +

Movement -

Size Lorem

Moving Direction Forward

Speed Comfortable

Accuracy Large target

Feedback + Dual task +

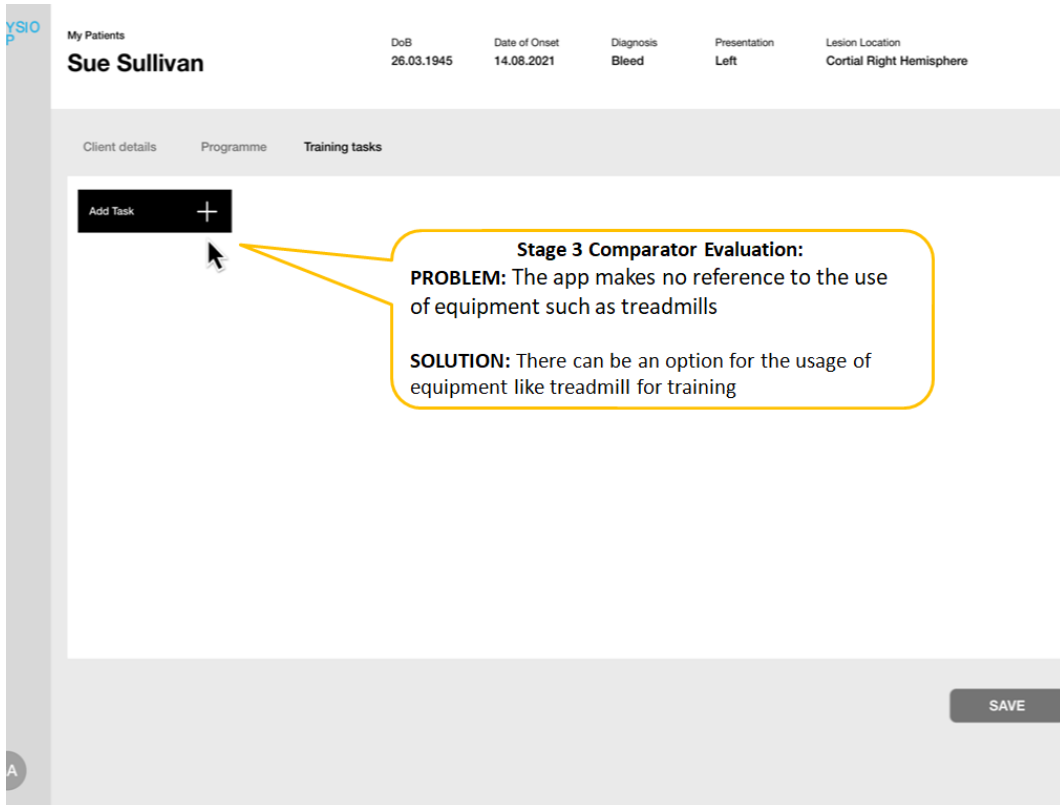
Remember to +

Stage 3 Comparator Evaluation:

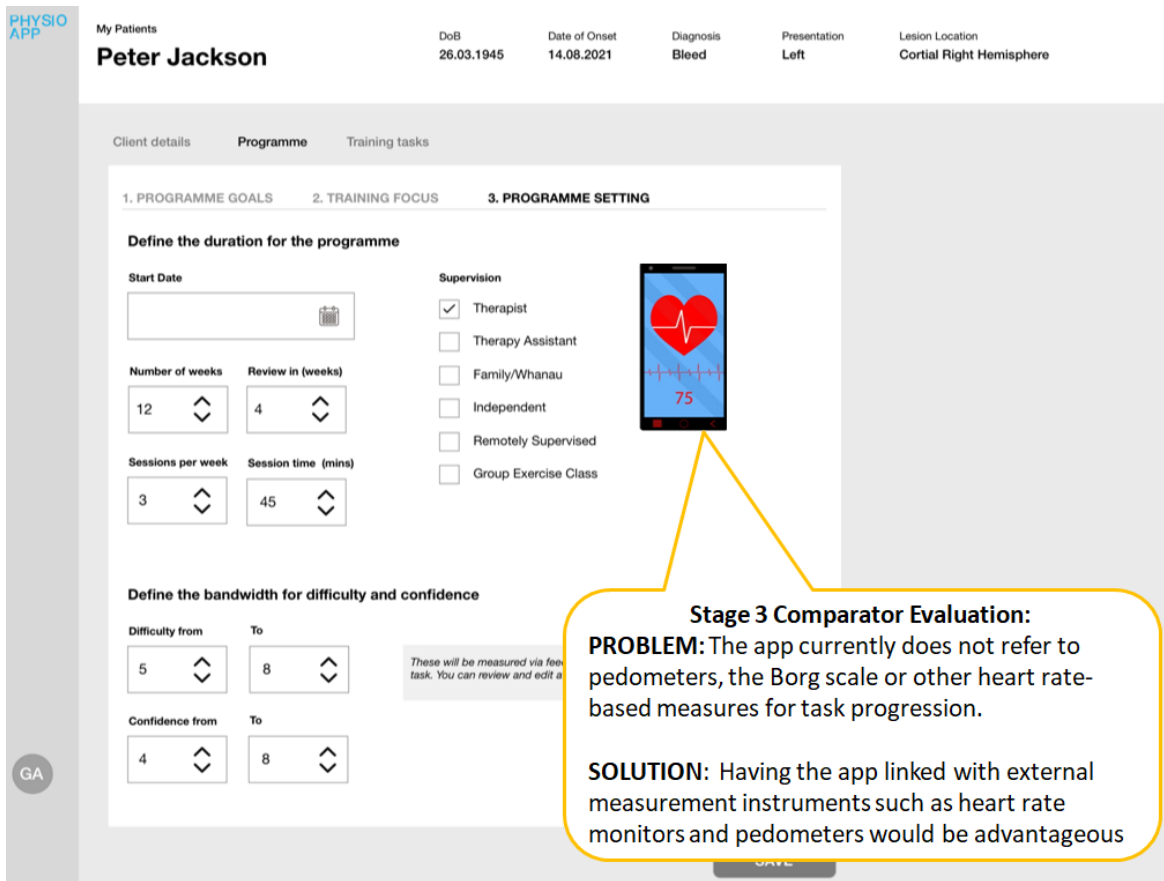
PROBLEM: The app does use metronomes for every step during walking-based tasks

SOLUTION: There can be an option for the usage of metronome for training

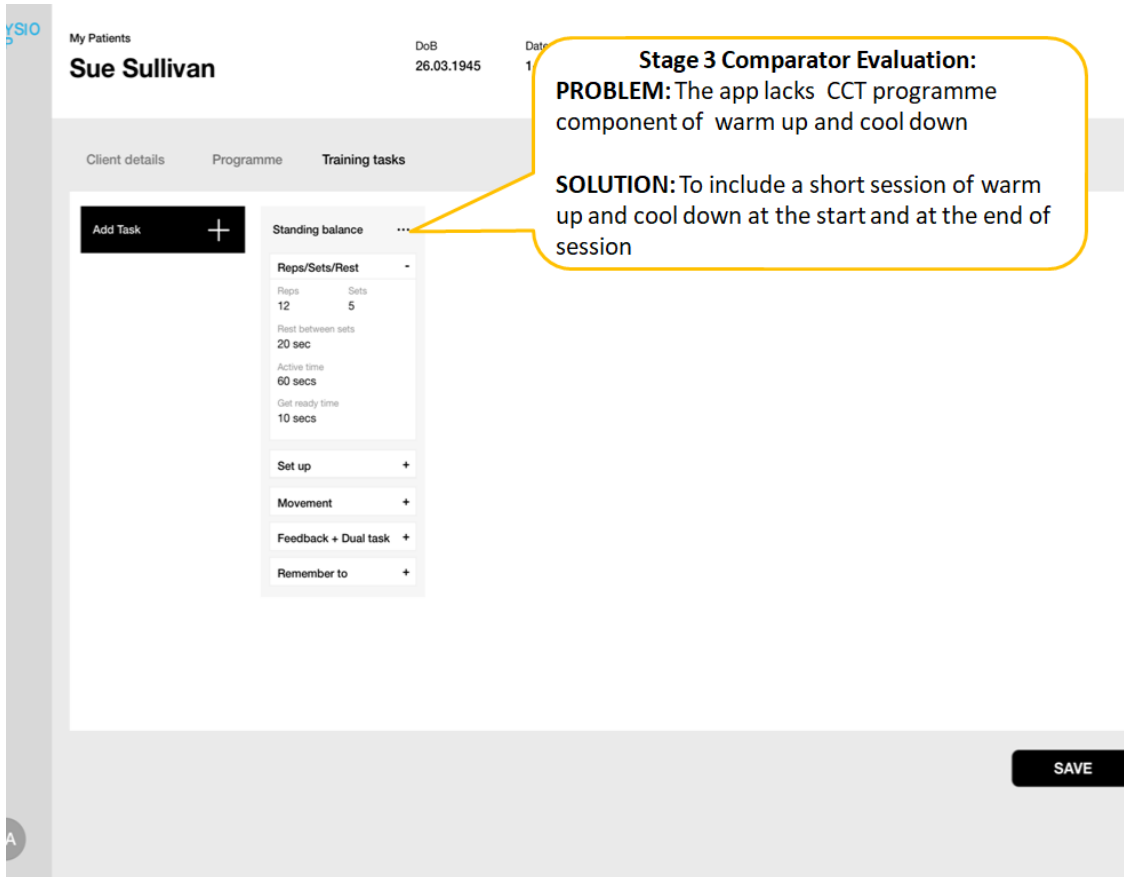
Physiotherapy Wireframe 4



Physiotherapy Wireframe 5



Physiotherapy Wireframe 6



SECTION 5: Stage 3 Comparator Evaluation of the TRT app prototype with Locomotor CCT Evidence in people with stroke

Table 1: Sitting Balance

Sitting Balance Tasks						
Task Parameters (progressions modifications)	Static sitting TRT App	CCT evidence	Weight shift TRT App	CCT evidence	Near reach TRT App	Far reach CCT evidence
Assistance	-Supervision -Assistance of 1 -Assistance of 2 -Customise	-	-Supervision -Assistance of 1 -Assistance of 2 -Customise	-	-Supervision -Assistance of 1 -Assistance of 2 -Customise	-
Starting position	-Back, arms, thighs, feet supported -Arms, thighs, feet supported -Thighs, feet supported -Feet off the ground -Cross legged Perch sitting -Customise	-	-Back, arms, thighs, feet supported -Arms, thighs, feet supported -Thighs, feet supported -Feet off the ground -Cross legged Perch sitting -Customise	-	-Back, arms, thighs, feet supported -Arms, thighs, feet supported -Thighs, feet supported -Feet off the ground -Cross legged Perch sitting -Customise	-
Physical Support	Chair with back and arms, Chair, Seat (plinth, chair or stool), Height adjustable seat (plinth, stool), Seat (plinth, chair or stool)	Chairs-Increase from various heights (Kim et al., 2016)	Chair with back and arms, Chair, Seat (plinth, chair or stool), Height adjustable seat (plinth, stool), Seat (plinth, chair or stool)	-	Chair with back and arms, Chair, Seat (plinth, chair or stool), Height adjustable seat (plinth, stool), Seat (plinth, chair or stool)	Increasing the no. of reps completed within 5mins at each station, increasing complexity at each workstation, such as the distance reached in sitting and standing, the height of the blocks, and reducing the height of the chair (Dean et al., 2000)
Movement size	Hold balance 5s- 120s	-	-	-	-	-

Movement direction	NA	-	Forwards, Backwards, Forwards & Backwards, Sideways-Left, Sideways-Right, Sideways- Left & Right, Customise	Customized progression to suit the ability of individual participants (Marsden et al., 2010)	Reach forward-touch/ pick up, Reach backwards-touch/pickup, Reach forward & backwards-touch/pickup, Reach left-touch/ pick up, Reach right- touch/pickup, Reach to the right and left touch/pick up, Reach up- touch/pick up, Reach down- touch/pick up	Sitting at a table & reaching in different directions for objects located beyond arm's length to promote loading of the affected leg and activation of affected leg muscles (Dean et al., 2000) Graded reaching activities in forward and backward reaching (Dean et al., 2012)
Movement speed	NA	-	Move at a comfortable speed, Move quickly, Move as fast as you can, Move in a slow and controlled way, Customise	-	Move at a comfortable speed, Move quickly, Move as fast as you can, Move in a slow and controlled way, Customise	-
Movement smoothness/ Accuracy	NA	-	NA	-	No target/ object, Large targets/ objects, Medium targets/ objects, Small targets/ objects, Line, Customise	-
Vision and vestibular input	Vision: Fixating on a visual reference, Obscure vision, Use vision for a secondary task, Alter visual complexity of background, Eyes closed Vestibular: Head turns(slow/fast), Head		Vision: Fixating on a visual reference, Obscure vision, Use vision for a secondary task, Alter visual complexity of background, Eyes closed Vestibular: Head turns(slow/fast), Head	-	Vision: Fixating on a visual reference, Obscure vision, Use vision for a secondary task, Alter visual complexity of background, Eyes closed Vestibular: Head turns(slow/fast), Head	-

	movt up/down (slow/fast), Diagonal movement of head		movt up/down (slow/fast), Diagonal movement of head		movt up/down (slow/fast), Diagonal movement of head
Somatosensory input	Light touch contact, Touch contact, Single hand support, Two hand support, Foam, customise	-	Light touch contact, Touch contact, Single hand support, Two hand support, Foam, customise	-	Light touch contact, Touch contact, Single hand support, Two hand support, Foam, customise
Motor task	Holding customise object, Holding heavy load, Holding an object that spills, Holding large object, Holding fragile object, Throwing/ Catching		Holding customise object, Holding heavy load, Holding an object that spills, Holding large object, Holding fragile object, Throwing/ Catching	Sitting position: open covered pots of different sizes and transfer flour to a cup with a spoon, then close the pot. Pick up coins and cards on the table and put the coins in a pot and gather the cards. Write and/or draw pictures on paper. Open a safe box with a key, pick up small objects inside the box, transfer them to a pot, then lock the safe box. Pick up and transfer jars, bottles, and glasses of different sizes, weights located on a table. Transfer the liquid contents from jars and bottles to glasses. throw and catch balls (in pairs) Caetano Martins et al., 2020	Holding customise object, Holding heavy load, Holding an object that spills, Holding large object, Holding fragile object, Throwing/ Catching
Cognitive task	Talking, Texting, Reading, Counting 3's	-	Talking, Texting, Reading, Counting 3's	-	Talking, Texting, Reading, Counting 3's
					Customised progression to suit the ability of individual participants (Marsden et al., 2010)

Up, Counting 7's Down,
Recipe, Directions,
customise

Up, Counting 7's Down,
Recipe, Directions,
customise

Up, Counting 7's Down,
Recipe, Directions,
customise

Table 2: Sit to Stand and Transfers

Sit to Stand and Transfers Task								
	Sit to Stand		Sliding board Transfer		Reach/Pivot Transfer		Stand and Step Transfer	
Task Parameters (progressions modifications)	TRT App	CCT evidence	TRT App	CCT evidence	TRT App	CCT evidence	TRT App	CCT evidence
Assistance	Supervision -Assistance of 1 -Assistance of 2 -Customise	-	Supervision -Assistance of 1 -Assistance of 2 -Customise	-	Supervision -Assistance of 1 -Assistance of 2 -Customise	-	Supervision -Assistance of 1 -Assistance of 2 -Customise	-
Starting Position	Wide BoS, Narrow BoS, Feet together, Step stance, Tandem, Customise	Sit-to-stand from chair by placing the paretic foot behind (Caetano Martins et al., 2020, Moore et al., 2015)	Sitting, Perch sitting, Customise	-	Sitting, Perch sitting, Customise	-	Sitting, Perch sitting, Customise	-
Physical Support	Chair arms, Beside wall, Kitchen bench/table, Plinth, Rail, Body weight support, Walking Aid (state), Customise	Customised and progressed to suit individual subjects. No detail about how and when reported (Blennerhassett 2004, Dean et al., 2012, Marsden et al., 2010, Pang et al., 2005, Stuart et al., 2019, Vahlberg, Lindmark, et al., 2017, Vahlberg, Cederholm, et	Chair arms, Beside wall, Kitchen bench/table, Plinth, Rail, Body weight support, Walking Aid (state), Customise	-	Chair arms, Beside wall, Kitchen bench/table, Plinth, Rail, Body weight support, Walking Aid (state), Customise	-	Chair arms, Beside wall, Kitchen bench/table, Plinth, Rail, Body weight support, Walking Aid (state), Customise	-

		al., 2017, Verma et al., 2011)					
Movement size	Low seat, High seat, Office chair, Lounge chair, Bar stool, Car seat, Customise	Sit-to-stand from various chair heights to strengthen the affected leg extensor muscles and practice this task (Dean et al., 2000, Graupelicer et al., 2020, Kim et al., 2016)	Low seat, High seat, Office chair, Lounge chair, Bar stool, Car seat, Customise	-	Low seat, High seat, Office chair, Lounge chair, Bar stool, Car seat, Customise	-	Low seat, High seat, Office chair, Lounge chair, Bar stool, Car seat, Customise
		Training intensity was prescribed using %HRRe = [(peak HR - resting HR) × % + resting HR], and peak HR was determined from the exercise test (Tang et al., 2014)					Start workload at 40–50% of HRR till to a max of 70–80% of HRR Exercises were carried out according to the observations + estimation of therapists and patients RPE (Outermans et al., 2010)
Movement direction	NA	-	Left, Right, Left and Right	-	Left, Right, Left and Right	-	Left, Right, Left and Right
Movement speed	Increased speed Max speed, Slow speed, Customise	Sit-to-stand movements (Marigold et al.,	Increased speed Max speed, Slow speed, Customise	-	Increased speed Max speed, Slow speed, Customise	-	Increased speed Max speed, Slow speed, Customise

2005, Mudge et al., 2009)

Movement smoothness/ Accuracy	NA	-	NA	-	NA	-	NA	-
Vision and vestibular input	Vision: Obscure vision, Lighting, use vision for a secondary task, Alter visual complexity of background, Shift position of objects in the visual field, Change the speed of moving objects, Eyes closed Vestibular: Slow head turns, Fast head turns, Slow head movt up and down, Fast head movt up and down, Vestibular: Other directional movt of head, Customise	-	Vision Lighting, Use vision for a secondary task, Alter visual complexity of background, Eyes closed Vestibular: Refer to Movement Speed, Customise	-	Vision Lighting, Use vision for a secondary task, Alter visual complexity of background, Eyes closed Vestibular: Refer to Movement Speed, Customise	-	Vision Lighting, Use vision for a secondary task, Alter visual complexity of background, Eyes closed Vestibular: Refer to Movement Speed, Customise	-
Somatosensory input	Foam, Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles), Ramps, Slopes	-	Foam, Unstable support surface	-	Foam, Unstable support surface	-	Foam, Unstable support surface	-
Motor task	Holding object Passing/Receiving object, Throwing/ Catching, Holding	-	Holding object Passing/Receiving object, Customise	-	Holding object Passing/Receiving object, Customise	-	Holding object Passing/Receiving object, Customise	-

	heavy object, Passing/Receiving heavy object, Holding object that spills, Holding large object, Passing/ Receiving large object, Holding fragile object, Passing/Receiving fragile object, customise				
Cognitive task	Talking, Texting, - Reading, Counting, Recipe, Directions, Customise	Talking, Texting, - Reading, Counting, Recipe, Directions, Customise	Talking, Texting, - Reading, Counting, Recipe, Directions, Customise	Talking, Texting, - Reading, Counting, Recipe, Directions, Customise	

Table 3A: Standing Balance- Standing

Standing Task		Weight shift		Near/Far Reach		
Task Parameters (progressions modifications)	TRT App	CCT evidence	TRT App	CCT evidence	TRT App	CCT evidence
Assistance	Supervision -Assistance of 1 -Assistance of 2 -Customise	-	Supervision -Assistance of 1 -Assistance of 2 -Customise	-	Supervision -Assistance of 1 -Assistance of 2 -Customise	-
Starting position	Standard BoS, Narrow BoS, Feet together, Step stance-Left/Right, Tandem- Left/Right, Single Leg-Left/Right, Customise	Customised and progressed to suit individual subjects (Blennerhassett , 2004) Standing position: heel raise while putting an object on a higher shelf (Caetano Martins et al., 2020) Standing with the base of support constrained, with feet in parallel and tandem conditions reaching for objects, including down to the floor, to improve standing balance (Dean et al., 2000)	Standard BoS, Narrow BoS, Feet together, Step stance-Left/Right, Tandem- Left/Right, Single Leg-Left/Right, Customise	Standing with reduced base of support, graded reaching activities in standing and forward (Dean et al., 2012) Standing in various postures (e.g, tandem or feet apart, one foot stance, and weight-shifting) (Marigold et al., 2005) Standing on 1 leg, Self sway, Standing balance, Balance beam, Standing balance, Standing hamstring curl, Tandem stance, Calf raise, Lunges, Side leg lifts, Marching in place (Moore et al., 2015)	Standard BoS, Narrow BoS, Feet together, Step stance-Left/Right, Tandem- Left/Right, Single Leg-Left/Right, Customise	Standing with the base of support constrained, with feet in parallel and tandem conditions reaching for objects, including down to the floor, to improve standing balance (Dean et al., 2000)
Physical Support	No support, beside wall, corner, Kitchen bench/ table, Heavy chair/ furniture, Plinth, Rail, Body weight support,	-	No support, beside wall, corner, Kitchen bench/ table, Heavy chair/ furniture, Plinth, Rail, Body weight support,	-	No support, beside wall, corner, Kitchen bench/ table, Heavy chair/ furniture, Plinth, Rail, Body weight support,	-

	Walking Aid (state), Customise		Walking Aid (state), Customise		Walking Aid (state), Customise	
Movement size	Hold balance for 5s-60s	-	NA	Use Theraband for strengthening exercises or increase repetition (Kim et al., 2016)	NA	Karvonen formula: [(HRR × Training %) + Resting heart rate] trained at 40% to 50% of max HR, increasing increments of 10% every 4wks up to 70% to 80%, as tolerated (Moore et al., 2015)
Movement direction	NA	-	Forward, Backwards, Forwards & Backwards, Sideways-Left/Right, Sideways- Left & Right, Customise	Standing with the base of support constrained, with feet in parallel and tandem conditions reaching for objects, including down to the floor, to improve standing balance (Dean et al., 2000) Standing balance and reaching (Marsden et al., 2010)	Reach forwards-touch/pick up, Reach backwards touch/ pick up, Reach forwards & backwards-touch/pickup, Reach to the left/right-touch/pickup, Reach to the right and left to touch/pickup, Reach up/down-touch/pick up	Graded reaching activities in standing and reaching task (Dean et al., 2012) Reaching exercises (Marsden et al., 2010)
Movement speed	NA	-	Comfortable speed, Increased, Max, Slow, customise	A series of 6 exercises based on the movement science approach focused on improving strength, balance, and task performance while standing, walking, and included an endurance walking station (Knox et al., 2018)	Comfortable speed, Increased, Max, Slow, customise	-
Movement smoothness/	NA	-	NA	-	No target/object, Large targets/objects, Medium	-

Accuracy			targets/objects, Small targets/objects, Line, Customise			
Vision and vestibular input	<p>Vision: Fixating on a visual reference, Obscure vision, Use vision for a secondary task, Alter visual complexity of background, Eyes closed</p> <p>Vestibular: Slow head turns, Fast head turns, Slow head movt up and down, Fast head movt up and down, Diagonal movement of head</p>	-	<p>Vision: Fixating on a visual reference, Obscure vision, Use vision for a secondary task, Alter visual complexity of background, Eyes closed</p> <p>Vestibular: Slow head turns, Fast head turns, Slow head movt up and down, Fast head movt up and down, Diagonal movement of head</p>	Rapid knee raise while standing+ standing perturbations (i.e., instructor pushing participant in a controlled manner or participant pushing instructor to destabilize balance and elicit postural reflexes). Eyes-closed conditions+ foam surface (Marigold et al., 2005)	<p>Vision: Fixating on a visual reference, Obscure vision, Use vision for a secondary task, A lter visual complexity of background, Eyes closed</p> <p>Vestibular: Slow head turns, Fast head turns, Slow head movt up and down, Fast head movt up and down, Diagonal movement of head</p>	-
Somatosensory input	Light touch contact, Touch contact, Single hand support, Two hand support, Foam, Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles), Ramps, Slopes	-	Light touch contact, Touch contact, Single hand support, Two hand support, Foam, Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles) Ramps, Slopes	Standing on the forefeet: train the gait propulsion phase. Balance and postural tonic activities on standing position (on the floor, on the forefeet and on unstable ground planes) (Grau-Pellicer et al., 2020)	Light touch contact, Touch contact, Single hand support, Two hand support, Foam, Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles), Ramps, Slopes	-
Motor task	Holding customise object, Passing/picking up customise object, Self-care (teeth, hair,face), Holding heavy load/ an object that spills, Holding a large object/ fragile object, Throwing/ Catching	-	Holding customise object, Passing/picking up customise object, Self-care (teeth, hair, face), Holding heavy load/ an object that spills, Holding a large object/ fragile object, Throwing/ Catching	Task-specific, included part- as well as whole-practice of tasks, with an emphasis on repetition and feedback (English et al., 2015)	Holding customise object, Passing/picking up customise object, Self-care (teeth, hair, face), Holding heavy load/ an object that spills, Holding a large object/ fragile object, Throwing/ Catching	Reaching, picking object and turning while standing (Verma et al., 2011)
Cognitive task	Talking, Texting, Reading, Counting 3's Up, Counting 7's Down,	-	Talking, Texting, Reading, Counting 3's Up, Counting 7's Down,	-	Talking, Texting, Reading, Counting 3's Up, Counting 7's Down,	-

Recipe, Directions,
customise

Recipe, Directions,
customise

Recipe, Directions,
customise

Table 3B: Walking-Stepping

Task Parameters (progressions modifications)	Stepping		Backward Right/Left		Sideways Right/Left	
	Forward Right/Left		TRT App	CCT evidence	TRT App	CCT evidence
Assistance	Supervision -Assistance of 1 -Assistance of 2 -Customise	-	Supervision -Assistance of 1 -Assistance of 2 -Customise	-	Supervision -Assistance of 1 -Assistance of 2 -Customise	-
Starting position	Standard BoS, Narrow BoS, Feet together, Step stance-Left/Right, Tandem- Left/Right, Single Leg-Left/Right, Customise	-	Standard BoS, Narrow BoS, Feet together, Step stance-Left/Right, Tandem- Left/Right, Single Leg-Left/Right, Customise	-	Talking, Texting, Reading, Counting 3's Up, Counting 7's Down, Recipe, Directions, customise	-
Physical Support	No support, beside wall, corner, Kitchen bench/ table, Heavy chair/ furniture, Plinth, Rail, Body weight support, Walking Aid (state), Customise	Start holding on for support. Progress depth of step into a lunge (Mudge et al., 2009)	No support, beside wall, corner, Kitchen bench/ table, Heavy chair/ furniture, Plinth, Rail, Body weight support, Walking Aid (state), Customise	-	No support, beside wall, corner, Kitchen bench/ table, Heavy chair/ furniture, Plinth, Rail, Body weight support, Walking Aid (state), Customise	-
Movement size	Small step length, Large step length, lunging step, customise	Step forward onto a step with the paretic limb (Caetano Martins et al., 2020) Stepping forwards (Moore et al., 2015; Stuart et al., 2019; Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017; Verma et al., 2011)	Small step length, Large step length, lunging step, customise	Stepping forward, backward, and sideways onto blocks of various heights to strengthen the affected leg muscles (Dean et al., 2000)	Small step length, Large step length, lunging step, customise	Stepping forward, backward, and sideways onto blocks of various heights to strengthen the affected leg muscles (Dean et al., 2000) Sideways stepping (Dean et al., 2012; Marigold et al., 2005) Adjusting the exercise performance (e.g.,

						deeper knee bends) or balance challenge (decreased support base) to increase the exercise demand (Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017)
Movement direction	-	-	-	-	-	-
Movement speed	Increased/Max, Slow speed, customise	-	Increased/Max, Slow speed, customise	-	Increased/Max, Slow speed, customise	-
Movement smoothness/ Accuracy	Large/medium/small target, Line, customise	Increasing the no. of reps completed within 5mins at each station, increasing complexity at each workstation, such as the distance reached in standing (Dean et al., 2000)	Large/medium/small target, Line, customise	Forward, side, and backward stepping (Stuart et al., 2019)	Large/medium/small target, Line, customise	Forward, side, and backward stepping (Stuart et al., 2019; Verma et al., 2011)
Vision and vestibular input	Vision: Fixating on a visual reference, Obscure vision, Use vision for a secondary task, Alter visual complexity of background, Eyes closed Vestibular: Slow head turns, Fast head turns, Slow head movt up and down, Fast head movt up and down, Diagonal movement of head	-	Vision: Fixating on a visual reference, Obscure vision, Use vision for a secondary task, Alter visual complexity of background, Eyes closed Vestibular: Slow head turns, Fast head turns, Slow head movt up and down, Fast head movt up and down, Diagonal movement of head	-	Vision: Fixating on a visual reference, Obscure vision, Use vision for a secondary task, Alter visual complexity of background, Eyes closed Vestibular: Slow head turns, Fast head turns, Slow head movt up and down, Fast head movt up and down, Diagonal movement of head	-
Somatosensory input	Light touch contact, Touch contact, Single hand support, Two hand support, Foam,	-	Light touch contact, Touch contact, Single hand support, Two hand support, Foam,	-	Light touch contact, Touch contact, Single hand support, Two hand support, Foam,	-

	Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles), Ramps, Slopes		Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles), Ramps, Slopes		Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles), Ramps, Slopes
Motor task	Holding customise object, Passing/picking up customise object, Self care (teeth, hair,face), Holding heavy load/ an object that spills, Holding a large object/ fragile object, Passing/picking up heavy load/an object that spills/large object Throwing/ Catching	-	Holding customise object, Passing/picking up customise object, Self care (teeth, hair,face), Holding heavy load/ an object that spills, Holding a large object/ fragile object, Passing/picking up heavy load/an object that spills/large object Throwing/ Catching	-	Holding customise object, Passing/picking up customise object, Self care (teeth, hair,face), Holding heavy load/ an object that spills, Holding a large object/ fragile object, Passing/picking up heavy load/an object that spills/large object Throwing/ Catching
Cognitive task	Talking, Texting, Reading, Counting 3's Up, Counting 7's Down, Recipe, Directions, customise	-	Talking, Texting, Reading, Counting 3's Up, Counting 7's Down, Recipe, Directions, customise	-	Talking, Texting, Reading, Counting 3's Up, Counting 7's Down, Recipe, Directions, customise

Table 4A: Walking - Forwards, backwards, sideways

Task Parameters (progressions modifications)	Walking Forwards		Backwards		Sideways Right/Left	
	TRT App	CCT evidence	TRT App	CCT evidence	TRT App	CCT evidence
Assistance	Supervision -Assistance of 1 -Assistance of 2 -Customise	-	Supervision -Assistance of 1 -Assistance of 2 -Customise	Walking in different directions, Progressed by reducing arm support, by increasing speed of movement, or both (Pang et al., 2005)	Supervision -Assistance of 1 -Assistance of 2 -Customise	Walking in different directions, Progressed by reducing arm support, by increasing speed of movement, or both (Pang et al., 2005)
Physical Support	Walking Aid (state), , Hallway, beside wall, Kitchen bench/ table, Plinth, Rail, Body weight support Customise	-	Hallway, Kitchen bench/ table, Heavy chair/ furniture, Plinth, Rail, Body weight support, Walking Aid (state), Customise	-	Walking Aid (state), Hallway, besides wall, Kitchen bench/ table, Plinth, Rail, Body weight support, , Customise	-
Movement size	Comfortable step length, small/large, even step length, Customise	Customised and progressed to suit individual subjects (Blennerhassett & Dite, 2004) Task-specific, included part- as well as whole-practice of tasks, with an emphasis on repetition and feedback (English et al., 2015) Increase workload on treadmill by speed or inclination (Kim et al., 2016)	Comfortable step length, small/large, even step length, Customise	The exercise progression included increasing the weights acc to the perceived exertion or adjusting the exercise performance (e.g., deeper knee bends) or balance challenge (decreased support base) to increase the exercise demand (Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017)	Comfortable step length, small/large, even step length, Customise	The nature and difficulty of the exercises were progressed regularly to ensure that the intervention remained challenging (Dean et al., 2012) Walking with various challenges (e.g., different step lengths and speeds) (Marigold et al., 2005) Walking + change direction, Walking backward +Side

		<p>Task performance while walking, and included an endurance walking station (Knox et al., 2018)</p> <p>Walking with various challenges (e.g., different step lengths and speeds, tandem walking, figure-eight walking, stepping up and over low risers, side stepping, crossover stepping, and stepping over obstacles) (Marigold et al., 2005)</p> <p>Walking forward in tandem gait, in various directions, with turns (Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017)</p>				<p>stepping (Moore et al., 2015)</p> <p>The exercise progression included increasing the weights acc to the perceived exertion or adjusting the exercise performance (e.g., deeper knee bends) or balance challenge (decreased support base) to increase the exercise demand (Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017)</p>
Distance	2m, 3m 10m, 20m, 100m, customise	<p>The nature and difficulty of the exercise were progressed regularly to ensure that the intervention remained challenging (Dean et al., 2012)</p> <p>Walking + change direction, Sit-to-stand+ walking around chair (Moore et al., 2015)</p>	2m, 3m 10m, 20m customise	Start with 5 minutes of exercise gradually increase to 15mins (Moore et al., 2015)	2m, 3m 10m, 20m customise	-

		Walking quickly and walking for specified distances (Outermans et al., 2010)				
		Walking for a goal (at a distance of 5 m) (Verma et al., 2011)				
Movement speed	Increased/Max, Slow speed, customise	Uninterrupted/continuous walking as fast as possible on a circuit with obstacles (Grau-Pellicer et al., 2020)	Increased/Max, Slow speed, customise	Start near wall for balance. Progress to center of room and shuttle runs (Mudge et al., 2009)	Increased/Max, Slow speed, customise	Walking with various challenges (e.g., different step lengths and speeds) (Marigold et al., 2005)
		Walking with various challenges (e.g., diff step lengths and speeds) (Marigold et al., 2005)		Walking in different directions, Progressed by reducing arm support, by increasing speed of movement, or both (Pang et al., 2005)		Walking in different directions, Progressed by reducing arm support, by increasing speed of movement, or both (Pang et al., 2005)
		Walking quickly and walking for specified distances (Outermans et al., 2010)				
		Walking in different directions, Tandem walking, Walking through an obstacle course, Sudden stops and turns during walking, Brisk walking (Pang et al., 2005)				
		Ambulate 6mins at each participant's				

		comfortable pace (Stuart et al., 2019)				
		Fast walking (Verma et al., 2011)				
Movement smoothness/ Accuracy	Increased step width, Narrow step width, line	Independent work at home: participants performed a progressive home ambulation program the remaining days of the week (Grau-Pellicer et al., 2020)	Increased step width, Narrow step width, line	-	NA	-
		Walking in different directions, Tandem walking, Walking through an obstacle course, Sudden stops and turns during walking, Brisk walking (Pang et al., 2005)				
		Training modalities included brisk level and inclined overground walking (Tang et al., 2014)				
		Motor imagery task: Walking in a real-life situation, Previous way of walking, Walking with long steps, Symmetrical walking Goal-directed walking (Verma et al., 2011)				

Vision and vestibular input	<p>Vision: Fixating on a visual reference, Attending to environment, Obscure vision, Use vision for a secondary task, Alter visual complexity of background</p> <p>Vestibular: Slow head turns, Fast head turns, Slow head movt up and down, Fast head movt up and down, Diagonal movement of head, customise</p>	-	<p>Vision: Fixating on a visual reference, Attending to environment, Obscure vision, Use vision for a secondary task, Alter visual complexity of background</p> <p>Vestibular: Slow head turns, Fast head turns, Slow head movt up and down, Fast head movt up and down, Diagonal movement of head, customise</p>	-	<p>Vision: Fixating on a visual reference, Attending to environment, Obscure vision, Use vision for a secondary task, Alter visual complexity of background</p> <p>Vestibular: Slow head turns, Fast head turns, Slow head movt up and down, Fast head movt up and down, Diagonal movement of head, customise</p>	-
Somatosensory input	<p>Light touch contact, Touch contact, Single hand support, Two hand support, Foam, Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles), Ramps,slopes</p>	<p>Over-ground walking with auditory stimulus: walk while listening a metronome beat (Caetano Martins et al., 2020)</p> <p>1.Standing up from a chair, walking a short distance, and returning to the chair to promote a smooth transition between the two tasks; the remaining stations</p> <p>2.Walking on a treadmill</p> <p>3. Walking over various surfaces and obstacles</p> <p>4. Walking over slopes and stairs provided the opportunity for practice of walking under variant conditions</p>	<p>Light touch contact, Touch contact, Single hand support, Foam, Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles), Ramps, slopes, customise</p>	-	<p>Light touch contact, Touch contact, Single hand support, Foam, Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles), Ramps, slopes, customise</p>	-

		(Dean et al., 2000)			
		Walking on different surfaces (carpet, foam) (Pang et al., 2005)			
		The exercises to be performed were retrieved from a high-intensity functional exercise (HIFE) program of lower limb strength and balance exercises, such as rising from a seated position and squats in parallel or walking stance or walking on a soft surface (Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017)			
Motor task	Holding customise object, Passing/picking up customise object, Carrying heavy load/ Holding an object that spills, Holding large object/ fragile object, Throwing/ Catching	Figure-of-eight walking (carrying an object) (Marsden et al., 2010) Sitting in a chair and walking, walking over the obstacles, carrying goods, turning the goods upside down, and walking fast in a circle (Song et al., 2015)	Holding customise object, Passing/picking up customise object, Carrying heavy load/ Holding an object that spills, Holding large object/ fragile object, Throwing/ Catching	-	Holding customise object, Passing/picking up customise object, Carrying heavy load/ Holding an object that spills, Holding large object/ fragile object, Throwing/ Catching
		Walking-related tasks: Walking through obstacles, Walking for a			

		goal (at a distance of 5 m), Walking while picking up objects from the floor, Walking carrying a object, Fast walking (Verma et al., 2011)			
Cognitive task	Talking, Texting, Reading, Counting 3's Up, Counting 7's Down, Recipe, Directions, customise	-	Talking, Texting, Reading, Counting 3's Up, Counting 7's Down, Recipe, Directions, customise	-	Talking, Texting, Reading, Counting 3's Up, Counting 7's Down, Recipe, Directions, customise

Table 4B: Walking – Turning

Task Parameters (progressions modifications)	Turning 90°		Turning 180°		Turning 360°		Step and turn	
	TRT App	CCT evidence	TRT App	CCT evidence	TRT App	CCT evidence	TRT App	CCT evidence
Assistance	Supervision -Assistance of 1 -Assistance of 2 -Customise	Progressed by reducing arm support, by increasing speed of movement (Pang et al., 2005)	Supervision -Assistance of 1 -Assistance of 2 -Customise	Progressed by reducing arm support, by increasing speed of movement (Pang et al., 2005)	Supervision -Assistance of 1 -Assistance of 2 -Customise	Progressed by reducing arm support, by increasing speed of movement (Pang et al., 2005)	Supervision -Assistance of 1 -Assistance of 2 -Customise	-
Starting position	Standard BoS, Narrow BoS, Feet together, Step stance- Left/Right, customise	The exercise progression included increasing the perceived exertion or adjusting the exercise performance (e.g., deeper knee bends) or balance challenge (decreased support base) to increase the exercise demand (Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017)	Standard BoS, Narrow BoS, Feet together, Step stance- Left/Right, customise	The exercise progression included increasing the perceived exertion or adjusting the exercise performance (e.g., deeper knee bends) or balance challenge (decreased support base) to increase the exercise demand (Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017)	Standard BoS, Narrow BoS, Feet together, Step stance- Left/Right, customise	Increasing the no. of reps completed within 5mins at each station, increasing complexity at each workstation (Dean et al., 2000) The exercise progressn included increasing the perceived exertion or adjusting the exercise performance (e.g., deeper knee bends) or balance challenge (decreased support base) to increase the exercise demand	Standard BoS, Narrow BoS, Feet together, Step stance- Left/Right, customise	-

						(Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017)	
Physical Support	Walking Aid (state), Hallway, beside wall, Kitchen bench/table, Plinth, Rail, Body weight support, Customise	-	Walking Aid (state), Hallway, beside wall, Kitchen bench/table, Plinth, Rail, Body weight support, Customise	-	Walking Aid (state), Hallway, beside wall, Kitchen bench/table, Plinth, Rail, Body weight support, Customise	-	Walking Aid (state), Hallway, beside wall, Kitchen bench/table, Plinth, Rail, Body weight support, Customise
Movement size	Comfortable step length, small/large, Customise	Karvonen formula: $[(HRR \times \text{Training } \%) + \text{Resting HR}]$ trained at 40% to 50% of max HR, increasing increments of 10% every 4 wks up to 70% to 80%, as tolerated (Moore et al., 2015)	Comfortable step length, small/large, Customise	Karvonen formula: $[(HRR \times \text{Training } \%) + \text{Resting HR}]$ trained at 40% to 50% of max HR, increasing increments of 10% every 4 wks up to 70% to 80%, as tolerated (Moore et al., 2015)	Comfortable step length, small/large, Customise	To progress the cardiovascular element of the exercise program, a heart rate training zone was calculated for participants using the Karvonen formula (Moore et al., 2015)	Comfortable step length, small/large, Customise
Movement direction	Left, Right, Alternating Left and Right, customise	Customised and progressed to suit individual subjects via increasing the workload through progressive target HR (Outermans et al., 2010)	Left, Right, Alternating Left and Right, customise	Customised and progressed to suit individual subjects via increasing the workload through progressive target HR (Outermans et al., 2010)	Left, Right, Alternating Left and Right, customise	-	Left, Right, Alternating Left and Right, customise
		Sudden stops and					

		turns during walking (Pang et al., 2005)						
Movement speed	Comfortable speed, Increased speed, Max speed, Slow speed, Customise	Progressed by reducing arm support, by increasing speed of movement (Pang et al., 2005)	Comfortable speed, Increased speed, Max speed, Slow speed, Customise	Progressed by reducing arm support, by increasing speed of movement (Pang et al., 2005)	Comfortable speed, Increased speed, Max speed, Slow speed, Customise	Progressed by reducing arm support, by increasing speed of movement (Pang et al., 2005)	Comfortable speed, Increased speed, Max speed, Slow speed, Customise	Sudden stops, step and turns during walking (Pang et al., 2005)
						Walking fast in a circle (Song et al., 2015)		
Movement smoothness/ Accuracy	NA	-	NA	-	NA	-	Step-90 turn, 180 turn, 360 turn, Walk-90 turn, 180 turn, 360 turn	-
Vision and vestibular input	Vision: Fixating on a visual reference, Attending to environment, Obscure vision, Use vision for a secondary task, Alter visual complexity of background Vestibular: Slow head turns, Fast head turns, Slow head movt up and down, Fast head movt up and down, Diagonal movement of head, customise	-	Vision: Fixating on a visual reference, Attending to environment, Obscure vision, Use vision for a secondary task, Alter visual complexity of background Vestibular: Slow head turns, Fast head turns, Slow head movt up and down, Fast head movt up and down, Diagonal movement of head, customise	-	Vision: Fixating on a visual reference, Attending to environment, Obscure vision, Use vision for a secondary task, Alter visual complexity of background Vestibular: Slow head turns, Fast head turns, Slow head movt up and down, Fast head movt up and down, Diagonal movement of head, customise	-	Vision: Fixating on a visual reference, Attending to environment, Obscure vision, Use vision for a secondary task, Alter visual complexity of background Vestibular: Slow head turns, Fast head turns, Slow head movt up and down, Fast head movt up and down, Diagonal movement of head, customise	-

Somatosensory input	Light touch contact, Touch contact, Single hand support, Foam, Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles), Ramps,slopes	-	Light touch contact, Touch contact, Single hand support, Foam, Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles), Ramps,slopes	-	Light touch contact, Touch contact, Single hand support, Foam, Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles), Ramps,slopes	-	Light touch contact, Touch contact, Single hand support, Foam, Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles), Ramps,slopes	-
Motor task	Holding customise object, Passing/picking up customise object, Self care (teeth, hair, face), Holding heavy load, Passing/picking up heavy load, Holding an object that spills, Passing/picking up an object that spills, Holding large object, Passing/picking up a large object, Holding fragile object, Passing /picking up a fragile object, Throwing / Catching, Customise	Reaching, picking object and turning while standing (Verma et al., 2011)	Holding customise object, Passing/picking up customise object, Self care (teeth, hair, face), Holding heavy load, Passing/picking up heavy load, Holding an object that spills, Passing/picking up an object that spills, Holding large object, Passing/picking up a large object, Holding fragile object, Passing /picking up a fragile object, Throwing / Catching, Customise	Reaching, picking object and turning while standing (Verma et al., 2011)	Holding customise object, Passing/picking up customise object, Self care (teeth, hair, face), Holding heavy load, Passing/picking up heavy load, Holding an object that spills, Passing/picking up an object that spills, Holding large object, Passing/picking up a large object, Holding fragile object, Passing /picking up a fragile object, Throwing / Catching, Customise	Reaching, picking object and turning while standing (Verma et al., 2011)	Holding customise object, Passing/picking up customise object, Self-care (teeth, hair, face), Holding heavy load, Passing/picking up heavy load, Holding an object that spills, Passing/picking up an object that spills, Holding large object, Passing/picking up a large object, Holding fragile object, Passing/picking up a fragile object, Throwing / Catching, Customise	-
Cognitive task	Talking, Texting, Reading,	-	Talking, Texting, Reading,	-	Talking, Texting, Reading,	-	Talking, Texting, Reading,	-

Counting 3's Up,
Counting 7's
Down, Recipe,
Directions,
customise

Counting 3's Up,
Counting 7's
Down, Recipe,
Directions,
customise

Counting 3's Up,
Counting 7's
Down, Recipe,
Directions,
customise

Counting 3's Up,
Counting 7's
Down, Recipe,
Directions,
customise

Table 4C: High-level mobility – Stairs, Step touch, Step up and down

	Walking Stairs		Step Touch		Step up/down	
Task Parameters (progressions modifications)	TRT App	CCT evidence	TRT App	CCT evidence	TRT App	CCT evidence
Assistance	Supervision -Assistance of 1 -Assistance of 2 -Customise	-	Supervision -Assistance of 1 -Assistance of 2 -Customise	-	Supervision -Assistance of 1 -Assistance of 2 -Customise	Alternate stepping onto low risers, Progressed by reducing arm support, by increasing speed of movement or decreasing support (Pang et al., 2005)
Starting position Physical Support	NA Beside wall, Kitchen bench/ table, Plinth, Rail, Body weight support, Walking Aid (state), Customise	- -	NA Beside wall, Kitchen bench/ table, Plinth, Rail, Body weight support, Walking Aid (state), Customise	- -	NA Beside wall, Kitchen bench/ table, Plinth, Rail, Body weight support, Walking Aid (state), Customise	- -
Movement size	Step height 15cm, 30cm, 45cm, customise	Steps: to train the task of climbing stairs (Grau-Pellicer et al., 2020) Stepper/stairs, customized progression to suit the ability of individual participants (Marsden et al., 2010) Stair climbing (Verma et al., 2011)	Step height 15cm, 30cm, 45cm, customise	To progress the cardiovascular element of the exercise program, a heart rate training zone was calculated for participants using the Karvonen formula (Moore et al., 2015)	Step height 15cm, 30cm, 45cm, customise	Customised and progressed to suit individual subjects (Blennerhassett & Dite, 2004) Step up onto a step, starting with the paretic limb, and step down, starting with the non-paretic limb (Caetano Martins et al., 2020) Task-oriented exercises: steps- to train the task

					of climbing stairs (Grau-Pellicer et al., 2020)
					Start with low step. Progress by increasing height of step (Mudge et al., 2009)
					Alternate stepping onto low risers, Progressed by reducing arm support, by increasing speed of movement (Pang et al., 2005)
					Step ups sing Borg Rating of Perceived Exertion Scale (Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017)
Movement direction	Forwards, Sideways, Diagonal, Customise	-	Forwards, Sideways, Diagonal, Customise	-	Forwards, Sideways, Diagonal, Customise
					stepping forward, backward, and sideways onto blocks of various heights to strengthen the affected leg muscles (Dean et al., 2000)
					Stepping up and over low risers, side stepping, crossover stepping, and stepping over obstacles (Marigold et al., 2005)

						Forward, side, box step onto a step (Moore et al., 2015)
Movement speed	Comfortable speed, Increased speed, Max speed, Slow speed, Customise	High-intensity training-programme focused on improving postural control and gait-related activities such as stair walking (Outermans et al., 2010)	Comfortable speed, Increased speed, Max speed, Slow speed, Customise	-	Comfortable speed, Increased speed, Max speed, Slow speed, Customise	Customized progression to suit the ability of individual participants (Marigold et al., 2005)
						Alternate stepping onto low risers, Progressed by reducing arm support, by increasing speed of movement (Pang et al., 2005)
						Step ups, customized progression to suit the ability of individual participants (Tang et al., 2014)
Movement smoothness/ Accuracy	Wide, narrow pathway, on a line and customise	-	Wide, narrow pathway, on a line and customise	-	Wide, narrow pathway, on a line and customise	-
	Large, medium, small target, customise		Large, medium, small target, customise		Large, medium, small target, customise	
Vision and vestibular input	Vision: Obscure vision, Lighting, Use vision for a secondary task, Alter visual complexity of background, Shift position of objects in the visual field, Change the speed of moving objects, Eyes closed Vestibular: Slow head turns, Fast head turns, Slow head movt up and	-	Vision: Obscure vision, Lighting, Use vision for a secondary task, Alter visual complexity of background, Shift position of objects in the visual field, Change the speed of moving objects, Eyes closed Vestibular: Slow head turns, Fast head turns, Slow head movt up and	-	Vision: Obscure vision, Lighting, Use vision for a secondary task, Alter visual complexity of background, Shift position of objects in the visual field, Change the speed of moving objects, Eyes closed Vestibular: Slow head turns, Fast head turns, Slow head movt up and	-

	down, Fast head movt up and down, Diagonal movement of head, customise		down, Fast head movt up and down, Diagonal movement of head, customise		down, Fast head movt up and down, Diagonal movement of head, customise
Somatosensory input	Foam, Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles)	Walking over slopes and stairs provided the opportunity for practice of walking under variant conditions (Dean et al., 2000)	Foam, Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles)	-	Foam, Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles)
Motor task	Holding object, Passing/Receiving object, Holding heavy object, Passing/ receiving heavy object, Holding object that spills, Passing/ receiving object that spills, Holding large object, Passing/ receiving large object, Holding fragile object, Passing /receiving fragile object, Customise	-	Holding object, Passing/Receiving object, Holding heavy object, Passing/ receiving heavy object, Holding object that spills, Passing/ receiving object that spills, Holding large object, Passing/ receiving large object, Holding fragile object, Passing /receiving fragile object, Customise	-	Holding object, Passing/Receiving object, Holding heavy object, Passing/ receiving heavy object, Holding object that spills, Passing/ receiving object that spills, Holding large object, Passing/ receiving large object, Holding fragile object, Passing /receiving fragile object, Customise
Cognitive task	Talking, Texting, Reading, Counting, Recipe, Directions, customise	-	Talking, Texting, Reading, Counting, Recipe, Directions, customise	-	Talking, Texting, Reading, Counting, Recipe, Directions, customise

Table 4D: High-level mobility –Obstacles

Task Parameters (progressions modifications)	Walking around obstacles		Stepping over obstacle		On/ Off obstacles		Avoiding moving objects	
	TRT App	CCT evidence	TRT App	CCT evidence	TRT App	CCT evidence	TRT App	CCT evidence
Assistance	Supervision -Assistance of 1 -Assistance of 2 -Customise	Progressed by reducing arm support, by increasing speed of movement (Pang et al., 2005)	Supervision -Assistance of 1 -Assistance of 2 -Customise	Obstacle course on different surfaces with reducing arm support (carpet, foam) (Pang et al., 2005)	Supervision -Assistance of 1 -Assistance of 2 -Customise	-	Supervision -Assistance of 1 -Assistance of 2 -Customise	-
Starting position	Standard BoS, Narrow BoS, Feet together, Step stance- Left/Right, customise	Decreased support base when walking around obstacles (Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017)	Standard BoS, Narrow BoS, Feet together, Step stance-Left/Right, customise	Decreased support base when walking during obstacles course (Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017)	Standard BoS, Narrow BoS, Feet together, Step stance- Left/Right, customise	-	Standard BoS, Narrow BoS, Feet together, Step stance- Left/Right, customise	-
Physical Support	Walking Aid (state), Hallway, beside wall, Kitchen bench/ table, Plinth, Rail, Body weight support, Customise	-	Walking Aid (state), Hallway, beside wall, Kitchen bench/ table, Plinth, Rail, Body weight support, Customise	-	Walking Aid (state), Hallway, beside wall, Kitchen bench/ table, Plinth, Rail, Body weight support, Customise	-	Walking Aid (state), Hallway, beside wall, Kitchen bench/ table, Plinth, Rail, Body weight support, Customise	-
Movement size	Obstacle height 15cm, 30cm, 45cm and customise 3m, 5m, 10m, 20m and Comfortable step	Obstacle course customised and progressed to suit individual subjects (Blennerhassett & Dite, 2004)	Obstacle height 15cm, 30cm, 45cm and customise 3m, 5m, 10m, 20m and Comfortable	Crossover stepping, and stepping over obstacles (Marigold et al., 2005) The exercise	Obstacle height 15cm, 30cm, 45cm and customise 3m, 5m, 10m,	-	Obstacle height 15cm, 30cm, 45cm and customise 3m, 5m, 10m,	-

	length, small/large, Customise	Walking over various surfaces and obstacles and walking over slopes and stairs provided the opportunity for practice of walking under variant conditions (Dean et al., 2000) Walking with various challenges (e.g., different step lengths and speeds, tandem walking, figure-eight walking, stepping up and over low risers, side stepping, crossover stepping, and stepping over obstacles). (Marigold et al., 2005)	step length, small/large, Customise	progression included increasing the weights acc to the perceived exertion or adjusting the exercise performance (Vahlberg, Cederholm, et al., 2017; Vahlberg, Lindmark, et al., 2017)	20m and Comfortable step length, small/large, Customise		20m and Comfortable step length, small/large, Customise	
Movement direction	NA	-	NA	-	NA	-	NA	-
Movement speed	Comfortable speed, Increased speed, Max speed, Slow speed, Customise	Uninterrupted/continuous walking as fast as possible on a circuit with obstacles (Grau-Pellicer et al., 2020) Obstacles with varying speed (Marigold et al.,	Comfortable speed, Increased speed, Max speed, Slow speed, Customise	Progress by increasing speed, varying obstacles (Mudge et al., 2009) Obstacle course on different surfaces by increasing speed of movement (carpet, foam) (Pang	Comfortable speed, Increased speed, Max speed, Slow speed, Customise	-	Comfortable speed, Increased speed, Max speed, Slow speed, Customise	-

		2005)		et al., 2005)				
		Progressed by reducing arm support, by increasing speed of movement (Pang et al., 2005)						
Movement smoothness/ Accuracy	Small/Medium/ Large/ customise Obstacle size Vary narrow/narrow/ wide pathway, customise	To progress the cardiovascular element of the exercise program, a heart rate training zone was calculated for participants using the Karvonen formula (Moore et al., 2015)	Small/Medium/ Large/ customise Obstacle size Vary narrow/ narrow/ wide pathway, customise	To progress the cardiovascular element of the exercise program, a heart rate training zone was calculated for participants using the Karvonen formula (Moore et al., 2015)	Small/Medium/ Large/ customise Obstacle size Vary narrow/narrow/ wide pathway, customise	-	Small/Medium/ Large/ customise Obstacle size Vary narrow/narrow/ wide pathway, customise	-
		walking over the obstacles, carrying goods, turning the goods upside down, and walking fast in a circle (Song et al., 2015)		Progress by increasing speed, varying obstacles (Mudge et al., 2009)				
Vision and vestibular input	Vision: Fixating on a visual reference, Attending to environment, Obscure vision, Use vision for a secondary task, Alter visual complexity of background Vestibular: Slow head turns, Fast head	-	Vision: Fixating on a visual reference, Attending to environment, Obscure vision, Use vision for a secondary task, Alter visual complexity of background Vestibular: Slow head turns, Fast	-	Vision: Fixating on a visual reference, Attending to environment, Obscure vision, Use vision for a secondary task, Alter visual complexity of background	-	Vision: Fixating on a visual reference, Attending to environment, Obscure vision, Use vision for a secondary task, Alter visual complexity of background	-

	turns, Slow head movt up and down, Fast head movt up and down, Diagonal movement of head, customise		head turns, Slow head movt up and down, Fast head movt up and down, Diagonal movement of head, customise		Vestibular: Slow head turns, Fast head turns, Slow head movt up and down, Fast head movt up and down, Diagonal movement of head, customise		Vestibular: Slow head turns, Fast head turns, Slow head movt up and down, Fast head movt up and down, Diagonal movement of head, customise	
Somatosensory input	Light touch contact, Touch contact, Single hand support, Firm surface, Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles), Ramps, slopes	Walking over various surfaces and obstacles and walking over slopes and stairs provided the opportunity for practice of walking under variant conditions (Dean et al., 2000)	Light touch contact, Touch contact, Single hand support, Firm surface, Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles), Ramps, slopes	Obstacle course on different surfaces (carpet, foam) (Pang et al., 2005)	Light touch contact, Touch contact, Single hand support, Firm surface, Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles), Ramps, slopes	-	Light touch contact, Touch contact, Single hand support, Firm surface, Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles), Ramps, slopes	-
Motor task	Holding customise object, Passing/picking up customise object, Self-care (teeth, hair, face), Holding heavy load, Passing/picking up heavy load, Holding an object that spills, Passing/picking up an object that spills, Holding large object, Passing/picking up a large object, Holding	Walking over the obstacles, carrying goods, turning the goods upside down, and walking fast in a circle (Song et al., 2015)	Holding customise object, Passing/picking up customise object, Self-care (teeth, hair, face), Holding heavy load, Passing/picking up heavy load, Holding an object that spills, Passing/picking up an object that spills, Holding large object, Passing/picking up a large object, Holding	-	Holding customise object, Passing/picking up customise object, Self-care (teeth, hair, face), Holding heavy load, Passing/picking up heavy load, Holding an object that spills, Passing/picking up an object that spills, Holding	-	Holding customise object, Passing/picking up customise object, Self-care (teeth, hair, face), Holding heavy load, Passing/picking up heavy load, Holding an object that spills, Passing/picking up an object that spills, Holding	-

	fragile object, Passing/ picking up a fragile object, Throwing / Catching, Customise		fragile object, Passing/ picking up a fragile object, Throwing / Catching, Customise		large object, Passing/picking up a large object, Holding fragile object, Passing/ picking up a fragile object, Throwing / Catching, Customise		large object, Passing/picking up a large object, Holding fragile object, Passing/ picking up a fragile object, Throwing / Catching, Customise
Cognitive task	Talking, Texting, - Reading, Counting 3's Up, Counting 7's Down, Recipe, Directions, customise		Talking, Texting, - Reading, Counting 3's Up, Counting 7's Down, Recipe, Directions, customise		Talking, Texting, - Reading, Counting 3's Up, Counting 7's Down, Recipe, Directions, customise		Talking, Texting, - Reading, Counting 3's Up, Counting 7's Down, Recipe, Directions, customise

Table 4E: High level Mobility –Jumping, hopping, bounding, skipping, jogging an running

	Walking		Jogging to Running	
	Jumping, hopping, bounding, skipping		Jogging to Running	
Task Parameters (progressions modifications)	TRT App	CCT evidence	TRT App	CCT evidence
Assistance	Supervision -Assistance of 1 -Assistance of 2 -Customise	-	Supervision -Assistance of 1 -Assistance of 2 -Customise	-
Starting position	Standard BoS, Narrow BoS, Feet together, Step stance, Tandem, customise	-	NA	-
Physical Support	Beside wall, Kitchen bench/ table, Heavy chair/furniture, Plinth, Rail, Body weight support, Walking Aid (state), Customise	-	Beside wall, Rail, Body weight support, Customise	-
Movement size	Comfortable step length, small/large, Customise	Jumping Verma et al., 2011	Comfortable step length, small/large, Customise	Used Karvonen formula: [(HRR × Training %) + Resting heart rate] trained at 40% to 50% of max HR, increasing increments of 10% every 4wks up to 70% to 80%, as tolerated (Moore et al., 2015)
Movement direction	Forwards, backwards, Sideways, Forward Diagonal, Backward Diagonal, Quarter turn, 180°,360°, Customise	-	NA	-
Movement speed	Comfortable speed, Increased speed, Max speed, Slow speed, Customise	-	Comfortable speed, Increased speed, Max speed, Slow speed, Customise	Motor imagery task: Fast walking, Running Jumping (Verma et al., 2011) Start near wall for balance, progress to center of room, progress to shuttke runs (Mudge et al., 2009)

Movement smoothness/ Accuracy	Wide, narrow pathway, on a line and customise Large, medium, small target, customise	-	Wide, narrow pathway, on a line and customise Large, medium, small target, customise	-
Vision and vestibular input	Vision: Obscure vision, Lighting, Use vision for a secondary task, Alter visual complexity of background, Shift position of objects in the visual field, Change the speed of moving objects, Eyes closed Vestibular: Slow head turns, Fast head turns, Slow head movt up and down, Fast head movt up and down, Diagonal movement of head, customise	-	NA	-
Somatosensory input	Foam, Uneven ground (grass, concrete), Unstable ground (sand, bark, pebbles), Ramps, Slopes	-	NA	-
Motor task	Holding object, Passing/receiving object, Throwing/ catching, Holding heavy object, Passing/receiving heavy object, Holding object that spills, Passing/receiving object that spills, Holding large object, Passing/ receiving large object, Holding fragile object, Passing /receiving fragile object, Customise	-	Holding object, Passing/receiving object, Throwing/ catching, Holding heavy object, Passing/receiving heavy object, Holding large object, Passing/ receiving large object, Holding fragile object, Passing /receiving fragile object, Customise	-
Cognitive task	Talking, Texting, Reading, Counting, Recipe, Directions, customise	-	Talking, Texting, Reading, Counting, Recipe, Directions, customise	-