

Delivering Effective Physical Therapy Remotely via a Wearable Sleeve and Mobile App
(Technical Topic)

Addressing the Impact of Motivation and Engagement in Physical Therapy
(STS Topic)

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Creating a Low-bandwidth, Highly Personable Virtual Physical Therapy World

The current state of physical therapy telehealth and home exercise programs are important to understand. Prior to the COVID-19 pandemic, insurance provided limited coverage for physical therapists to complete telehealth and was “not listed as Medicare-eligible telehealth providers in the United States” (Lee et al., 2018, 238; APTA, 2020). Telehealth inherently relies on technology, which bridges the gap in both geographical space and time, though patients, especially the older ones who are less technically adept, prefer seeing a human over “a robot” or phone screen (Sluijs & Knibbe, 1991). In some cases, they need the physical therapist (PT) physically there to move them into the correct position. As going into a physical therapy clinic isn't always possible, especially during the pandemic, the need for improved contactless physical therapy is greater than ever before. Improved remote physical therapy also has an effect on the opioid epidemic that harms society as a whole, part of the greater health crisis with an aging population (APTA, 2018).

Currently, two of the top three obstacles to telehealth are related to technology which has been stress-tested during COVID-19; a main technical limitation has been a lack of bandwidth, which remains an issue as currently ~45% of PTs use Zoom to deliver care (APTA, 2020). My team and I propose to improve the situation with a low-bandwidth solution that is easy to use, personable, and gamified. This will save PTs time by compiling the data collected while patients are personally engaged to level up in a virtual world, one in which they interact with their PT remotely (APTA, 2018).

Delivering Effective Remote Physical Therapy via a Wearable Sleeve and Mobile App

Monitoring patient health via remote technologies has become increasingly prevalent in today's pandemic driven world. With new wearables and computer vision algorithms, medical

devices are beginning to revolutionize the world of telehealth. At the same time, there is an increasing need for physical therapists to provide a novel way of prescribing at-home exercise programs (HEPs) that yield high patient compliance with the ability to be accessed remotely (Grant et al., 2005; Coppola & Collins, 2009; Tuncer et al., 2013). Currently, telehealth technology fails to bridge the gap between patients and physical therapists for both telehealth visits and HEP (Hensley et al., 2020). Telehealth is done primarily through Zoom, a platform that does not allow PTs to get quality information of a patient's motion and body position, especially limited by bandwidth which frame rate and resolution rely on (APTA, 2018; APTA, 2020). Current HEP solutions do not engage patients effectively as well as don't provide proper communication channels with physical therapists (Nelson et al., 2020). Patients will continue to go without care during the pandemic, especially those in rural areas or those unable to physically go to a clinic (Lee et al., 2018).

The deliverable of this project is a wireless motion capture wearable that tracks, analyzes, and shares human motion data over Bluetooth Low Energy. The sleeve will consist of a 9-axis inertial motion sensor and Bluetooth Low Energy chip that will send coordinate data to a phone or central server utilizing the Bluetooth. The work will build on the use of video-based motion analysis, as while 47.8% of orthopedic physical therapists use it, the most common barriers to using it include "lack of device/equipment, lack of space, and time constraints" (Hensley et al., 2020). I anticipate that an approach using small, lightweight IMUs paired with machine learning will overcome these technical obstacles, as well as that of patients not having sufficient bandwidth for telehealth. The results will be delivered directly to the patient's physical therapist, improving the communication between the patient and physical therapist, and increasing the

reimbursements PTs earn on average with concrete quantitative results. The system as a whole, named BravePT, can be seen in Figure 1.

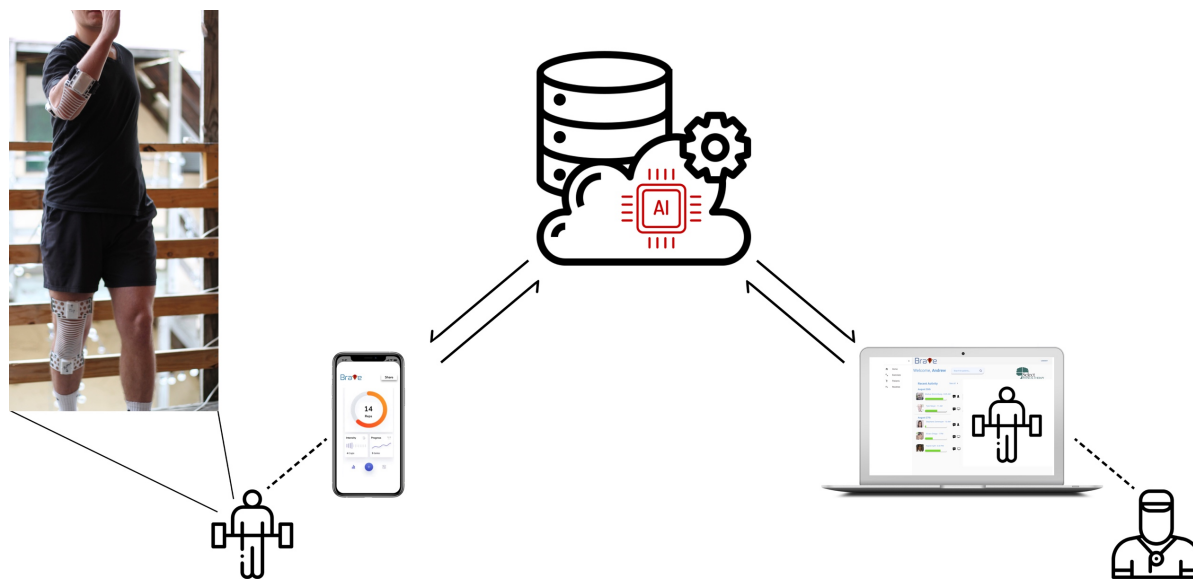


Figure 1. Overview of the BravePT Platform

With patients already suffering from a life-changing event, the need to recover quickly and efficiently is placed at a greater importance. Yet, patients are overwhelmed by the number of visits per week to PT clinics, travel constraints, and the opportunity cost of time away from jobs and families. This causes patients to end their course of physical therapy well before successfully recovering. Research indicates that 70% of patients do not complete their prescribed course of treatment and never reach their full potential wellbeing (Klepps, 2015). This is because as patients begin to see even slight improvements in mobility and relief from crippling pain, their incentives to sacrifice time, work, and family obligations for PT sessions drop significantly. Thus, the project's sleeve provides the convenience of enabling at-home therapy routines with quantitative data collection to ensure recovery. This eliminates the need to sacrifice time by receiving professional care anytime, anywhere.

Health insurance companies spend unnecessary costs per year for patients with a physical injury who undergo long term drug use, chronic pain, or reinjury. These can all have a high likelihood of being avoided if patients undergo physical therapy as stated anecdotally and in literature by PTs and surgeons. For example, in an APTQI report from 2017, beneficiaries who receive therapy within the first 15 days, compared to 45-90 days after being diagnosed, are observed to have downstream costs that are ~27% lower on average (Athletico, 2020). However, insurance companies, Medicare, and physical therapists are missing the quantitative measurements, and reports needed to justify such claims and treatments are effective. Additionally, Medicare has become the most susceptible government mandated program in the United States to lose money due to fraudulent claims, with over \$60 billion lost to waste in 2017 (Eaton, 2018). This can be mitigated through accurate data reporting using the group's sleeve.

Addressing the Impact of Engagement and Motivation in Physical Therapy

Physical therapy patients are often older, as one PT put it, “many older patients are not tech-savvy. Most of our patients are over 60 years old” (APTA, 2020). In addition, increased technology in the field of PT may push the practice to become more hands-off, though patients prefer care from a human rather than technology alone (APTA, 2018). Technology has the ability to save PTs time, as well as increase their reimbursements from insurance with quantitative data (Zielinski & Marino, 2020). Even so, it has the potential to get in between the personal connection between a PT and patient instead of enhancing it.

When technology in the physical therapy space is used to enhance the relationship between a physical therapist and a patient, rather than attempt to replace the aspects unique to the practitioner, a winning combination emerges. The realm that stands to be enhanced the most is that of the home exercise program (HEP), but neither technology nor the physical therapist alone

can improve HEPs. Specifically, “motivation and engagement are crucial aspects of rehabilitation” (Janssen et al., 2017). As such, it is important that a two-prong approach must be taken to improve the effective outcomes of rehabilitation, requiring both the physical therapist and their technology to address that of motivation and engagement as a sociotechnical unit. For motivation, gamification should be the primary way HEPs are improved to psychologically change the way patients approach the exercises assigned to them as homework by their PT. Studies have been done with a control group that received a paper-based home exercise program while the intervention group had a “technology-based home exercise program using an iPad application,” resulting in “the intervention group [being] more compliant with their home exercise program” (Nelson et al., 2020). Even so, the authors of “Gamification in Physical Therapy: More Than Using Games” mention that there is currently a “gap” between game designers and therapy designers, reasoning that physical therapists and the technical experts should work together to improve the at-home care for patients (Janssen et al., 2017).

The consequences of physical therapists not adopting a new approach of greater engagement and motivation utilizing new technology include PTs spending extra time using current technology that could otherwise be saved, missing out on money from insurance reimbursements, and patients not adhering to their home exercise programs, inhibiting their recovery (Zielinski & Marino, 2020). It is important that on top of the proposed technical solution, there are elements making it easy to use, personable, and gamified for patients. All of these elements are psychological rather than technical in nature and require a sociotechnical approach to implement them (Janssen et al., 2017).

The Case for an Engaging and Motivating Virtual Physical Therapy World

Deliverables include a wearable sleeve that works with a mobile app using Bluetooth to improve how physical therapists interact with their patients remotely using a low-bandwidth solution that is easy to use, personable, and gamified. This will save PTs time by compiling the data collected while patients are personally engaged to level up in a virtual world, one in which enables them to interact with their PT remotely. In order to successfully motivate and engage patients, the sociotechnical system of a patient's physical therapy care program must become more cohesive. This should be accomplished by physical therapists utilizing one platform that allows for accessible, in-depth motion capture in addition to a direct line of communication to the patient's phone. This deliverable will save both PTs and patients time, increase insurance reimbursements for PTs, and help patients get better faster as they complete physical therapy.

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