BrainTrack: Concussion Monitoring And Recovery

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ABSTRACT
We are exploring the use of wearable technology to improve the recovery of children with concussions. Our formative work reveals issues of patient adherence to recovery regimens and communication with their healthcare providers. To address these issues, we use sensors in the Microsoft Band to monitor their physical activity and we offer instructive therapy through our mobile application. Future work will include working closely with the local children's hospital and testing our prototype in a clinical setting.

General Terms

Keywords

1. INTRODUCTION
People have been using mobile applications and consumer devices to track personal information regarding health and one's wellbeing, such as sleep and exercise. Technology has been assisting patients and healthcare providers independently but can be used to improve communication between patient and provider. The significance of improving communication standards within healthcare organizations have been recognized to improve patient recovery [1].

A concussion is a traumatic brain injury caused by a blow or impact to the head or another injury that shakes the brain in the skull. It can be observed through disorientation and impaired balance, slower reaction time, and impaired memory and learning [citation]. Our team is taking advantage of the existence of wearable technology to provide instructive therapy to children with concussions to assist their recovery. There is opportunity for wearable technology to improve the recovery of children with concussions by increasing adherence to the prescribed protocol. We are incorporating the use of Microsoft Band and its available sensors to explore the cognitive and physical changes in the patients. To detect physical movement of the patient, we are using the accelerometer as a proxy because the rate of change in coordinates represent the rigor of motion. We are also using the heart rate monitor to further understand physical movements of the patient. To increase patient engagement in therapy, we made a mobile application which displays physician's instructions and sends notifications to the patient. The objective of this project is to increase patient adherence to protocol and to facilitate communication between physicians and patients which, in turn, would restore the cognitive and physical abilities of the patients prior to their concussion.

2. BACKGROUND AND RELATED WORK
A variety of wearable technology has been used to help patients in the field of rehabilitation [2], to improve patient outcomes [3], and to monitor balance in patients with concussions [4]. These systems have focused on the use of wearable technology to provide home monitoring for patients in order to provide a more efficient and personal experience. Our researcher explores detecting physically stressful situations and sending daily reminders to patients to improve adherence and increase patient recovery time. Offering in situ therapy through mobile and band notification allows us to explore the relationship between increased communication between patient and physician, through means of a mobile

application, and patient recovery. Our goal is to help increase the speed of recovery for patients with concussions by presenting reminders and instructions that lead to long-term cognitive and physical improvement in the patient.

In addition to using Microsoft Band to inform the patient, we are also using the Band to inform the physician by providing sensor data from the Heart Rate sensor and Pedometer. We hope to analyze the sensor data to further understand concussions and instructive therapy for patients with concussions.

3. DESIGN FOR CONCUSSION PATIENTS AND THEIR PHYSICIANS

The mobile application will be used to remind patients of their current cognitive and physical stages. Reminders are critical to the recovery of the patient because, in order to recover from a concussion, a patient must go through multiple instructions during the process of recovery. Information about the guidelines, depicted in **Figure 1**, for each stage is, at times, not readily available to the patients. Our mobile application allows the patients to view such information easily.

3.1 DESIGN REQUIREMENTS

Our design constraints influenced our choices for the design flow for the mobile application and web interface. Our constraints include designing for patients with concussions, providing privacy for the patient in data collection, and collecting survey answers for evaluating cognitive progress.

Designing for patients with concussions influenced our choice to use concise language for instructions and minimize the interactions the user should make with the application.

On the login page, the user is prompted to enter their ID based on information provided by their physician, as shown in **Figure 2**. We plan to give each patient a separate ID to maintain privacy and anonymity in data collection.

In order for the physician to evaluate the cognitive level, the patient is required to take a symptom evaluation survey twice a day consisting of a symptom checklist with answers one through six - one being not severe and six being severe **(Figure 2)**.

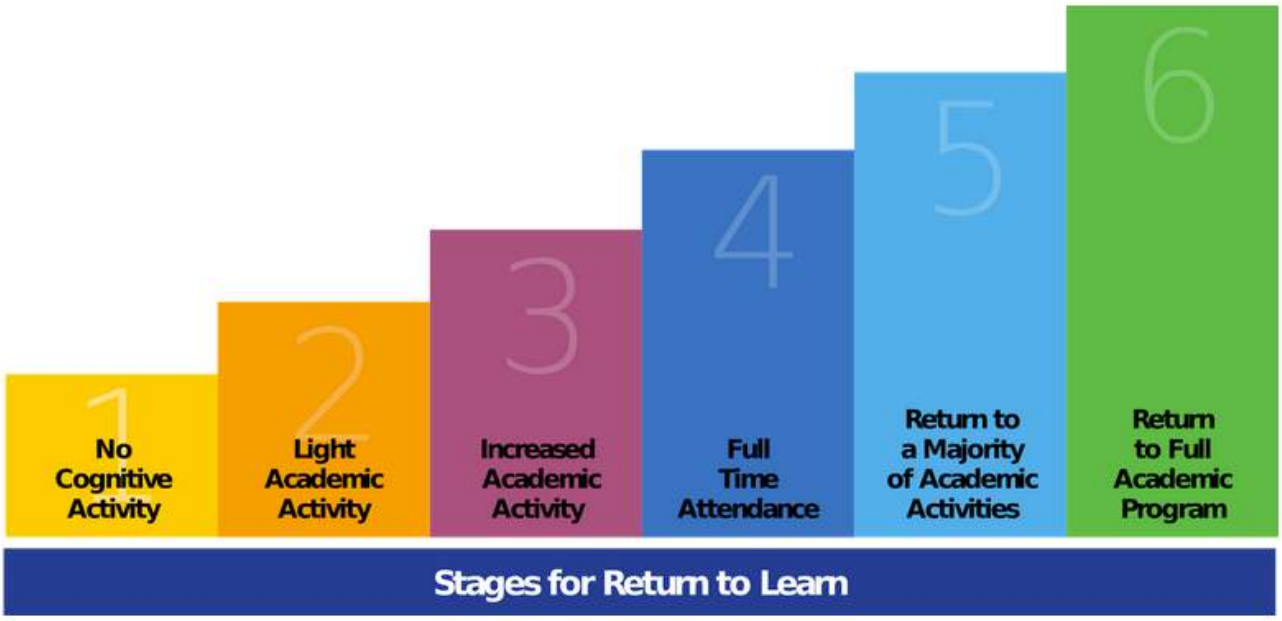


Figure 1. Recovery Stages for Concussion Patients

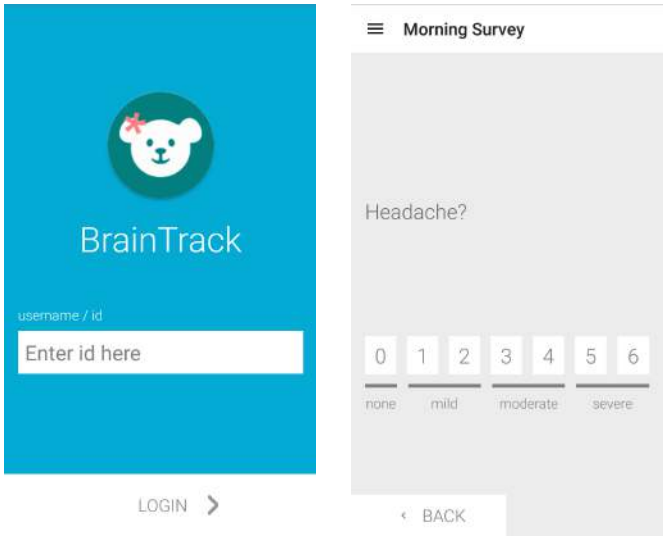


Figure 2. Login Page and Symptom Evaluation Survey

3.2 DESIGN SPECIFICATIONS

The most important aspect of designing the mobile application is the ease of access and usability when the concussed patient is navigating through the pages. The application is designed to enable quick access to information through a navigation section and the application makes use of implementing large text to enhance viewing. The navigation consists of six pages: the "Dashboard" page, "Survey" page, "Cognitive activities" page, "Physical activities" page, "Band" page, and "Settings" page.

Reminders are displayed on the front page, or the "Dashboard", to reduce cognitive load on the patient. The "Survey" page contains the symptom evaluation checklist where answers are sent to a database on our local servers. The "Cognitive" and "Physical" pages include descriptions of prescribed tasks required in such stages, the "Band" page contains information on collected sensor information, and the "Settings" page allows the patient to change the notification times for their scheduled surveys, as exemplified in **Figure 3**.

The information displayed on BrainTrack is also displayed on a web interface available to researchers and the physician. Currently, symptom evaluation survey answers can only assess the progress of recovery from a patient perspective and it is their physician who decides their actual progress. For this reason, the website is used by the physician to manually update and current cognitive and physical stages of the patient. If updated, the patient receives a notification of their new cognitive or physical stage on their phone and on their Microsoft Band.

The web interface that parallels the BrainTrack application contains individual detailed pages for each patient. Patient pages contain sensor information and recovery stages displayed in graphs. **Figure 4** demonstrates the simple format of the webpage which allows efficient retrieval of information regarding a specific patient.

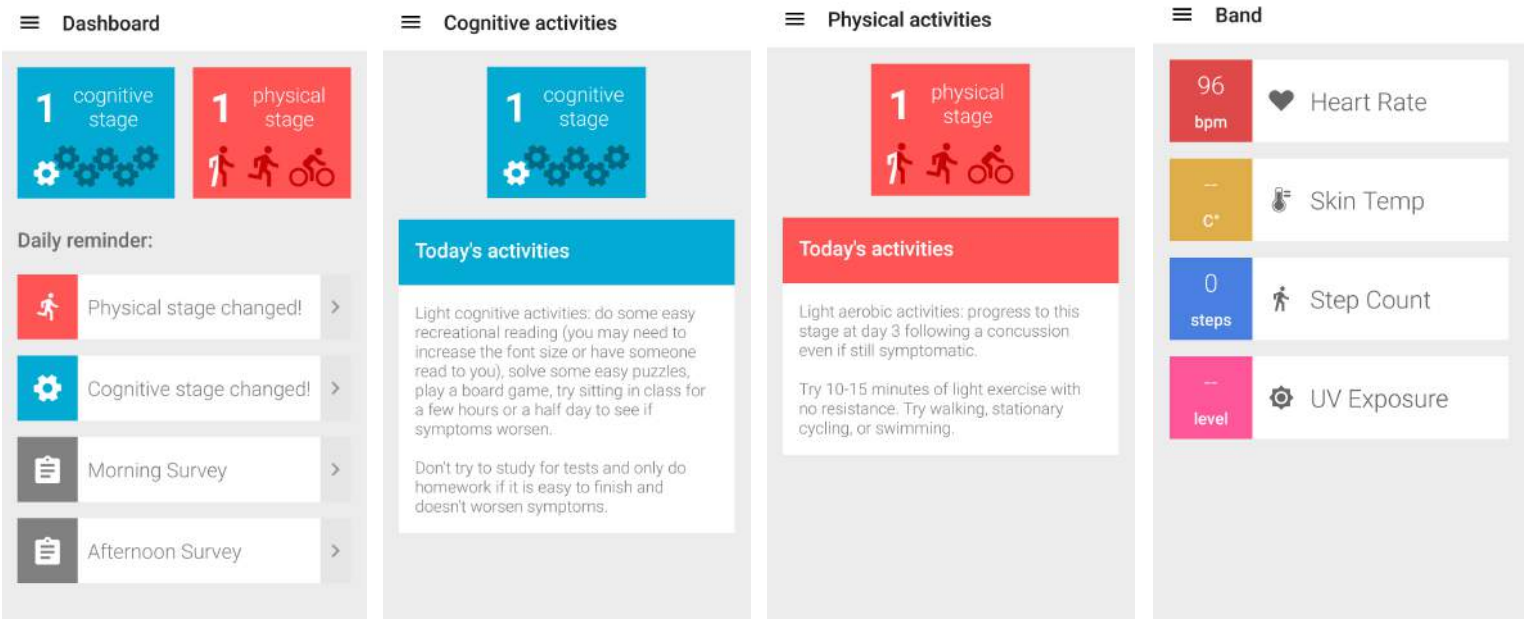
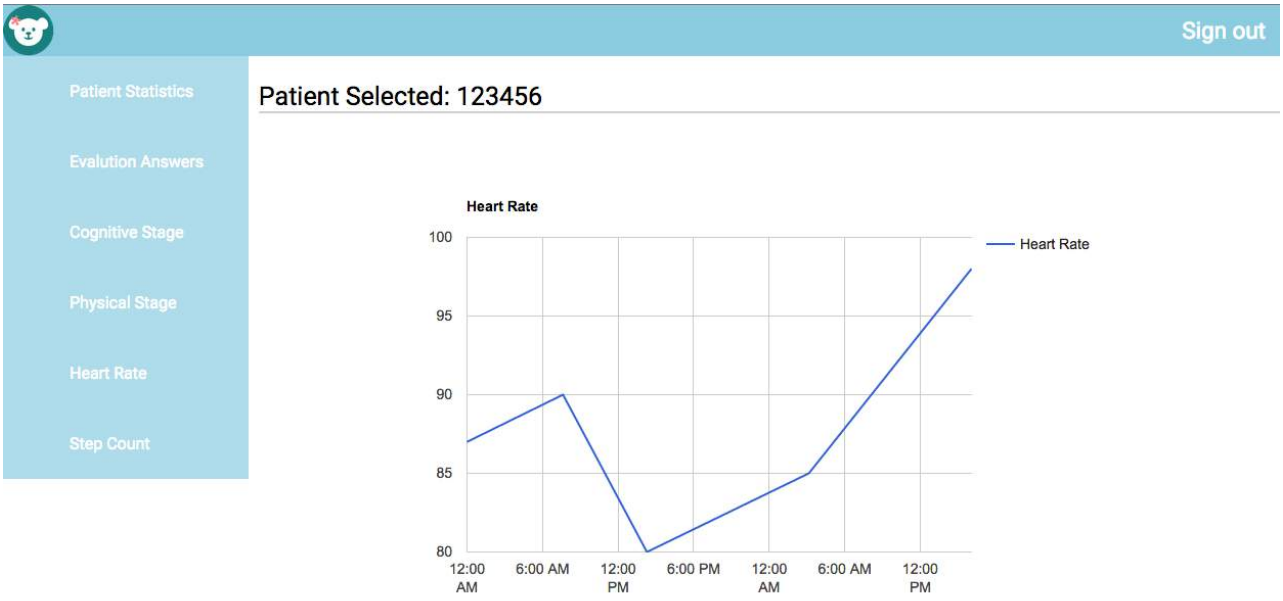


Figure 3. Examples of BrainTrack pages.

Figure 4. Individual Patient Statistics Heart Rate Page.



4. DISCUSSION

There are advantages and disadvantages in using the Microsoft Band as opposed to other available wearable fitness trackers. We decided to use the Microsoft Band despite its short battery life in comparison to other trackers, such as the Fitbit, because the screen allows the application to send haptic notifications to the user. With the Microsoft Band, the patient is also able to send replies from the Band to the BrainTrack application which we believe is important for accurate data collection.

5. FUTURE WORK

Our goal is to have a system that assists communication between patient and physician and enables physicians to manage concussion patients from any remote location. We plan to test our platform at the Children's Hospital of Orange County and hope that our application and web interface proves to be an effective tool for helping provide instructive therapy to concussion patients.

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