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Usability evaluation of the SMART application for youth with mTBI

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ABSTRACT

Objective: There is a dearth of evidence-based treatments available to address the significant morbidity associated with mild traumatic brain injury (mTBI). To address this gap, we designed a novel user-friendly, web-based application. We describe the preliminary evaluation of feasibility and usability of the application to promote recovery following mTBI in youth, the Self-Monitoring Activity-Restriction and Relaxation Treatment (SMART). SMART incorporates real-time recommendations for individualized symptom management and activity restriction along with training in cognitive-behavioral coping strategies.

Methods: We conducted a usability evaluation to assess and modify the SMART system prior to further study and deployment. Children ages 11–18 years presenting to the emergency department were recruited after symptoms resolved. Usability was assessed using a 60-min think-aloud protocol of teens and parents describing their interaction with the application. Upon completion of the tasks, each participant also completed the system usability scale (SUS).

Results: We performed tests with 4 parent/child dyads. The average age of the children was 13 years (standard deviation = 1.8). The parents were an average of 41.5 years old (standard deviation = 6.2). Research revealed that the participants were enthusiastic about the interactive portions of the tool particularly the video based sessions. Parents were concerned about the speed at which their child might move through the program and the children thought that the system required large amounts of reading. Based on user feedback, researchers modified SMART to include an audio file in every module and improved the system's aesthetic properties. The mean SUS score was 85, with high SUS scores (>68) indicating satisfactory usability.

Conclusion: High initial usability and favorable user feedback provide a foundation for further iterative development and testing of the SMART application as a tool for managing recovery from concussion.

1. Introduction

Mild traumatic brain injury (mTBI) is the one of the most common injuries sustained by youth in the United States with an estimated 3.8 million occurring annually [1–3], seventy percent are sustained by adolescents aged 10–19 years old [1]. Following the injury, over half of these youth experience acute physical, cognitive, emotional, and/or sleep-related dysfunction. For 10–30% of youth with mTBI, these symptoms persist for 30 days or more and become known as post-concussion syndrome (PCS) [1]. Effective treatments delivered soon after injury aimed to reduce impairment would have a significant public health impact. However, evidence-based treatments are lacking as detailed in a report to Congress on mTBI published by the Centers for Disease Control and Prevention (CDC) and proceedings from the World Health Organization (WHO) Collaborating Centre Task Force on mTBI [4–7].

Since mTBI symptoms emerge and resolve fairly quickly, a web-based approach to intervention delivery may be ideal because it would allow easy and repeated access to information and man-

Abbreviations: mTBI, mild traumatic brain injury; SMART, Self-Monitoring Activity-Restriction and Relaxation Treatment program; WHO, World Health Organization; PCS, post-concussion syndrome; SUS, system usability scale; ED, Emergency Department.

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agement strategies without multiple outpatient follow-up visits. Previous research involving youth with complicated mild to severe TBI has demonstrated the feasibility and efficacy of web-based therapy in improving executive and behavioral dysfunction [8–14].

Although treatments for pediatric mTBI are lacking, existing studies support the utility of anticipatory guidance and education in reducing subsequent sequelae. Specifically, parental education on expected concussion symptoms and recovery course initiated upon discharge from the emergency department reduced persistence of behavioral symptoms [15]. These findings support the potential utility of psychoeducational approaches in promoting recovery following mTBI in children.

To address this critical public health need for easily accessed, evidence-based treatments for mTBI, we developed an interactive individualized web-based intervention program for youth and their families. In accordance with recent consensus and position paper statements that cite pacing of return to cognitive and physical activities as a corner stone of concussion management [16], we created the Self-Monitoring Activity-Restriction and Relaxation Treatment (SMART) application. SMART incorporates real-time recommendations for individualized symptom management and activity restrictions tied to current symptoms, as well as anticipatory guidance, and training in evidence-based stress management, relaxation, and problem-solving skills.

Consumer health tools to help patients manage treatment and monitor care progression are becoming more wide-spread; however, the design of these systems must be able to support the consumer's needs. Specifically this means that it must be both usable and accepted by consumers [15,17,18]. A product is said to be usable if the people that are the intended users can do what they want with it in a way that is effective, efficiency and satisfying [19]. Usability testing conducted with actual users early in the development process has been previously shown to uncover potential issues related to poor interface design that can modified to better meet the needs of the users [20,21]. Usability testing facilitates discovery of system errors and potential gaps in efficient, effective, and satisfactory use such as issues relating to poor interface design [22–24]. Effectiveness is typically measured by error rates, efficiency by task completion times, and satisfaction using subjective surveys. Naïve users' ability to use technology without training (learnability) and the detailed analysis of users' interactions with design elements can provide insights as to why and/or how inefficiencies, errors, and low levels of satisfaction occur and how they might be resolved [25].

Below we describe the usability evaluation of the SMART application prototype conducted with children who sustained mTBI and their parents. Prior to launching an open label pilot trial, we conducted this evaluation to identify issues with logging on, navigation, aesthetics, content clarity, error recovery and user satisfaction. Our goal was to obtain both qualitative and quantitative user data to inform iterative modifications of the SMART application to improve system usability and acceptability.

2. Materials and methods

2.1. Participants

Children and their parents were eligible to participate in the usability testing if they presented to the pediatric emergency department (ED) March 1–31, 2013. Individuals were eligible if they were between 11 and 18 years of age, English was their primary language, had sustained mTBI, and were available to return to the hospital after symptom resolution. mTBI was defined using the following criteria: 1) a blow to the head or body, 2) the injury was witnessed or there was physical evidence of a head injury and 3) loss of consciousness, amnesia or a change in mental status occurred [26]. Loss consciousness was limited to 30 min or less, amnesia was limited to 24 h or less, and changes in mental status included feeling dazed, disoriented, or confused at the time of the injury [26]. Determination of criteria for mTBI was based on review of medical records and discussion with the treating ED physician and/or family. Participants were excluded if they had pre-existing neurologic, cognitive, psychological, or developmental problems based on parent report. Four participants and their parents or caregivers were approached and all agreed to participate in the study.

2.2. SMART application

The design of the SMART application is presented in Figs. 1 and 2. Each user of SMART receives a unique log on. Youth with mTBI are instructed to log into the SMART application daily after their injuries following discharge from the ED. Once logged into the system, the user is asked to rate their symptoms using questions contained on the Post Concussion Symptom Scale (PCSS) [27,28]. The PCSS, a 22-item questionnaire with scores ranging from 0 (no symptoms) to 7 (severe), has a total score of 154. A total score of 6 or less for females and 8 or less for males is considered normal [27,28]. The PCSS is a brief self-report measure of daily symptom burden and is commonly used to monitor symptom recovery after concussion. The user's total PCSS score is compared to his or her previous score or the "normal" score for their gender, if this is the user's first time on the website. The user is then shown a summary screen with feedback regarding his/her symptom levels (Fig. 1) (i.e the symptoms are better, worse, or about the same).

To allow the user to link his/her behavior to changes in mTBI symptoms, the user is asked to rate his/her sleep, school, brain activity, screen time, daily activities, and physical activities on the following scale: increase, decrease, no change, and not doing. After completing these ratings, the user is asked to indicate what behaviors may have contributed to the symptom changes and what she/he will change tomorrow to reduce symptoms. This approach encourages real-time self-monitoring and increased awareness of the association between behavior and symptoms. After completing these daily evaluations, the user is directed to the psychoeducational modules.

Module content was developed from several sources including CDC guidelines for return to activities following mTBI and an existing evidence-based problem-solving treatment for adolescents with more severe brain injuries [8–14]. With respect to the latter, content on staying positive, stress management, problem-solving, and staying focused was streamlined and tailored to address the unique challenges of mTBI. New modules providing an overview of the program, typical symptoms and recovery trajectories following mTBI, guidelines for returning to school and activities, tips for self-care (taking care of you) were developed along with new videos reflecting the adolescent's experience following mTBI. As detailed in Table 1, a total of eight modules (four new and four adapted from previous interventions) comprised the SMART program.

For the trial, the user interface and logic was set up based on the assumption that patients would be recruited in the ED shortly after sustaining their injury. Consequently, content is released based on time since injury and current symptoms scores. Specifically, the introduction module was available to all users 24 h after injury upon logging in to the system. The other modules were released based on the date of injury and the severity score provided in the daily questions. Participants with normal and mild PCSS scores had all modules open to them by day 4 post-injury. Participants with moderate, severe, and very severe scores had an extra day of rest suggested by the system before any modules were open. The module order varied slightly depending on the severity of the injury