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Usability evaluation of the SMART application for youth with mTBI

Judith W. Dexheimer, PhD^{a,b,*}, Brad G. Kurowski, MD MS^c, Shilo H. Anders, PhD^d, Nicole McClanahan, BS^a, Shari L. Wade, PhD^c, and Lynn Babcock, MD MS^a

^aDivision of Emergency Medicine, Cincinnati Children's Hospital Medical Center, Cincinnati, OH, United States

^bDivision of Biomedical Informatics, Cincinnati Children's Hospital Medical Center, Cincinnati, OH, United States

^cDivision of Physical Medicine and Rehabilitation, Cincinnati Children's Hospital Medical Center, Cincinnati, OH, United States

^dDepartment of Biomedical Informatics, Vanderbilt University, Nashville, TN, United States

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

*Corresponding author at: Division of Emergency Medicine, Cincinnati Children's Hospital Medical Center, MLC 2008, 3333 Burnet Avenue, Cincinnati, OH 45229-3039, United States. Judith.Dexheimer@cchmc.org (J.W. Dexheimer).

Conflict of interest

The authors declare that they have no competing interests.

Authors' contribution

All authors contributed materially to the production of this manuscript.

JWD participated in the design, acquisition of data, drafting of the manuscript, critical revision, and technical, and material support.

BGK participated in article review, conception, design, and revisions.

SHA was involved with drafting of the manuscript, usability study design, and critical revisions.

NM participated in the design, usability testing, review, and revisions.

SLW participated in study design, article review, conception, design, and critical revisions.

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= 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.

Keywords

User-computer interface; Brain injuries; Telehealth; Adolescents

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 management 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 be 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 based on expert opinion about what the participant may be able asked to do. By one week post injury, all modules were available for completion for all participants. Module title text was displayed as gray if the module was not open, green if the module was open to be used and

black if the participant had completed the module. For the usability trial, we had participants test only specific modules and they were all open.

2.3. System setup

The usability testing was performed on a 13" HP laptop computer with the Windows (Microsoft, Redmond, WA) operating system. The participants were provided with a mouse to use, although the touch-pad was available and active. The Web-based application was tested using the Internet Explorer browser, but was tested in other common browsers during design by IT personnel and researchers. Parent and child testing were performed on the same laptop computer.

2.4. Questionnaires

2.4.1. Post-module questionnaire—A post-module questionnaire was developed specifically for this study and was administered to elicit participant's thoughts about various aspects of the program including functionality and navigation using a 5-point Likert scale response for some items. Example items include: "The module was easy to use" and "I felt comfortable using the website." Additionally, the open-ended questions included: "What do you like/dislike about this module?" and "What would you change?"

2.4.2. Post-test usability questionnaire—The post-test questionnaire included the SUS and open-ended questions. The SUS is a widely-used validated and reliable survey instrument (cited in over 2700 times according to google scholar) [29,30]. Prior studies have used to SUS to assess the usability of tools with patient successfully [31–33]. Based on previous research, a score of 68 is considered to be average with higher scores reflecting greater than average usability across comparable applications. The SUS consists of 10-items, as shown in Table 2 rated, on a 5-point agreement scale that is widely used in usability testing because of its versatility and ease of use [29]. The open-ended questions included: "What are your overall impression of the user interface design?", "What 3 things do you like most about design, specifically in terms of what you can do in the interface?", "What three things do you like least about design", and "Is there anything that you would change to improve design (Especially in terms of usability, functionality, and efficiency)?"

2.5. Procedures

Children and their parents separately interacted with the SMART program modules for 60 min. All participants were asked to think aloud while performing task in the study. This type of methodology has been used to study usability because it provides further insight of the participant's thought processes while attempting to perform a specific task [34,35]. This is particularly useful with small sample sizes and can capture on both usability and content data about SMART as participants are experiencing it.

Each participant was asked to complete the introductory module and was randomized to complete two of the remaining seven modules. Children used a different SMART interface than their parents. Additionally, child participants first completed the daily scoring and questionnaire from the SMART website.

Prior to moving onto the next module, the participant completed the post-module questionnaire about their experience with that module. This was completed for each module. When the participant had completed all the assigned modules, they next filled out the post-test usability questionnaire.

Each session was audio-recorded and transcribed, and a second researcher took handwritten notes during session. Data were compiled and analyzed to examine the system's strengths, opportunities for improvement, and user errors. A highly iterative approach was utilized such that modifications to the SMART application were made based on the usability results from initial participants that were tested by subsequent participants.

2.6. Data analysis

From the usability test session, the data were transcribed, compiled and consolidated to a single file. Investigators analyzed the think aloud transcripts and interview data to identify the interfaces' strengths and areas where the usability of the system could be improved. Thorough review and discussion by investigators, consensus themes regarding strengths and weaknesses were developed iteratively. We also sought to descriptively, identify patterns of use, efficiency, effectiveness, and errors or lack of clarity from the observations and participant comments. The outcomes measures were the user feedback about interface acceptability and issues that they encountered while trying to use the system, as well as the data obtained from the post-test usability questionnaire.

3. Results

Three of the four usability tests were transcribed and evaluated. The fourth test did not have adequate audio for transcription. Individual notes were used in place of the transcription during for the fourth interview. All surveys and scoring were used.

3.1. Quantitative results

Table 3 lists the participant demographics and answers to survey questions. A total of 8 participants, 4 child/parent pairs, completed the usability testing. The average age of the children was 13.0 years old (standard deviation = 1.8); the parents were an average of 41.5 years old (standard deviation = 6.2). The average time since injury to testing was 21 days (range: 6–39 days). The average PCSS score was 15.3 (range: 1, 52). Users' perceived usability of the SMART system was measured by the SUS. The mean SUS score was 85; children's average score was 81 (standard deviation = 22.8) while parents' average score was 89 (standard deviation = 10.7). Page view times for children participants were recorded and are shown in Table 4. Participants were asked to complete the modules and provide feedback as if they were reading them post-injury including performing all suggested tasks.

3.2. Qualitative results

A summary of user comments about the program is provided in Table 5. User suggestions included requests for more pictures and graphics, fewer text boxes (requiring the user to answer questions when doing an activity) and less reading. Participants also suggested the addition of voiceover for the text and more videos of children undergoing similar

experiences. The analysis of the interview transcripts and the feedback given during testing revealed two main themes: (1) the system provided valuable information for children and participants that were not otherwise readily obtainable and (2) the system included too much reading.

3.3. Reading

Two children felt that the modules required too much reading, reporting that there was “too much reading” and “I didn’t like all the reading that had to be done.” One participant noted that “There are not too many words on the page but there’s still enough that if you hit your head really hard, that would not be fun.” Nonetheless, they reported that the system was easy to use and easy to read. All of the parents felt that the inclusion of audio would be good and two said they would read the information to their child. One parent reported that she would read and explain the information to the child.

3.4. Parent information

The parents reported that the system was informative and provided information they felt like they didn’t get in other places. While they felt it was clear and easy to understand, a parent suggested removing the text boxes because of concerns that teens were unlikely to “participate in a quality way.” Parents also requested “more examples on things real teens with concussions experienced and how they coped.” In relation to the staying focused module, one parent reported “I liked how everything was broken down into simple steps that anyone should be able to understand and do.” Although in other modules, the parents suggested that we “lessen the information or simplify if possible.” All 3 parents reported liking the information (2 reported liking the one-page form regarding returning to activities and stages) because it provided information that they either didn’t know or didn’t receive immediately after the injury and would have liked to have. One parent noted that “...this would have been good to have this. You know I saw on one of the discharge papers, it said use the return to school form but I don’t think we actually received [it].” And parents reported that it helped to alleviate their and their children’s concerns “The information was really good because I know [my child], she had a lot of questions ... like, ‘I have a headache’ or ‘I’m tired a lot is this normal’ and I think if she had known up front, you know what to expect it would have helped with the anxiety a little bit and she would have been a little more comfortable with the process.” Two parents reported liking the expectations that the form outlined.

The parents liked having access to the same information as the child, but also felt that the information greatly supplemented what they were told in the ED:

“I mean we did get the speech, no screen time, no this or that but you know all this information, this is really helpful to have, you know all the days, the guideline on this is typically this many days afterwards that gives better expectations on what to expect. She has a brother who had a concussion when he was at college last year and of course didn’t do it, I don’t think anyone told him to do anything of this stuff and his concussion, his headaches went on for months so umm, they told her what to do and she actually slept so much that I think she recovered pretty fast so her

timeline probably followed that pretty exactly right but this would have been great to have. (speaking of timeline one-page form)”

“[The information is] very informative, because I played sports in high school and I had a concussion before and so some of the things I read I didn’t know.”

3.5. Videos

Both children and parents reported enjoying the videos of other children who had experienced mTBI discussing their recovery and healing. A participant reported: “I liked the videos where things happened to kids like me and I got to see how they dealt with it.” And a parent reported that the video was “good to say that they would get better because that was a question she [the child] had at the time.” Parents reported that the videos were liked because they helped the patients see what was normal “I liked those videos, (Patient-I liked them too) because it kind of, it would have helped her because she kept asking, ‘is this normal, is this normal’ and it would have put it in to perspective for her that she isn’t the only and what was going on was normal.”

3.6. Module timeline

Two parents asked about the timeline for which the modules would be completed. One parent felt that it would have been particularly challenging for her child to complete the modules on the suggested timeline because she slept so much immediately after the injury. Another parent felt that that information may have been too much for the patient to comprehend right after the injury stating “...I was going to tell you there would have been no way she could have done all of that 24 h after the injury.”

3.7. Additional comments

Two parents noted that they liked the tailored aspect of the application. Both parents noted that while they were given diagnosis instructions and/or told information, it was more general and it would have been nice to have something like this that gave both the expectations but a timeline that could be followed. One parent liked the application because it relieved some of her child’s anxiety about the symptoms because they were all outlined and there were children in the videos who had experienced similar symptoms.

“Parent: I liked how easy it was to navigate through it, it was simple which was really good especially after a head injury. I liked the simple pictures that went along with some of the information. I thought that was beneficial, umm and the color scheme, I thought it was mild, nothing real bright and no patterns that made it busy.”

“Parent: This is nice too, the breakdown of what she should be able to do as she progressed, she was on spring break so she didn’t miss any school and we didn’t have any of this but if she had been, this would have been nice to have that information. (ED-03)”

Also, of note, one parent reported having a concussion previously and the other reported having another child with a concussion. It was interesting to see that while 2 families had

previous experiences with concussion, they both felt like this was new information they were learning.

One parent expressed how helpful it would have been to have all of the information up front. Due to a miscommunication at school, the parent, patient, and school counselor could not agree on a return to activities schedule.

“Parent: You know her counselor was driving us crazy at school because she was not letting her take any tests or quizzes and it didn’t say she couldn’t take tests or quizzes but um her counselor may have seen this because she kept saying it’s in all the, didn’t they give you more? And I’m like no, I sent you everything they gave me. It does say, Stage 2 no quizzes/test, Stage 3-1 quiz/test a day and I bet they saw this before that’s why she, she called me 3 times and said, ‘she wants to take a quiz’ and I’m like why don’t we let her take the quiz then ... and she went to consult with other people.

Patient: She (the school counselor) consulted with three of the administration and the nurse and oh it was terrible.

Parent: Then she called me back and said, “They said that if you really want her to take that quiz you can send in an email but we need that in writing and we need you to say in that email that you understand the doctor’s orders”. And I am like Ok. I will. All he said was you know.

Patient: It was like a 3–5 minute quiz

Parent: It would be less stressful if she could just start making up some work than just having it pile up. Anyway so she probably saw that too and we never saw it, she thought you were on stage II and you thought you were on stage V.”

4. Discussion

There is a lack of evidence-based treatments for patients recovering following a mTBI. Prior work suggests that education about concussion may reduce the symptom burden and that web-based therapy may be effective [8–14]. Previous work showed that education on expected concussion symptoms and recovery course initiated upon discharge from the acute injury reduced persistence of behavioral symptoms [15]. We sought to extend this work by integrating education with individualized feedback about symptoms and behaviors that may be contributing to symptoms. Self-management of symptoms has been widely used to support effective management of a variety of chronic conditions [36]. Promotion of positive expectations and a sense of self-efficacy regarding the ability to manage one’s symptoms has been shown to significantly affect health outcomes and functioning [37]. SMART was designed to promote self-management while encouraging positive expectations regarding recovery-features that were rated favorably by several parents. Although it builds upon prior telehealth interventions for more severe TBI, SMART incorporated specific guidelines, videos, and strategies to address the unique, and typically rapid, recovery trajectory following mTBI.

By involving users in the design of the tool, we are able to help ensure a more successful implementation and one we know possible users are comfortable with [38]. This suggests that future researching involving the clinical efficacy of the recommendations will relate to the information contained in the system and not the system itself [39].

Web-based applications can be useful tools for helping to convey disease-specific information to patients. Our goal was to improve SMART application for mTBI and make it a user-friendly web application. Toward this end, we conducted usability testing with four parent-child dyads. Results from this usability testing indicated adequate usability and high levels of satisfaction, and yielded specific feedback regarding ways to improve the user experience. These included reducing the amount of text and increasing videos. The current usability test represents the first step in a comprehensive iterative process to develop and refine SMART culminating in a pilot trial assessing feasibility and preliminary effects.

The think-aloud method was well-suited to stepping through our SMART application because it identified barriers and helped make our system as intuitive as possible. Specifically, it revealed the more iterative interface changes that occurred during the testing. For example, we adjusted the text size and location of links for the additional parent information to make it easier to find.

All participants rated usability on the SUS substantially high. Overall, the system was viewed as easy to log on and navigate. Specific feedback regarding color and font choices, the amount of written versus video content, and the desire to listen to rather than read written content resulted in modifications to the website prior to our next step, a pilot study.

4.1. Application modifications

As a result of this usability study, we decreased the amount of text and added an audio file allowing the user to listen to rather than read the text of every page. By assessing the usability of the system, we were able to improve the end-product and make the intervention more useful for the study population. We made color corrections and adjustments and fixed some minor typographic errors to help improve clarity. We plan on adding more videos of children undergoing similar experiences in the future. Additionally more substantial system improvements to the SMART application were implemented after this study based on this evaluation.

We had a very small group of participants performing usability testing. All patients approached to participate in the emergency department were enrolled and asked to come back at least two weeks after their injury when they were asymptomatic. Unfortunately all of our child participants were female, however we do not feel this had a noticeable effect on the feedback provided. The child and parent participants were both happy with the system. They made suggestions to improve clarity and content in the system. Although only 4 dyads were tested, we had each participant and their parent complete the modules for a total sample of 8 users. By including parents, we were able to get a wider array of feedback. Research suggests at least 5 participants are needed to discover 80% of the problems when usability testing [40], while we only had four child participants, we had a total of 8 participants

perform testing on the application. While more participants would be ideal for testing [41,42], with minimal changes requested by the users, we feel our sample was acceptable.

Results from the usability trial support the promise of SMART and identified areas for improvement. This preliminary development work represented an initial approach to improving user experience prior to implementing a broader test of usability and preliminary efficacy. Feedback from the pilot trial will be used to make additional modifications and updates to make the system more user-friendly prior to larger scale testing. We performed a feasibility study using the SMART application and results suggested that the application helped to improve patient outcomes [43]. We will evaluate the application in a larger study to evaluate the clinical efficacy of the interventions.

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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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Summary points

What's known

Mild traumatic brain injury (mTBI) is the one of the most common injuries sustained by youth in the United States. There is a dearth of evidence-based treatments available to address the significant morbidity associated with mild traumatic brain injury (mTBI).

What's new

We describe the feasibility and usability evaluation of a web-based 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.

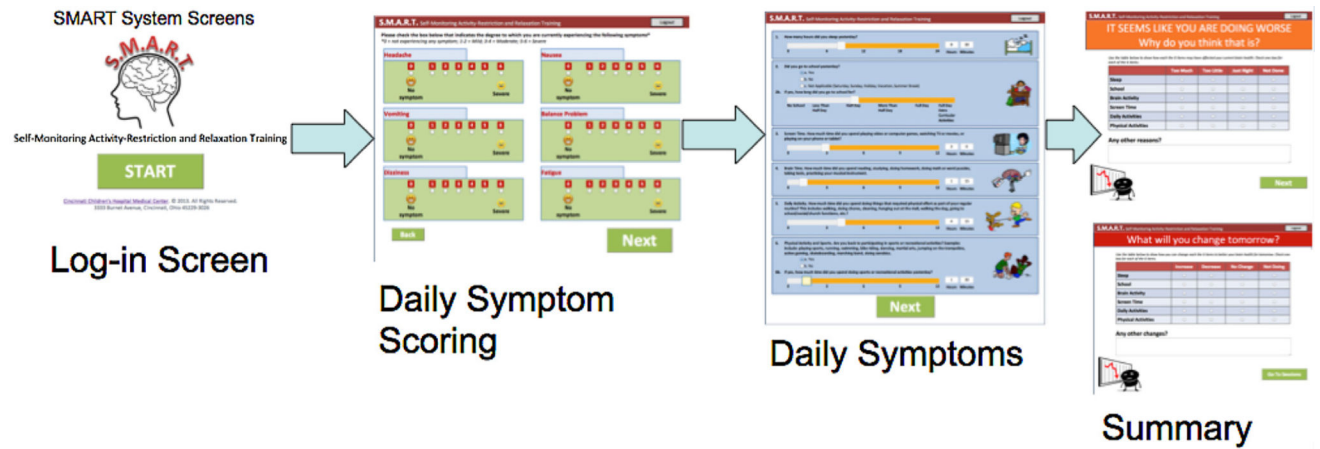


Fig. 1.
SMART walk through for daily symptom scoring.

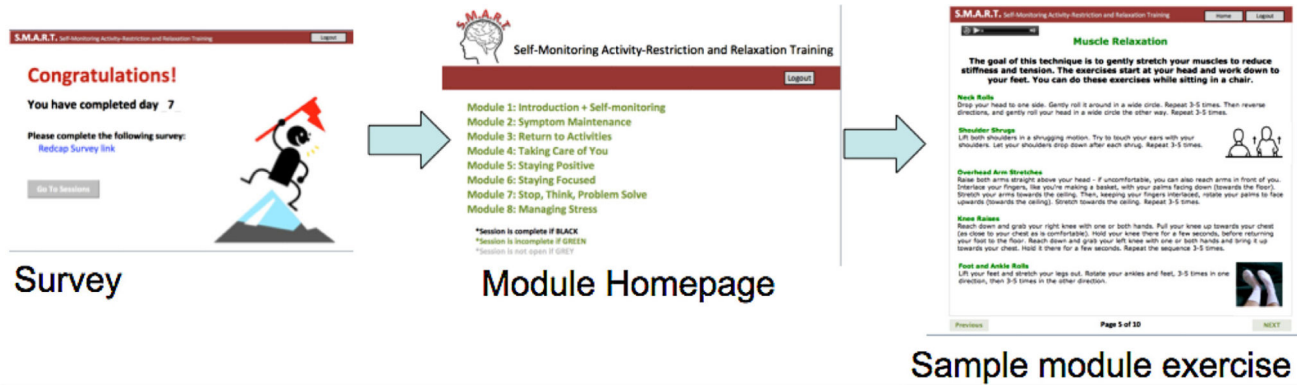


Fig. 2.
SMART walk through of a sample module.

Table 1

SMART Modules.

Module	Skills Addressed
1. Introduction and Self-Monitoring	A basic overview and introduction to the application and mTBI recovery
2. Symptom Maintenance	Information about common symptoms, timelines for recovery, and strategies for coping
3. Staying positive	Training in cognitive reframing strategies to address worries and negative cognitions about symptoms and missed activities
4. Managing stress	Instruction in relaxation and imagery to more effectively handle stress and manage headaches and other pain
5. Stop, Think, Problem Solve	Training in 5-step problem solving heuristic (Aim, Brainstorm, Choose, Do It, Evaluate) to address concerns regarding PCS-related issues
6. Returning to school/activities	Guidelines and strategies for working with the school and other non-athletic activities to ensure a successful re-entry without symptom exacerbation. Module also included a printable table explaining a step-wise approach to return to activities.
7. Taking Care of You	Strategies for healthy functioning including adequate sleep, proper nutrition, and hydration
8. Staying Focused	Tips for minimizing distractions and coping with attention and concentration difficulties.

Table 2

Post-test interview based on SUS.

1. I would like to use this website a lot	<div><div></div><div></div><div></div><div></div><div></div></div> <div>12345</div>
2. The website was very difficult to use	<div><div></div><div></div><div></div><div></div><div></div></div> <div>12345</div>
3. The website was easy to use	<div><div></div><div></div><div></div><div></div><div></div></div> <div>12345</div>
4. The website is too hard for me alone, and I need extra help	<div><div></div><div></div><div></div><div></div><div></div></div> <div>12345</div>
5. The website pages worked well together	<div><div></div><div></div><div></div><div></div><div></div></div> <div>12345</div>
6. Some things did not make sense.	<div><div></div><div></div><div></div><div></div><div></div></div> <div>12345</div>
7. Most teens could easily learn to use the program.	<div><div></div><div></div><div></div><div></div><div></div></div> <div>12345</div>
8. The website was difficult for me to use	<div><div></div><div></div><div></div><div></div><div></div></div> <div>12345</div>
9. I was comfortable/confident using the website	<div><div></div><div></div><div></div><div></div><div></div></div> <div>12345</div>
10. I needed to learn a lot before I could use the website.	<div><div></div><div></div><div></div><div></div><div></div></div> <div>12345</div>

Table 3

Participant demographics.

	Children (n=4)	Parents (n=4)
Gender (female)	100%	75%
Age in years (standard deviation)	13.0 (1.8)	41.5 (6.2)
Average system usability score (standard deviation)	81 (22.8)	89 (10.7)
Average PCSS score (standard deviation)	15.3 (24.6)	--
Education Level Elementary school Current middle school or high school student	25%	--
	75%	--
Some college/vocation school	--	25%
College graduate	--	75%
Race: White (%)	75	75
My attitude towards technology is		
My comfort level with technology is:		
I use a computer on average:		
I use a computer for (check all that apply): Work	--	75%
School	100%	--
Personal	75%	100%
I have a computer a home: Yes(%)	100%	
If yes, is it connected to the internet: Yes(%)	100%	75%

Table 4

SMART module view time in minutes and total number of pages.

Module Title	Average reading time (min)	Number of pages
1. Introduction and Self-Monitoring	8.4	10
2. Symptom Maintenance	10	16
3. Staying positive	Missing timing data	11
4. Managing stress	Missing timing data	10
5. Stop, Think, Problem Solve	10	22
6. Returning to school/activities	6	7
7. Taking Care of You	5.6	8
8. Staying Focused	9	19

Table 5

Select User Feedback on the SMART System.

Positive
I liked the audio recording of reading the modules (parent)
Tailored aspect of the application (parent)
Provided information that wasn't otherwise easily available (parent)
[Enjoyed] videos of concussed children (parent, child)
Negative
Worried that the timeline to move through is too quick (parent)
Too much reading (child)

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