BreatheWell Wear Smartwatch App for Managing Stress:
A Context-Based Model of Technology Development and Implementation

Shepherd Center
LiveWell RERC (Rehabilitation Engineering Research Center for Community Living, Health and Function)
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Focus

The research and development team used a context-based knowledge translation strategy for developing and disseminating the BreatheWell Wear App. This approach, similar to the Ottawa Model of Research Use (Sudsawad, 2007), emphasized three key components of the development cycle: (1) evidence-based innovation; (2) identifying needs, desires, and constraints of potential adopters; and (3) understanding the practice or use environment.

Context

BreatheWell Wear is a mobile app designed to assist military service members with post-traumatic stress disorder (PTSD) and traumatic brain injury (TBI) to manage stress through diaphragmatic (deep, slow) breathing. Developed for Android Wear smartwatches, BreatheWell Wear guides breathing through use of a graphical pacing bar that runs along the perimeter of the watch. Vibration at the end of each inhalation and exhalation provides a tactile cue to the user. The app offers the ability to program reminders to practice deep breathing at user-specified intervals, customize sound options with a user's own music, and the ability to view the user's heart rate in real time.

PTSD and TBI frequently co-occur in military service members returning from Iraq and Afghanistan, often impacting independent living and quality of life (Tschiffely, Ahlers, & Norris, 2015). Common clinical features of PTSD include increased anxiety and perceived threat, avoidance of anxiety, and the presence of hyper-arousal symptoms: anger, startle response, hyper-

vigilance, and difficulty concentrating (American Psychiatric Association, 2013). Deficits in memory and executive functioning, which are common cognitive sequelae of TBI, can add to stress and anxiety and can complicate and even hinder recovery from PTSD. Further, the physiological and emotional impacts of intense and prolonged stress appear to hinder recovery from TBI (Cooper et al., 2011).

When a person is exposed to a stressor, the sympathetic nervous system is activated, resulting in the "fight or flight" response (Jansen, Nguyen, Karpitskiy, Mettenleiter, & Loewy, 1995). This response produces a physiological reaction causing heart rate and respiration to increase, pupils to dilate, and the digestive and reproductive systems to slow down. The American Institute of Stress (2012) recommends deep, focused breathing to activate the body's parasympathetic nervous system, which facilitates homeostasis after the fight or flight response. Deep breathing increases the supply of oxygen to the brain and initiates a "relaxation response" by decreasing metabolism, heart rate, and blood pressure, which together cause muscles to relax and tension to ease (American Institute of Stress, 2012). Slow diaphragmatic breathing has been documented to improve mood stabilization and anxiety/anger management and is commonly used as a tool for emotion regulation (Brown, Gerbarg, & Muench, 2013). Breathing retraining—the practice of using slow, deep breathing to promote relaxation—is a widely used technique in stress reduction therapies. It can be used to manage acute stress and help processing during cognitive behavioral therapy interventions (O'Donohue & Fisher, 2009; Ursano et al., 2004; U.S. Department of Veterans Affairs & U.S. Department of Defense, 2010). Pacing breathing correctly and remembering to practice the technique are critical to its effectiveness, both of which can be particularly challenging for people living with PTSD and TBI.

Knowledge Translation Strategies

The BreatheWell Wear app for Android Wear devices is the product of the App Factory development project of the LiveWell RERC. The App Factory is an innovative model for rapid development and deployment of new assistive and technology solutions. It focuses on short-term development cycles (typically 1 year) across multiple projects to maximize impact in a rapidly evolving technological environment (Jones, Mueller, & Morris, forthcoming). This short-term focus facilitates a high degree of flexibility for research and development across the 5 years of the LiveWell RERC grant. The App Factory has three key features:

1. Reliance on a broad base of expertise (clinical, technical, research, policy, and advocacy) within the RERC and beyond, which is

supported in part by an annual request for proposals to external and internal development teams;

2. Early and ongoing engagement throughout the development and deployment processes with users and stakeholders (e.g., people with disabilities and their family members, clinicians/therapists, and caregivers); and

3. Utilization of existing channels of mass distribution of technology outputs (mobile app marketplaces).

LiveWell RERC staff pioneered the App Factory model under the Wireless RERC grant (2011–2016). Since 2011, the App Factory model under the two RERCs has undertaken internally or funded externally 29 app development projects, which have recorded over 700,000 installs on user devices.

The knowledge translation strategy informing the App Factory in general, and BreatheWell Wear in particular, most closely reflects the Ottawa Model of Research Use, which rests on three pillars for research and development: evidence-based innovation, understanding potential adopters, and understanding the practice/use environment. These three pillars are also central to user-centered design (Luna et al., 2015) and universal design (Burgstahler, 2015), which guides the LiveWell RERC's development efforts.

The evidence base for diaphragmatic breathing is well-established in the literature and in clinical practice. Diaphragmatic breathing is also central to the SHARE Military Initiative, the rehabilitation program for veterans with TBI and PTSD at Shepherd Center in Atlanta, GA. However, patients and clinicians report that learning the technique and pacing the breathing effectively are often challenging and that patients generally have difficulty remembering to practice and recognizing when to implement it outside of the clinical environment.

The idea of developing a mobile app for wearable technology platforms and the specific features and functions of such an app for wearables were extensively researched among veterans with TBI and PTSD at Shepherd Center. Clinical staff and patients at Shepherd Center were consulted about the utility of such a solution. One focus group was conducted with five veterans with PTSD and TBI, seven individual interviews were conducted with veterans with PTSD and TBI using a one-on-one format, and four individual interviews were conducted with clinical staff. These resulted in clear support for the concept and specific requests for functionality that would permit customizability of background sounds and music that users could select from their personal music libraries, choice of male or female voices for voice guidance for inhalation and exhalation, and the ability to turn off all sounds. Clinicians and patients also requested the ability to (a) change the number of breathing cycles during breathing sessions (one cycle

is a full inhalation and a full exhalation); (b) change the duration of inhalation and exhalation independently of each other (e.g., 4 seconds for inhalation, 6 seconds for exhalation); and (c) toggle on and off and change the duration of a pause between inhalation and exhalation. All reported having the ability to program reminders to practice deep breathing at user-specified intervals and to see the user's heartrate in real time while using the app would be helpful features. The BreatheWell Wear app underwent seven "builds" as a result of usability requests uncovered during continuous user-testing with clinicians and veterans with PTSD and TBI.

Dissemination and adoption strategies began with developing supporting materials (two videos) to demonstrate how to perform diaphragmatic breathing and how to use the BreatheWell Wear app. These were posted, along with a press release, on the LiveWell RERC website, the Shepherd Center website and Facebook page, and YouTube. Once those were in place, project staff developed and delivered presentations for several professional and assistive technology conferences, including the Assistive Technology Industry Association Conference (2016), TBI Model Systems Leadership Summit (2016), the annual conference of the Center for Knowledge Translation on Disability and Rehabilitation Research (2016), American Congress of Rehabilitation Medicine Annual Meeting (2016), and CSUN Technology Conference (2017). The team also utilized established channels of communication and dissemination, including the LiveWell RERC's quarterly newsletter, which is distributed to more than 2400 people with disabilities and professionals in rehabilitation research and development; the National Rehabilitation Information Center newsletter; and Shepherd Center's Spinal Column quarterly magazine. The principal investigators also posted the press release and videos on their personal LinkedIn and Facebook pages and on the SHARE Military Alumni Facebook group page in order to reach more targeted users. The press release then "went viral" and was posted on other organizations' social media sites.

Impact

Impact was measured in several ways. First, during pilot testing, we measured patients' subjective evaluation of the BreatheWell Wear solution and conducted clinical evaluations of patients using the PTSD Checklist for DSM-5 (PCL-5). The PCL-5 is a 20-item self-report measure that assesses the 20 DSM-5 symptoms of PTSD (Weathers et al., 2013). The PCL-5 has a variety of purposes, including monitoring changes in PTSD symptoms during and after treatment. Scores for each of the 20 items range from 0 to 4 and are added to yield a total symptom severity score with a range from 0 to 80. Pre- and post-measurement for six of the seven patients piloting BreatheWell Wear to date showed changes in PCL-5 scores of 5 points or

greater, with two of those showed changes in scores of 10 points or greater. All were measured before treatment and then again after 2–4 weeks of treatment. The PCL-5 is relatively new, and change scores are still being determined, but it is expected they will be similar to the ranges in the previous version of the assessment. In the previous version, changes of 5 points or greater indicated that the individual had responded to treatment and 10 points or greater indicated improvement that was clinically significant and meaningful.

Second, qualitative measurement in the form of patient reports on experiences using the BreatheWell Wear app in their daily lives also provided detailed information on impact. One patient reported using the app on New Year's Eve to calm his anger and frustration when his neighbor set off fireworks nearby. Another patient used the app to overcome fears during a group activity at an indoor climbing wall, and several patients used it routinely to calm their anxiety before entering community venues, such as a grocery store or a movie theater. All seven patients reported they would be very likely to continue to use the app. Additionally, most participants reported they felt using a breathing app on a smartwatch was superior to using one on a smartphone because the smartwatch offers more accessibility due to the wearable format, the ability to use tactile cues (the app causes the watch to vibrate to signal the need for the user to change direction of breathing between inhalations and exhalations), and the display of real-time heart rate. User testing continues even though the app is already available in the Google Play store. At the same time, we are tracking download activity and user comments as well as analyzing information users are entering in the app regarding their stress levels before and after using the app. We plan to add a feature to proactively ask users of the app to complete a short questionnaire on usability and effectiveness of the app. This is part of a larger effort by the LiveWell RERC to implement techniques to gather richer user impact data on App Factory products.

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For More information about the BreatheWell Wear Smartwatch App:

- Google Play store: https://play.google.com/store/apps/details?id=org.shepherd.breathewell
- Demonstration video: www.youtube.com/watch?v=ZPUMwgiyuK4
- Instructional video on diaphragmatic breathing: www.youtube.com/watch?v=Otwskdxv55U

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