Design and Adoption of Mobile Yoga Applications for Breast Cancer Survivors

By

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This dissertation is dedicated to
my parents (Manjula Sarkar & Biswajit Sarkar), sister (Roshni Sarkar), maternal grandmother (Parul Singha), and husband (Dr. Subhadip Dey)
for holding my hands and loving me always

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Abstract

Background & Significance

Yoga, an age-old fusion of somatic movement, breathing, and meditation, is expanding in popularity in the United States as well as around the globe due to its positive influence on physical, psychological, social, and spiritual health (Andelkar et al., 2018). A recent secondary analysis of the National Health Interview Survey (NHIS) denoted an 8.6% steady increase in the number of yoga users within 15 years (the year 2002 to 2017) (Zhang et al., 2021). The global crisis due to COVID-19 has aggravated stress and anxiety in the general public (Husky et al., 2020; Shevlin et al., 2020) as well as in vulnerable populations such as breast cancer survivors (Seven et al., 2021). Yoga might be good stress and anxiety alleviation strategy during the global pandemic, as shown in different studies (Sahni et al., 2021; Sharma et al., 2020). Furthermore, social distancing practices to control infection spread have motivated virtual yoga support (Sharma et al., 2020; Trevino et al., 2021). Despite many commercial apps for self-management and wellness support, the validity and usability of these apps generally have not been well established (Scott et al., 2018). Studies have recommended the necessity of evaluating and testing apps with breast cancer patients and their caregivers in order to provide uninterrupted wellness and physical activity support while considering individualized challenges associated with breast cancer (Monteiro-Guerra et al., 2020). Besides providing insight into the range of commercially available mobile apps for yoga support with a validated tool, this dissertation research evaluates breast cancer survivors' acceptance and use of a specific mobile yoga tool. For that evaluation, I implemented a non-randomized small intervention with a convenience sample of breast cancer survivors. The findings of this study emphasize the usability of a mobile app for yoga support.

Specific Aims

Aim 1

To conduct a systematic evaluation of commercially available mobile health applications for yoga practice for the potential benefit of breast cancer survivors

Method Aim 1 is achieved by selecting a group of yoga apps from the popular app stores (Google Play Store and Apple App Store) based on a pre-determined selection criterion and utilizing the well-tested Mobile Application Rating Scale (MARS) to assess the app quality.

Aim 2

To explore the relationships between technology acceptance and use as measured by the Health Technology Acceptance and Use Scale (HTAU) and actual use of a mobile yoga application.

Method Aim 2 is accomplished with a brief intervention study with breast cancer survivors. Following a seven-day intervention with a specific yoga app, a validated instrument was used to assess participants' use of the app.

Results

Android and Apple yoga app review

After the MARS evaluation, we noted that the majority of the apps from both app stores (Google Play store: 78%; Apple App Store: 50%) scored a minimum of 4 or above out of a maximum 5-rating score. The lowest mean score was observed in the information and engagement domain. Most of the apps performed well in the aesthetics and functionality domain.

Yoga app intervention study

Out of 92 participants, 48 participants were included in our final sample. The participants were self-reported, utilizing the yoga app for practicing yoga on average 64.48 minutes

(SD=44.47) in the intervention week. Additionally, our study observes the highest HTAU score in the facilitating condition (Mean=4.30; SD=1.04) followed by effort expectancy (Mean=4.26; SD=1.45) and another six constructs. A statistically significant relationship is noted between the HTAU mean construct score and the future intention of continued app use.

Conclusion

Our findings of both app review studies highlighted the need for attention in the information section of the yoga apps on both Android and Apple platforms. 59% of the respondents of our post-study survey wished to continue using the yoga app after completing our study. This denotes that a commercial app that has yoga support content may attract some breast cancer survivors. The findings of this study will be helpful to identify the pros and cons of commercially available yoga tools and the usability of these apps to support breast cancer survivors. This study will be helpful in improving design-specific constraints in the future and providing survivors with a better yoga practice environment after evaluating their user-specific needs. However, the findings of our study should be interpreted with caution, considering our limitations. Our preliminary investigation sought further research in this area.

CHAPTER 1: INTRODUCTION

Breast cancer is a heterogenous disease with distinct identifiable clinical and histological attributes along with multi-dimensional care needs (Polyak, 2011; Weigelt et al., 2010). Breast cancer was estimated to be responsible for 279,100 new cases and 42,690 deaths in 2020 (Siegel et al., 2020). Based on the estimate in January 2020, more than 3.8 million women live in the United States with a history of breast cancer (Miller et al., 2019). Certain physical and psychological complications interfere with the quality of life and functional capability of breast cancer survivors. These include chronic pain (Belfer et al., 2013; Gärtner et al., 2009), fatigue (Abrahams et al., 2016; Andrykowski et al., 2010; Berger et al., 2012), anxiety and depression (Keyzer-Dekker et al., 2012), fear of cancer recurrence (Custers et al., 2017), sleep disturbances (Berger et al., 2012) and disturbed sexuality (Dizon, 2009; Kornblith & Ligibel, 2003). However, improvement in modern cancer treatment has increased the survival rate for breast cancer patients, and a recent estimate indicates that almost 90% of breast cancer patients survived five years after being diagnosed with breast cancer (Siegel et al., 2020). The growing number of survivors has also increased the demand for appropriate healthcare to support long-term survivors' cancer needs (Alfano et al., 2019).

Many cancer survivors utilize non-toxic and organic approaches like Complementary and Alternative Medicine (CAM) along with conventional oncology therapies (Bell, 2010). Considering the person as a whole and providing them with holistic support and necessary therapies is crucial to addressing cancer patients' emotional and spiritual needs (Cadet et al., 2016). For managing multiple negative consequences during the treatment phase, breast cancer survivors often use different CAM interventions for managing psychological distress, treatment-related side effects, and overall quality of life (Fox et al., 2013; Hammersen et al., 2020). Yoga is recognized

by the National Center for Complementary and Integrative Health (NCCIH) as a form of CAM in the category of "mind-body" medicine (NCCIH, n.d.). Recent statistics suggest that almost 42% of Americans have identified yoga as an intervention to preserve mental wellbeing, and the number of people doing yoga was expected to reach nearly 50 million by the end of the year 2020 (Gough, 2018). A recent systematic review and meta-analysis, which included 16 randomized control trials and 930 female breast cancer survivors, found significant improvement in depression, anxiety, gastrointestinal symptoms, and quality of life following yoga practice (Pan et al., 2017). The Society for Integrative Oncology (SIO) also identifies yoga as a helpful intervention for breast cancer survivors in managing anxiety and depression-related symptoms, post-treatment fatigue, sleep, and quality of life (Lyman et al., 2018). After observing multiple positive benefits of yoga in cancer survivorship, findings from a recent systematic review that analyzed 138 clinical trials further encourage the incorporation of yoga therapy along with conventional oncology treatment (Agarwal & Maroko-Afek, 2018).

Typically, yoga is taught in an in-person setting, usually in yoga studios or gyms. However, previous studies have identified multiple barriers of the in-person yoga class such as transportation, availability of appropriate yoga classes, cost (Atkinson & Permuth-Levine, 2009), time (Atkinson & Permuth-Levine, 2009; Dayananda et al., 2014), etc. Some of these barriers, especially time and transportation needs, might be addressed using alternative methods like technology-enabled yoga support tools. A pilot trial enrolled four women with stage 0 to stage III breast cancer and provided yoga intervention with the help of a video conferencing system (Addington et al., 2018). Two out of the four participants were comfortable practicing yoga in their home-based setting, where one found it inconvenient due to lack of illumination in her home (Addington et al., 2018). Although this is a small pilot study, the findings may suggest the need for a flexible schedule, individualistic

preferences about the place of practice, and technological developments that may improve the online yoga experience (Addington et al., 2018). Three of the participants were happy with learning yoga in a digital platform led by a certified yoga instructor, and one participant found the speed and content of the class to be much slower than desired (Addington et al., 2018). Overall, their findings suggest that the potential acceptability of technical hazard-free, flexible group remote classes and online classes for addressing disease-specific needs might be acceptable, along with the need for vigorous research in larger samples before conclusions are drawn (Addington et al., 2018). Although their study used internet-connected computers, similar technical facilities can be provided by mobile yoga applications. It might have the potential to address some of the issues faced with desktop computers, especially in terms of flexibility with the place of practice. Compared to computers, mobile phones are lightweight and easy to carry outside of the home, which can allow people to practice yoga where they want. The National Cancer Institute's Health Information National Trends Survey (HINTS) investigated responses of 3,677 U.S. adults and found that people with mobile exercise apps have a statistically significant ($p<0.05$) better adherence to the recommended exercise schedule (>150 minutes per week) than those who do not use apps, denoting exercise apps as a positive motivation to improve exercise adherence (Carroll et al., 2017).

According to the Food and Drug Administration (FDA), "a mobile application" or "mobile app" is defined as a software application that can be executed (run) on a mobile platform (i.e., a handheld commercial off-the-shelf computing platform, with or without wireless connectivity), or a web-based software application that is tailored to a mobile platform but is executed on a server" (FDA, 2019). Unfortunately, the growing and highly competitive app market launch apps without proper regulation or control for financial profit (Gnadinger, 2014). The FDA has made several

approaches to regulate apps intended for medical purposes, and they have oversight of numerous health and wellness apps (Kasperbauer & Wright, 2020). The FDA's current strategy with health and wellness apps has been insufficient, leaving people with no way to make informed decisions about the apps they use to meet their exercise and wellness goals (Kasperbauer & Wright, 2020).

According to a recent estimate, the Google Play Store and Apple App Store include 53,024 and 53,979 health apps, respectively, as of the first quarter of 2020 (Statista, 2021a, 2021b). This survey also indicates the current addition of 9,740 new health apps in the Google Play store between the first quarter of 2020 and 2021 (Statista, 2021a). Similarly, 8,501 new health apps were added to the Apple App Store in the same period (Statista, 2021b).

Although there are several apps to support yoga and exercise, there is a lack of evidence about the effectiveness of these apps. Moreover, these apps do not go through any standardized criteria or regulations before being available in the app stores (ex.: Apple App Store, Google Play store) (Kasperbauer & Wright, 2020). Hence, there is a higher need to evaluate the efficacy and performance of these apps. Apps can provide people with a platform to record their yoga practice through self-tracking, suggestions via artificial intelligence technology, and the ability to monitor various health parameters via sensors (Prasanna et al., 2017). A pilot study investigating the role of a specific yoga application found a significant reduction of sleepiness after using a mobile yoga application tool (Sugano, 2013). However, this study was conducted on 12 university students who were young and likely to be digitally skilled (Sugano & Ueno, 2013). A trial with a newly developed mental health care app (that offers yoga, meditation, and sound) on a sample of 56 people found statistically significant lower perceived stress scores (p=.035), emotional labor (p=.025), and an increased wellness and self-efficacy score among the experimental group following four weeks of app use (Hwang & Jo, 2019). Although the findings of this study indicate

improved mental health following use of the app, the generalizability of these findings can be questionable as they only included nurses from the same organization as their participants (Hwang & Jo, 2019).

Less than half of the breast cancer survivors reported utilizing an exercise or diet mobile app (41.2%) and activity trackers (40.5%) in a survey with 270 breast cancer survivors with an average age of 60.7 years (Phillips et al., 2017). Findings of a non-randomized prospective study with 64 breast cancer survivors observed significant improvement in total weekly steps and reduction in distress after participating in an Android mobile app-based community (Chung et al., 2020). This study divided its participants into two groups (first Arm mobile community and later Arm mobile community) and provided a free Android mobile app with the capacity to track steps and distress in their 12-week-long intervention (Chung et al., 2020). Their findings hold great promise (an 8,723.4 steps increase and decrease distress score by .73 in a week) after the app-based mobile community participation (Chung et al., 2020). Although many studies involving breast cancer survivors were optimistic about the mobile app as a platform to deliver exercise to breast cancer survivors, none thoroughly studied the potential of commercially available mobile apps to support the remote practice of yoga. Considering the risk of the spread of COVID-19 in fitness classes (Groves et al., 2021), it is an appropriate and timely topic to explore.

According to Norman, "Good design starts with an understanding of psychology and technology," so the user's opinions and feelings associated with a product are essential to determine the product's success (Norman, 2013). Therefore, in our project, we strived to gain some knowledge regarding the potential of mobile apps to provide yoga support and considerations for enhancing the design and adoption of this technology.

In this dissertation, I report findings in three publishable papers.

Paper 1: Paper one describes the review and evaluation of Android mobile yoga apps using a systematic, structured methodology. The evaluation was used to select a commercial yoga app for a brief intervention with breast cancer survivors, which is described in paper 3.

Paper 2: Paper two describes the review and evaluation of Apple mobile yoga applications. With the rising popularity of mobile applications, developers tend to introduce the same app in multiple platforms for more extensive financial benefits (Joorabchi et al., 2015; Joorabchi et al., 2013). Although the same app should perform equally, existing evidence has highlighted major differences across platforms responsible for diverse app performance and user experience (Hu et al., 2019; Joorabchi et al., 2013). Furthermore, as each app platform requires specific customization for the app installations, developers also consider the app separately based on their platform (Joorabchi et al., 2013). User feedback (star rating and written reviews) may differ based on the platform (Hu et al., 2019). Therefore, the apps for the Apple platform are reviewed separately from those in the Android platform.

Paper 3: Paper three reports findings of a brief non-randomized intervention study with the selected yoga app to understand the potential benefit of this technology for yoga support and explore enhancements for the design of future apps.

Significance in Nursing

The philosophy and traditions of nursing are always grounded in the principles of caring and healing (Vance, 2003). Nurses, the vital cornerstone of the healthcare delivery system, are responsible for considering an individual as a 'whole,' not only defined by their disease (Dossey, 2013). Traditionally, they work as a liaison between a patient, family, and other healthcare team members. It is observed that they often develop better interpersonal relationships with the patient

than other healthcare professionals (Shumskiy, 2019). A disease such as cancer creates enormous mental and physical distress among affected individuals (Stein et al., 2008). They often seek help from different CAM therapies to reduce disease-related suffering and promote well-being (Sibbritt et al., 2003; Wolf et al., 2021). Therefore, incorporating CAM therapy like yoga, a non-invasive healing tradition to address both mind and body, is consistent with the core philosophical foundations of nursing. This study involved using mobile yoga tools to address survivorship needs, which is highly relevant to nursing.

CHAPTER 2: A STRUCTURED REVIEW AND EVALUATION OF ANDROID MOBILE APPLICATIONS FOR YOGA SUPPORT

Abstract

Yoga is a promising Complementary and Alternative Medicine (CAM) intervention to promote health and wellbeing in breast cancer survivors. Mobile health apps may be one way to provide access to CAM interventions such as yoga practice. However, with hundreds of mobile yoga apps in the app market space, the quality and usefulness of these apps have not been systematically tested. Besides, it is unclear whether these commercial mobile yoga tools support yoga practice for breast cancer survivors. The purpose of this pilot study is to select a commercial app from the popular Google Play store for a brief intervention study of the acceptance of mobile yoga among breast cancer survivors. We conducted a structured quality evaluation of apps from the Google Play store, applying the validated Mobile Application Rating Scale (MARS) by two independent raters. As a result, 18 out of 250 apps were identified for evaluation after applying inclusion/exclusion criteria. The mean MARS score of these apps is 4.11 (out of a total possibility of 5) with SD = 0.38. There was high interrater reliability (ICC = .88; 95% CI 0.85-0.91); however, there is much room for improvement, particularly in the information and engagement domain of the MARS. Future studies should evaluate the full features of these apps for further development of these mobile yoga applications.

Introduction

Background/rationale

Breast cancer is the most prevalent cancer in women, affecting more than 3.8 million women in the United States (Miller et al., 2019). Besides the modern medical therapies, for preserving health and wellness, breast cancer survivors often use different Complementary and

Alternative Medicine (CAM) services (Boon et al., 2007; Fox et al., 2013; Hammersen et al., 2020; Molassiotis et al., 2006; Wanchai et al., 2010).

Yoga, an age-old Eastern healing tradition, is widely accepted and practiced by more than 37 million Americans (Ipsos, 2016). According to many scholars, yoga has gone through several transformative changes as a result of cultural assimilation, and it is widely adopted as a fitness activity in the West (Singleton, 2010). A survey with young mothers with breast cancer found yoga to be the third most popular CAM activity (23.6%) after homeopathy (73.9%) and dietary supplements (35.6%) (Hammersen et al., 2020). In addition, 31.04% of the participants who completed the Mayo Clinic Breast Disease Registry (MCBDR) (total sample size = 3,379) reported past or current practice of yoga (Patel et al., 2021).

For the management of the numerous physical and psychological consequences of survivorship like pain (Carson et al., 2020), lymphadenopathy (Wei et al., 2019), fatigue (Yi et al., 2020), sleep disturbances (Rao et al., 2017), stress and anxiety (Prakash & Saini, 2018), and menopausal symptoms (Cramer et al., 2018), yoga has been an advantageous approach. A meta-analysis, which included 16 randomized control trials in their final analysis, observed significant alleviation of symptoms such as gastrointestinal symptoms (*SMD*: −0.39, 95% *CI*: −0.54, −0.25; $P = 0.00$), anxiety (SMD: −0.98, 95% CI: −1.38, −0.57; $P < 0.00$), and depression (SMD: −0.17, 95% CI: −0.32, −0.01; $P = 0.00$) following yoga intervention (Pan et al., 2017) Overall, this meta-analysis found a significant enhancement of health-related quality of life (SMD: 0.85, 95% CI: 0.37, 1.34; $P = 0.001$) among people who were in the yoga group (Pan et al., 2017). Similar findings were noted in another randomized control trial of 100 breast cancer survivors, where anxiety, depression, and stress scores improved significantly in the intervention group during some specific cycle of chemotherapy (Prakash & Saini, 2018). A recent trial (n = 91

metastatic breast cancer patients) found significant differences in several parameters such as symptom distress score (yoga group: t = 3.1, p = .004; control group: t = -1.32, p = .19), sleep distress (yoga group: t = 2.5, p = .01; control group: t = -1.30, p = .20), and sleep total distress score (yoga group: t = 3.3, p = .002; control group: t = -1.33, p = .19) between yoga and control group (Rao et al., 2017).

Yoga was traditionally taught by in-person training; however, with the progress of technology and increasing healthcare demand, we have explored different technology-aided distance learning methods to deliver yoga to people interested in practicing it. For example, tele-yoga interventions with video-conferencing technology are feasible and safe in a handful of studies with veterans (Schulz-Heik et al., 2017), people with chronic pain (Baker, 2018; Mathersul et al., 2018), and people with heart failure and chronic obstructive pulmonary disease (Citron et al., 2013; Selman et al., 2015).

Although technology-aided exercise interventions are an acceptable and feasible approach for breast cancer survivors (Phillips et al., 2017), little is known about mobile apps for yoga support. Mobile health applications (m-Health apps) are an up-and-coming tool for self-management and behavioral modification in the digital era, especially among people suffering from chronic diseases and requiring long-term treatment adherence (Lee et al., 2018; Scott et al., 2018). Existing evidence recognizes the role of mobile tools in behavior modification (Hartin et al., 2016). For example, A survey publicized by Amazon Mechanical Turk (MTurk) identified more active individuals (people who exercise a minimum of two times a week) belong to the current exercise app user group (73%) compared to the other two groups (non-users: 45.8%, past users: 46.1%) (Litman et al., 2015). This study also showed total leisure time metabolic equivalent of task (MET) expenditure (current app user: 1,169; non-users: 577; past users: 612) and lower

Body Mass Index (BMI) among individuals who are currently using apps for performing exercise (Litman et al., 2015). Findings of a systematic review of 39 individuals (RCT = 22; non-randomized = 17) also highlighted mass popularity and acceptance of mobile apps to promote healthy eating habits, exercise, and weight management (Dounavi & Tsoumani, 2019).

After considering the promising role of mobile apps for improving treatment adherence (Pérez-Jover et al., 2019), self-management (Lee et al., 2018; Nasi et al., 2015), and exercise and fitness support (Higgins, 2016) in the diverse healthcare arena, it is vital to evaluate the usefulness of mobile apps to provide yoga support. An intervention study with a mobile application that offered yoga, meditation, breathing techniques, health advice (diet, exercise), and healing found significant improvement in the mental health status among the experimental group after four weeks (Hwang & Jo, 2019). Another study that involved a prototype yoga app and tested its functionality with 11 participants (mean age = 39 years) supported the efficiency of apps to support yoga practice and to track multiple health parameters (ex.: BP, heart rate) (Prasanna et al., 2017). Another small-scale study with 11 university students also observed reduced sleepiness following the use of a yoga app after waking in the morning (Sugano & Ueno, 2013). Mobile apps may offer the convenience of doing yoga when an individual chooses and eliminate the need for transportation and scheduling. However, little is known about the quality and usefulness of yoga apps. To provide a better user experience, evaluation of the functionality and quality of the yoga apps is necessary (Yu & Huang, 2020).

There are hundreds of commercial yoga apps available on popular app platforms; however, there is a lack of evidence about the potential usability of these apps. Commercial apps often contain misinformation and exaggerated claims (Adam et al., 2019), which have increased the need to evaluate commercial app quality to provide a better user experience.

Objectives

In this pilot study, we aimed to rigorously evaluate mobile yoga tools from the Google Play store to inform the selection of a mobile app for yoga support to be used in a brief intervention study with adult breast cancer survivors. The primary purpose of our study was to select a yoga app that will be used in a future intervention with breast cancer survivors. We will use this app to give participants information about a mobile app, and we will also investigate their acceptance and context of the use of the given app in their life. We will also use this app to facilitate conversation during an interview with a selected group of breast cancer survivors to capture their perspectives, expectations, and needs regarding similar mobile apps for yoga support.

Methods

Two distinct processes were applied for this study. At first, we selected a few apps based on our selection criteria established a priori and further described below. Then, in the second step, we evaluated our final sample of apps with a validated tool.

Search Strategy

We used the publicly available Python library Google-Play-Scraper (GitHub, 2020) to retrieve app information from the Google Play store. We used the search keyword ‘yoga’ for retrieving all yoga and yoga-related apps. The search was run on 4/18/2019 and found 250 apps. We selected apps for inclusion in the study if they fulfilled the following criteria:

1) English language. If the app was available in more than one language, one of the languages must be English.
2) Targeted towards the general adult population. We eliminated any that were explicitly targeted only to children or teenagers. The target population was identified by reading the description page and determining if the app was meant for everyone or mature adults (17+).

If the app description identified ‘Teen’ as a target population of the app, it was excluded. App names that included a specific term like ‘Kid’ or ‘Pregnant’ but were targeted to ‘Everyone’ or ‘Mature (17+)’ were retained.

3) To select apps that were available to the public and were more likely to have ongoing technical support, we screened for apps that had a recent update in the year 2017 or later.
4) This study was focused exclusively on apps that provide textual, visual, and audio guidance of the Asana or yoga postures, and this information was verified from the app description. Much of the widespread practice of yoga in the United States (Hatha Yoga, Bikram Yoga, Power Yoga) emphasizes more on the physical posture as a part of their yoga training (Garfinkel & Schumacher Jr, 2000; Ghose, 2014; Pizer, 2020). Western adaptation of yoga is more focused on the physical posture, according to the claim made by Mark Singleton (Singleton, 2010). Therefore, we gave emphasis on yoga poses while selecting the apps. The criteria ‘Poses’ or ‘Asana’ helped us differentiate yoga apps from other similar kinds of apps that support meditation, mindfulness, and breathing exercise. We selected apps that specifically offer support for performing Asanas with or without breathing exercises, relaxing music, or mindfulness meditation. It is important to note here that we excluded apps that offered only yoga wallpapers or yoga magazine articles. Although Yoga magazine apps are a good source of yoga-related information in a written form, we removed those apps as they lacked continuous audio-visual demonstration/guidance of yoga poses. After downloading the app, if we found that the app did not contain any information or guidance about Asanas, we eliminated it.
5) Current star rating in the app store above 4 with a minimum of 1,824 raters. This number of raters represents the mean number of raters across all apps in the original 250 identified.

The number of raters varied from the lowest (2) to the highest (86,761). We wanted to narrow the apps to those with a higher number of raters and a 4-star rating, as we were looking for more credible and widely used apps rather than selecting apps with a low number of raters. In addition, an equal star rating with a large number of raters is more reliable than one with a small number of raters (Hoffart et al., 2019).

6) We were also focused on the apps that are free to download and offer some yoga support free of cost. We did not make any in-app purchases within the app. The majority of apps in the Google Play store are free (Statista, 2021a). Usually, free apps have more capacity to attract people, and they have a higher number of downloads compared to the paid ones (Mistry, 2021). Therefore, we were only focused on the apps that offered yoga support features that could be accessed without any in-app purchases.

Measures/Rating Tools

App store rating system provides a numerical attribute that largely influences a consumer's choice of downloading a particular app (Harman et al., 2012). It also gives developers information and a basic understanding of the popularity and relevance of an app from a consumer's viewpoint and helps consumers make conscious decisions regarding the usability of an app (Harman et al., 2012). However, a study that retrieved data from 10,000 apps from the Google Play store identified that this rating system often failed to capture actual consumer scenarios (Ruiz et al., 2015). This current system offers an aggregated score given by all users across the version (Ruiz et al., 2015). Understanding the reaction of the users regarding the newer version is problematic and often discourages developers from making substantial improvements (Ruiz et al., 2015). Moreover, studies have also pointed towards the discrepancy between descriptive app reviews written by the consumers and the star rating (Aralikatte et al., 2018). These inconsistencies further enhance the

need to evaluate the app with a standardized criterion other than relying blindly on the app store rating and reviews.

Many studies have made recommendations regarding the process of evaluating the app content and quality. Findings of a recent systematic review of 23 studies that include mHealth app assessment tools indicate the wide heterogeneity of mobile tool assessment criteria and tools (Nouri et al., 2018). Some of the tools are focused on assessing the general mobile apps (Jin & Kim, 2015; Zapata et al., 2015), while others target evaluating a specific category of mobile apps. For our study, we decided to use the Mobile Application Rating Scale (MARS) because of its widespread use in assessing mobile apps from multiple fields and the simplicity of implementation of the scale. This is developed on the knowledge base of available assessment criteria to evaluate mobile apps (Stoyanov et al., 2015). In this comprehensive scale, inventors of the MARS organized 349 criteria into six major categories (Stoyanov et al., 2015). The MARS covers the majority of the domains identified by a recent systematic review which broadly classified evaluation criteria into seven domains (Design, Information/Content, Usability, Functionality, Ethical Issues, Security and Privacy, and User-perceived Value) and 37 subgroups (Nouri et al., 2018). The MARS is a widely used tool that studies mobile apps in a diverse field, e.g., diet & physical activity (Schoeppe et al., 2017), weight (Bardus et al., 2016), sleep (Choi et al., 2018), rheumatoid arthritis (Grainger et al., 2017), medication adherence (Santo et al., 2016), alcohol and substance use (Tofighi et al., 2019), genito-urinary tumors (Amor-García et al., 2020), gestational diabetes (Kalhori et al., 2021), and renal diet (Lambert et al., 2017). A recent study that analyzed data from 15 app quality review studies portrayed the MARS as a highly reliable (Omega .79 to .93) and objective (ICC = .82) tool that can help stakeholders make an informed choice about the app (Terhorst et al., 2020). This evaluation tool helps review an app with respect to multiple

dimensions, which include engagement (entertainment, interest, customization, interactivity, target group), functionality (performance, ease of use, navigation, gestural design), aesthetics (layout, graphics, visual appeal), information (accuracy of app description, goals, quality and quantity of information, visual information, credibility, evidence base), and subjective quality (Stoyanov et al., 2015). Stoyanov et al. developed this tool to assess the quality of a mobile application after synthesizing published articles and scientific resources, and they evaluated the accuracy of the apps using 50 mental health apps, including two that were yoga apps (Stoyanov et al., 2015). Each of these MARS components consists of a 5-point Likert scale (1- Inadequate, 2- Poor, 3- Acceptable, 4- Good, 5- Excellent) with distinct, identifiable measurement characteristics (see Appendix A). The use of this evaluation tool requires minimal training using a video developed by the developers of the MARS (Stoyanov, 2016). Developers of the MARS found very high internal consistency (Cronbach alpha = .90) and inter-rater reliability intraclass correlation coefficient (2-way Mixed ICC = .79, 95% CI .75-.83) (Stoyanov et al., 2015). The MARS score is calculated as a mean score instead of a total score so that raters can omit a section or subcategory, which is not applicable for a specific app.

App review using the MARS methodology

One researcher conducted the initial screening of the apps based on the pre-determined inclusion criteria. Two investigators completed the video training (Stoyanov, 2016), consulted with senior researchers (YC and KK) on the methodology, and discussed the interpretation of the MARS components until there was a shared understanding among them. These two investigators (SS and KM) reviewed each app independently, spending 30 to 40 minutes with each. After individually rating several apps, they met to discuss their ratings and any discrepancies in the interpretation of the scale. Most of the conflicts occurred in the scores of aesthetics and credibility of the source, which were

clarified and discussed by both investigators, and they reached an agreement based on their perception and the MARS training. In our paper, researchers determined the MARS score after evaluating the selected yoga apps in four categories (Engagement, Functionality, Aesthetics, and Information). Raters did not use the subjective quality rating as part of the evaluation, as it was deemed to be quite subjective; this decision is similar to that of several other studies which used the MARS tool (Bardus et al., 2016; Wilson et al., 2016).

Results

The flow chart (Figure 1.1) describes the step-by-step method of selecting 18 apps for our final analysis from the pool of 250 apps.

The initial search in the Google Play store yielded 250 apps (Figure 1.1). After reading the app description, we eliminated 62 apps. Among these apps, six apps were eliminated due to language, nine eliminated due to targeting a teen population, and 28 due to having the most recent update outside the inclusion timeframe. Additionally, nine music-only apps that lacked Asanas were excluded. There were three additional irrelevant apps (ex.: VPN, Shopping). There was a pranayama app that only had a breathing count, and it did not include any description or guidance of yoga poses. There was another app that was focused on quotes on yoga which we eliminated. There were three apps whose link was broken at the time of review, and we were unable to see those apps. We focused on apps with a minimum 4-star rating (see Appendix B); therefore, 46 apps with less than 4-star ratings were removed. Our preset selection criteria eliminated 119 above 4-star rating apps because the number of raters was less than 1,824, leaving 23 apps in the final data set (see Figure 1.1). Upon full review of these apps, we eliminated five additional apps: three because the free versions did not provide access to adequate features to evaluate. Among another two apps, one of the apps was focused on finger poses (mudras), and it did not include poses that

involved large limbs. Considering the need to address upper body stiffness, lymphadenopathy, and flexibility issues of breast cancer survivors, we eliminated this app. The free content of another app was mainly focused on the philosophical aspects of yoga, and it did not contain step-by-step guidance for yoga poses.

After all these eliminations, 18 apps were included for the final review with the MARS scale (see Table 1.1).

Figure 1.1 *Flow Chart Describing App Selection Process*

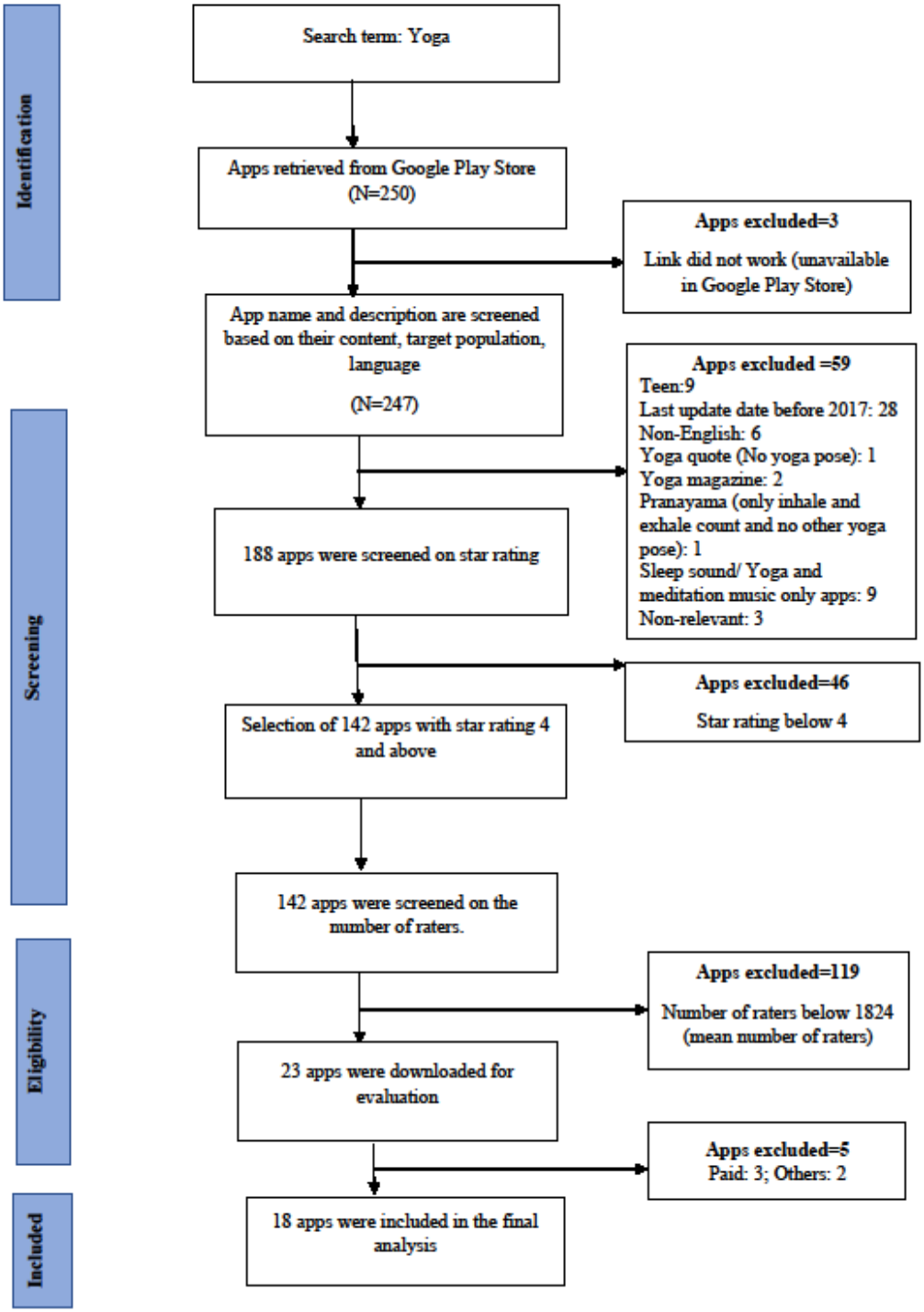

Table 1.1

The MARS Scores Compared to Google Play Star Ratings for Yoga Applications

Name of App	Average sub-score based on the MARS by two reviewers				Average total score $\frac{a+b+c+d}{4}$	Google star rating*
	Engagement (a)	Functionality (b)	Aesthetics (c)	Information (d)		
Daily Yoga – Yoga Fitness Plans	4.50	3.50	4.33	3.75	4.02	4.4
Keep Yoga - Yoga &Meditation, Yoga Daily Fitness	4.30	4.62	4.16	4.08	4.29	4.7
5 Minute Yoga	3.30	5.00	4.49	4.08	4.21	4.5
Yoga poses & Classes	3.57	4.75	4.33	3.83	4.12	4.3
Yoga-Track Yoga	4.90	5.00	4.83	4.58	4.82	4.5
Yoga for weight loss - Loss weight in 30 days plan	4.70	4.5	4.33	4.33	4.46	4.6
Simply Yoga - Fitness Trainer for Workouts & Poses	3.70	4.62	4.00	4.33	4.16	4.1
Yoga Challenge App1	3.00	4.37	3.83	1.58	3.19	4.4
Yoga daily fitness - Yoga workout plan	4.30	4.50	4.00	3.91	4.17	4.6
Yoga Studio: Mind & Body	3.40	4.50	4.83	3.74	4.11	4.3
Yoga Workout - Yoga for Beginners - Daily Yoga	4.50	4.87	4.49	3.99	4.46	4.7

Yoga for Beginners	3.40	5.00	4.66	4.24	4.32	4.3
7pranayama: Yoga Daily Breath Fitness Habit – Calm	4.00	4.62	3.83	4.49	4.23	4.6
Yoga Flexibility for Beginners	3.60	4.62	4.49	4.08	4.19	4.1
Yoga for Kids	3.30	4.62	3.66	2.41	3.49	4.4
Yoga for Weight Loss	4.20	4.75	4.66	3.99	4.40	4.2
Complete Yoga Guide	2.60	4.87	3.66	4.08	3.80	4.2
Yoga Challenge App2	3.70	5.00	3.49	2.16	3.58	4.6

Note. Yoga Challenge App1 and Yoga Challenge App2 are two different apps with the same name.
*Google star rating is the customer satisfaction score that is publicly available by the Google Play store. This score is not evaluating the same criteria as the MARS score. This score is included based on our search date, which has a high probability of being changed with time.

Fourteen out of 18 apps received an average score above 4 based on the MARS, and four received less than 4 (Table 1). Based on the findings of this MARS score-based analysis, the Track Yoga app has the highest score (4.82), which is 0.32 higher than its average star rating described in the Google play store. The lowest MARS score is observed in the Yoga Challenge App1, which had a higher Google star rating by the users. Most apps performed well on functionality (M = 4.65; SD = 0.34) and aesthetics (M = 4.22; SD = 0.41) compared to the information (M= 3.75; SD = 0.83) and engagement (M= 3.83; SD = 0.62) domain.

We were unable to consider the MARS item 19 (Evidence Base: Has the app been trialed/tested; must be verified by evidence in the published scientific literature?), which asks the rater to assess the evidence from the literature as most of the apps lack evidence in the scientific research. Even the initial reliability study of the MARS (Stoyanov et al., 2015) had to skip this

item, and many app review studies (Choi et al., 2018; Grainger et al., 2017) also could not consider this criterion (evidence-base), which indicates the necessity of scientific investigation on the usability of mobile apps. We did not include subjective quality, which asks about the rater's personal feelings on four components (possibility of recommending the app to others, possibility about the frequency of use in 12 months, willingness to pay for the app, and star rating) within the consideration of our final MARS score. Some other app reviews (Bardus et al., 2016; Wilson et al., 2016) were also focused on using only the objective subscales of the MARS. The study showed excellent inter-rater reliability between the two independent raters (two-way mixed ICC = .88; 95% CI 0.85-0.91).

Discussion

We selected the Track Yoga app for our intervention study with breast cancer survivors based on the MARS score and the app features based on the MARS evaluation. This app had the highest MARS score and several features that would be beneficial to study participants, such as reminders, a tracker, a weekly goal, and gamified badges at the end of the successful completion of the class to motivate users. The app also offered different classes and the ability for the user to select the level of practice desired. Although some features of this app were free, there was also the opportunity to select in-app purchases for premium features which give access to all the programs within the app. This app can be projected on the television for a better viewing experience with a specific setup (example: Chromecast, Apple TV). This app was also available on the iOS platform, which helped us to attract both Apple and Android users for our intervention study.

Overall, 78% of our evaluated apps scored above 4 out of 5, while 22% got less than 4. The range of the MARS score is 3.19 to 4.82, with a mean of 4.11 and a standard deviation of 0.38, which

indicates reduced variability of the MARS score in our selected apps. One of the reasons behind it is the selection of all 4-star apps with a high number of raters. Three apps had the same MARS score as the Google star rating, but the majority of apps (72.2%) scored lower on the MARS than the Google star rating. This is consistent with other MARS studies (Bardus et al., 2016; Knitza et al., 2019; Salazar et al., 2018), which also found a lower score in the MARS compared to the Google rating in the majority of selected apps. We discovered a lower score in the information and engagement domain compared to the functionality and aesthetics. A study focused on the evaluation of physical activity apps (Wang et al., 2020) with the MARS also indicated the necessity of improvement in the information domain. This study could not consider item 19 (Evidence Base) in their information score as there was a lack of evidence in the existing scientific literature. Another study with mindfulness apps (Mani et al., 2015) also found the lowest MARS score in the engagement domain and suggested future additional gamification features to motivate users. We found high functionality scores in our apps; most of the apps were easy to use, and navigation was accurate.

During our assessment with the MARS, we observed advertisements in the apps, which caused a hindrance in the logical flow between screens. However, most of our apps were visually appealing, and they used logical graphics and layouts. Therefore, most of the selected apps performed well in the aesthetics domain of the MARS. We did not consider apps that have lower than the mean number of raters and 4- and above-star ratings in our selection phase. Although star rating is considered as a selection criterion in several similar studies (Bardus et al., 2016; Wang et al., 2020), there is a high possibility that we eliminated some high-quality apps. Usually, newly launched apps have a low number of raters which usually increase with time. With our goal to evaluate apps with high star ratings and a high number of raters, those newly launched apps got eliminated.

In the final stage of yoga app selection, we only analyzed the yoga app's free features. It has limited our assessment as often paid features to provide some additional services and advertisement-free content. Cost is an essential determinant of mobile app adoption (Pagani, 2004). Therefore, we were only focused on free apps to download; however, some of these apps have an in-app purchase option to access more services. Therefore, our result should be interpreted with caution. Elimination of the apps that exclusively focused on finger yoga poses (Yoga mudra), yoga, or meditation music-only apps (no yoga poses-related instruction) might limit the scope of this research.

Our study only used the search term 'yoga,' which might eliminate some of the apps that contain yoga support components. For example, an app that had the yoga component (Nike Training Club-Work Outs & Fitness Guidance) was missing from our retrieval of the Google apps. Future researchers should use multiple search terms (for example, 'yogic posture,' 'meditation,' 'physical activity,' 'workout,' 'fitness') and then manually review those apps to reduce the possibility of such automatic elimination of the target apps.

None of our research team members were professionally trained in yoga. However, the purpose of our app review was to evaluate apps from a general user's perspective based on the MARS criteria.

After our study, we could emphasize further that the MARS is a useful tool for the initial evaluation. Still, it is not a replacement for other evidence-based research methods to evaluate an app's usefulness. Like many other app review studies (Grainger et al., 2017; Knitza et al., 2019; Wilson et al., 2016), we are also aware of the constant evolution of the app market. There is a possibility that the recent status of the apps after publication may differ from the app status when we evaluated the market.

There is a necessity to define yoga apps and the components necessary to specify a particular app as a yoga app, and we felt the need to develop new tools or criteria specific to yoga, which will be an area to explore in a future investigation. Some of the apps got higher ratings because they fulfilled the requirements of the MARS, but these are not necessarily excellent yoga support tools. Both raters perceived continuous interactive video and audio guidance of yoga as beneficial, which is not addressed by some of the yoga apps with a high MARS score. The areas that the MARS does not cover include crucial domains like privacy and security issues, access, and interoperability, limiting the extent of our evaluation (Levine et al., 2020). A study that focused on existing laws regarding mHealth in the U.S. and the EU stated that the laws and regulations to control mobile health applications are old and require thorough revisions (Martínez-Pérez et al., 2015) to minimize the risk of data breaches via these applications. Even the current stance of the FDA to regulate health and wellness apps are also questionable (Kasperbauer & Wright, 2020). Depending on the type of data the app collects, users face varying privacy and security threats (Benjumea et al., 2020). A scoping review study with 24 articles that investigated either privacy or security, both privacy, and security, or both with other quality assessment criteria found heterogeneous standards for privacy and security evaluation across their selected studies (Benjumea et al., 2020). Although our selected instrument, the MARS, does not highlight much on issues like privacy and security, it is a well-tested and highly evaluated tool for assessing the quality of mobile applications (Terhorst et al., 2020). However, recognizing the wide variation of perception and individual choice, further investigation is highly encouraged.

More research is needed to explore new features to provide more customization, high-resolution pictures, and uninterrupted video functionality. There is some evidence with distance

yoga teaching that the participants found a video conference with a yoga instructor beneficial (Baker, 2018; Mathersul et al., 2018; Schulz-Heik et al., 2017).

Most of the free apps included some pre-loaded videos and limited resource information. The addition of more external links to resources will be an additional motivation for the persistent use of the apps. For example, future apps might consider video conferencing options to provide a human touch and support to the people doing yoga. In addition, future apps might benefit by adding more customization features to mitigate individual needs, gamification, instant feedback features, user manual, contacts for technical solutions, and external links to online resources.

Despite limitations, our study identified some standard features of yoga apps and identified some quality issues with these apps. With the increasing trend of yoga practice, future investigations should test the efficacy of these yoga apps in clinical trials. This review has given a preliminary idea about the status of the selected yoga apps' existing free features. We are hopeful that our future intervention study will explore new dimensions of the user experience. Future research must investigate these apps' full features (both paid and unpaid versions) to draw better conclusive findings.

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CHAPTER 3: A STRUCTURED REVIEW AND EVALUATION OF APPLE MOBILE APPLICATIONS FOR YOGA SUPPORT

Abstract

Apps for exercise are getting wide attention from the general public due to multiple benefits such as convenience, flexibility, tracking, and self-control or autonomy over exercise. However, for the benefits of users and better service, evaluation of quality and functionality is necessary. Therefore, the purpose of this study is to evaluate the quality of commercial apps present in the iOS platform, which offer yoga support with a well-tested tool called the Mobile Application Rating Scale (MARS). Based on our inclusion and exclusion criteria, we selected six apps from a pool of 200 apps for the MARS analysis. The range of the MARS score was noted between 3.94 to 4.59 out of a total possible score of 5. A good score was observed in the aesthetics (M = 4.57; SD = .27), functionality (M = 4.27; SD = .24) and engagement domain (M = 4.15; SD = .64) indicating the need of improvement in the information domain. Moderate interrater reliability (ICC = .69; 95% CI .55-.79) was observed between the two raters.

Background

Background/rationale

According to the recent statistical projection, more than 284 million Americans are expected to be smartphone owners by 2022 (Statista, 2019). This increasing trend of smartphone use has fueled the use of different health apps for managing health and wellness. A national survey in the United States showed that most of their participants (58.23%) downloaded health apps on their mobile devices (Krebs & Duncan, 2015). Among these users, 52.8% self-reported monitoring their physical exercise, 46.8% used apps for maintaining their weight target, and 34% of them used their mobile apps to learn exercise methods (Krebs & Duncan, 2015). With the tremendous surge in smartphone technology, mobile devices are now acting as a daily life companion and a key

solution to our everyday problems (TOD, 2020). Different mobile-aided apps empower individuals to participate in healthcare decision-making, self-management, and self-monitoring (Mahmood et al., 2019). Recent trends indicate that people trust their mobile devices for performing their exercise and fitness activities (Fanning et al., 2012; Yerrakalva et al., 2019). A small-scale pilot study has also observed the multiple benefits (ex.: real-time health parameters monitoring, feedback, audio-visual guidance of exercise, tracking) of using fitness and exercise apps (Padmasekara, 2014). According to a global survey arranged by the American College of Sports Medicine's (ACSM) Health & Fitness Journal, yoga holds the 7th position in the top 20 worldwide fitness trends (Thompson, 2018).

Yoga, an ancient healing tradition, may transform life and lifestyle with the systematic implementation of mind-body techniques (Nagendra, 2008). It is estimated that 36 million Americans practice yoga, which is almost 10% of the total population, for various health & wellness reasons (Ipsos, 2016). Apart from the self-identified & self-reported benefits of yoga, several structured investigations also identified the positive aspects of yoga, especially for people with long-term illness and multidimensional therapeutic needs (Buffart et al., 2012; Sharma, 2014). Existing literature has found yoga as a useful intervention to reduce stress and anxiety (Li & Goldsmith, 2012), for weight management (Braun et al., 2012; Dhananjai et al., 2013), for increasing muscle strength and flexibility (Amin & Goodman, 2014; Kim et al., 2012; Woodyard, 2011), and for improving the quality of life (Halpern, 2011; Lakkireddy et al., 2013; Woodyard, 2011). Studies have also found the positive influence of yoga in disease management, including cardiovascular disease (Cramer et al., 2014), arthritis (Sharma, 2014), diabetes (Innes & Selfe, 2016), cancer (Agarwal & Maroko-Afek, 2016; Agarwal & Maroko-Afek, 2018; Lin et al., 2011), and pain (Cho et al., 2015). Therefore, it is widely practiced by people with chronic diseases

(Desveaux et al., 2015) and fatal diseases like cancer for better self-management and enhancement of quality of life (Agarwal & Maroko-Afek, 2018; Lin et al., 2011). A recent study with a small number of participants (*n*=7 dyads with cancer patient and caregiver) recognized video-conferencing systems as an acceptable medium of yoga practice; however, preference still goes with the in-person yoga class (Snyder et al., 2021).

A systematic review study that compared older adults' (age group: 67 to 86 years) adherence towards technology-aided and conventional exercise programs observed more adherence (8% higher median) in the technology-aided exercise interventions (Valenzuela et al., 2018). Moreover, technology might have the potential to address some of the identified constraints of the in-person yoga class; for example, scheduling (Atkinson & Permuth-Levine, 2009; Quilty et al., 2013; Spadola et al., 2017; Wertman et al., 2016), transportation (Atkinson & Permuth-Levine, 2009), and cost (Quilty et al., 2013; Wertman et al., 2016). A randomized control trial with mothers of young children observed positive changes in the mother's sedentary lifestyle following exercise support intervention with a mobile app that offers multiple fitness activities, including yoga (Mascarenhas et al., 2018). Although the popularity of a mobile app is widely determined by the number of app downloads, star rating, and reviews, studies observed substantial consumer loss within the first week of app installation, which pointed to these apps failing to keep motivated users for a more extended period (Sigg et al., 2019). Hence, there is a need for system updates and capturing user-specific needs to increase consumers' retention rates with an app. Despite the presence of hundreds of apps for yoga support, to our best knowledge, none of the prior studies have systematically evaluated apps that offer yoga.

Objective

In this paper, we aimed to evaluate the quality and functionality of commercial yoga applications from the Apple App Store (iOS platform) with a highly reliable rating scale named Mobile Application Rating Scale (MARS).

Method

This study was conducted in two steps. First, mobile apps were identified according to pre-determined criteria in the App Store. Second, two reviewers independently assessed the selected apps with a validated and widely implemented tool for rating mobile applications.

Selection of mobile apps

We ran our search on the keyword "Yoga" on 4/18/2019 to extract all the App Store information, which pulled out 200 apps. We determined inclusion and exclusion criteria for selecting relevant apps. Apps were included in the study if they met the following criteria:

1) Offered in English.
2) Current version release date is not before 2017; the rationale behind this criteria selection was to choose apps that are continuously monitored or updated. It is seen in the studies that frequent updates help the app to sustain its position on the popular list of the Apple App Store (Lee & Raghu, 2014).
3) Average user rating of 4 or more as described in the App Store; The reason behind this was selecting apps that have a higher number of star ratings, which denotes the popularity and quality of the app based on the previous user's feedback. Moreover, consumers often choose based on the feedback and star rating of the prior users before installing an app (Harman et al., 2012).

4) App Store description says that the app offers written/audio/video guidance about yoga poses.

We were only focused on the app store's written description for selecting relevant apps in the earlier selection phases. We excluded apps if they did not offer free services relevant to yoga practice. Moreover, it is observed that users tend to download free apps more often than paid apps (Petsas et al., 2013). Another study that analyzed the probability of the existence of an app on the top 300 list of the Apple App Store depends on some attributes, including price (Lee & Raghu, 2014). This study found that a free app is two times more likely to be included in the top 300 list than a similar app that must be paid for (Lee & Raghu, 2014). Therefore, we were more focused on the more popular choice of apps that are free or the paid apps which offer free yoga content.

Evaluation of mobile yoga apps

An app's popularity is widely measured based on the user-rating score of the App Store (Harman et al., 2012; Lee & Raghu, 2014). Apple App Store provides both an average user rating and the current version user rating. In spite of the wide acceptance of user ratings as a measure of app quality from a consumer as well as developer's perspective, it cannot be a stand-alone determinant of an app's quality (Ruiz et al., 2015). Hence, our study used a validated scale to determine the quality of our mobile apps. Previous studies which were focused on different health and wellness apps of similar areas, for example, mindfulness (Mani et al., 2015) and weight management (Bardus et al., 2016), also used this validated tool named the Mobile Application Rating Scale (MARS). Findings of a recent study also recommended the MARS as a useful tool that can help clinicians help their clients to choose apps that belong to the wellness category, for example, mindfulness, weight control, activity tracker, glucose monitoring, and medication-related information (Stec et al., 2019). A systematic review that analyzed different available mobile

assessment tools highlighted seven significant aspects that can determine app quality: Design, Information, Usability, Functionality, Ethical Issues, Security and Privacy, and User-perceived Value (Nouri et al., 2018), and the MARS covers most of these domains. Multidimensional components of the MARS (see Appendix A) include engagement (entertainment, interest, customization, interactivity, target group), functionality (performance, ease of use, navigation, gestural design), aesthetics (layout, graphics, visual appeal), information (accuracy of app description, goals, quality and quantity of information, visual information, credibility, evidence base), and subjective quality (Stoyanov et al., 2015). The scoring system of the MARS is a 5-point Likert Scale (1- Inadequate, 2- Poor, 3- Acceptable, 4- Good, 5- Excellent) (Stoyanov et al., 2015). This scale calculates values as a mean score so a rater can eliminate a nonrelevant section from the total score. The MARS is a highly reliable and largely tested tool to evaluate different mobile applications with highly reliable internal consistency. This tool has high internal consistency (Cronbach alpha = .90) and a inter-rater reliability intraclass correlation coefficient (2-way Mixed *ICC* = .79, 95% *CI* .75-.83) as indicated by the inventors of the MARS.

The principal investigator conducted the initial screening of the apps based on objective inclusion criteria. The MARS inventors developed a training video from which our two raters (principal investigator & YC) learned the tool applications (Stoyanov, 2016). One of the investigators (YC) had previous experience of doing app evaluation with the MARS scale, and his study was published in a peer-reviewed journal (Choi et al., 2018) . He trained the principal investigator (SS).

Two reviewers reviewed these apps with the MARS criteria independently and then met to discuss them. In this paper, researchers determined the MARS score after evaluating the selected

yoga apps under four categories (Engagement, Functionality, Aesthetics, and Information). Raters did not consider the subjective quality score in their final MARS score calculation.

Result

We followed specific steps to identify the apps for our final evaluation (Figure 2.1).

Step 1: We read all the app descriptions carefully and excluded 85 apps that did not maintain our selection criteria as yoga apps.

Step 2: We eliminated 20 yoga apps with the current version release date before the year 2017. We wanted to focus only on the apps which were regularly updated and maintained by developers. Therefore, we eliminated old apps.

Step 3: We excluded 11 apps with an average user rating of less than 4. Additionally, we had to exclude four apps with no average user rating information at the time of our search because they were either very new or were about to launch within a few days.

Step 4: Out of 75 relevant apps above 4 average user rating apps, we selected only the apps with a more than average user rating count (>12,297). Only 16 apps met all the criteria.

Step 5: We downloaded 16 apps (see Appendix C) on our iPhone to evaluate their content and included only six apps for our MARS evaluation after removing 10 apps. Seven apps did not have any free features for yoga practice. Two apps were scheduling or class-finding apps that did not have any feature to support people's yoga practice by their app's free content. There is no doubt these apps were a resource for finding nearby yoga classes or for booking classes. We also eliminated Udemy, which is an online learning platform, from our final analysis.

Step 6: two of our raters (SS & YC) spent time in their homes reviewing six apps based on the MARS criteria.

Figure 2.1 *Flow Chart Describing App Selection Process*

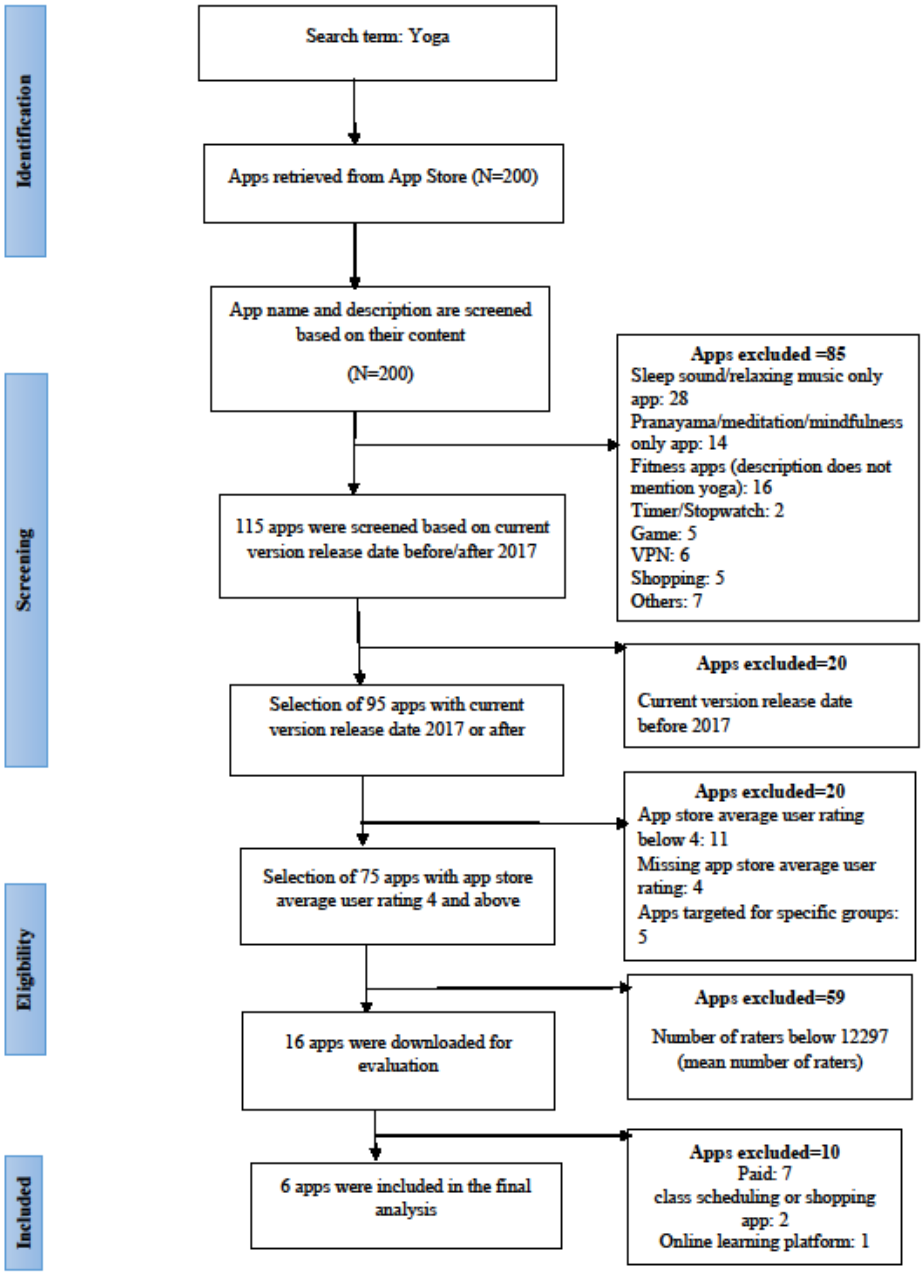

Table 2.1

MARS Scores Compared to Average App Store Ratings for Yoga Applications

Name of App	Average sub-score based on MARS by two reviewers				Average total score $\frac{a+b+c+d}{4}$	Average app store rating
	Engagement (a)	Functionality (b)	Aesthetics (c)	Information (d)		
Nike Training Club	4.9	4.5	4.66	4.33	4.59	4.5
Class Pass	3.7	3.87	4.83	3.41	3.95	5
Down Dog| Great Yoga Anywhere	3.8	4.5	4.66	3.49	4.11	5
Daily Yoga - Workout & Fitness	5	4.25	4.83	4.08	4.54	4.5
Yoga Studio: Mind & Body	3.5	4.12	4.33	3.83	3.94	4.5
Yoga for Beginners | Mind+ Body	4	4.37	4.16	3.41	3.98	4.5

After applying the MARS criteria, we found that our selected six apps' range of MARS scores was between lowest (3.94) and highest (4.59). Fifty percent of our apps scored above 4 out of 5, and 50% of our apps scored below 4 in the MARS evaluation. The MARS score of the app Nike Training Club app was almost the same as the average App Store rating. Most of the apps performed well in the aesthetics (*M* = 4.57; *SD* = .27), functionality (*M*= 4.27; *SD* = .24), and engagement domain (*M*= 4.15; *SD* = .64) compared to the information domain (*M* = 3.76; *SD* = .38). The two raters independently recorded subjective quality scores (*M*= 2.39; *SD* = .87) based

on their personal feelings. We calculated the interrater reliability of the MARS score between the raters with the reliability index ICC (intraclass correlation coefficient). We used a two-way mixed-effects model as two specific raters participated in this reliability experiment (Koo & Li, 2016).

At a 95% confidence interval, the ICC estimate is between .55 to .79, indicating moderate reliability. Overall, we found moderate interrater reliability (*ICC* =. 69) between our raters. We used R studio to calculate interrater reliability.

Discussion

Overall, 50% of the apps scored above 4, which means these apps fall under good quality according to the MARS criteria. The rest of the apps also scored slightly less than 4, so we can infer that they fall under the acceptable quality range. In our study, most apps (67%) scored less in the MARS evaluation than the average App Store user rating. Compared to the other three domains (aesthetics, functionality, engagement), the information domain score was lower, consistent with other MARS app review studies (Bardus et al., 2016; Wang et al., 2020). A lower information score indicates the need for good content within the app. We found a good engagement score based on the MARS criteria. Most of our apps used gamification features (ex: badges) to give acknowledgment upon completion of their exercise session. According to the existing literature, gamified features within apps always act as an incentive and engage users for a more extended period (Kamboj et al., 2020; Law et al., 2011).

We could not consider Evidence Base (item 19) as we could not find any scientific literature on our selected apps except Nike Training Club. Although some scientific studies (Cady et al., 2016; Padmasekara, 2014) have used Nike Training Club in their investigation, this tool's validity and effectiveness are unclear (Adamakis, 2018). Moreover, we only evaluated the free content related to yoga within this app, and we could not find any studies that evaluated the yoga

part of this app. Many other MARS studies have also skipped Evidence Base because of a lack of scientific investigation on the usability of mobile apps (Choi & Kim, 2016; Creber et al., 2016; Larco et al., 2018). All of our apps provided audio-visual guidance of yoga, and they had basic features (sharing in social media, scheduling, reminder, feedback by written review, or star rating). The majority of the apps track the exercise duration time and type. Most apps had certain gamification features (ex: badges) to encourage users to complete their exercise. We noticed frequent advertisements which were interrupting the navigation of the apps. Premium features probably offer more flawless service. We downloaded these apps on an iPhone7 and evaluated these features. Future researchers might benefit by testing these apps on different devices to see if they function differently. As the global app market is very competitive (and developers keep updating apps according to user demand and feedback), these apps may have changed their features a lot from the time we assessed them. Besides limitations, our study has discovered some important insights about the current status of Apple yoga apps. To our best knowledge, it is the first Apple yoga app review study with the MARS criteria. Future researchers must consider more vigorous research in this arena. Clinical trials and a human-centered design approach are needed to understand the usability and functionality of these apps.

Acknowledgment

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CHAPTER 4: ACCEPTANCE AND USE OF A MOBILE YOGA APPLICATION BY BREAST CANCER SURVIVORS: A BRIEF INTERVENTION STUDY

Abstract

For improving quality of life, many breast cancer survivors practice yoga. However, attending yoga in an in-person setting can bring challenges related to transportation, the cost of in-person classes, scheduling, etc. Some of these challenges can be addressed by a yoga app or similar kinds of virtual services. The purpose of this seven-day intervention study is to investigate the adoption and acceptance of a selected commercial yoga app among breast cancer survivors. Our enrolled participants (N=92) were asked to use the app for practicing yoga for a week. After that, they were asked to complete a post-seven-day and a post-30-day follow-up questionnaire. After elimination, our final sample size was 48. Participants' mean recorded Health Technology Acceptance and Use (HTAU) score is 106.08 (*SD* = 38.80) out of a maximum possible score of 198. In the post-30-day follow-up survey, almost 59 % of the respondents expressed their interest in continuing using the app after our study. The logistic regression model found a statistically significant positive relationship between the HTAU mean construct score and the intention to continue yoga app use beyond our study (p = .043). Overall, our result indicates that a commercial yoga app may seem helpful for some users. However, our result should be considered with caution.

Background/rationale

With modern medical treatment and research, the life expectancy of patients with breast cancer has risen significantly (Mariotto et al., 2017). According to a published report by the American Cancer Society (ACS), the term "cancer survivor" is defined as "..any person with a history of cancer, from the time of diagnosis through the remainder of their life." (ACS, 2016, 2019). Additionally, this report also mentioned,

"The definition of cancer survivorship has evolved from a focus on three phases (the time from diagnosis to the end of initial treatment, the transition from treatment to extended survival, and long-term survival) to encompass a wide range of experiences and trajectories. For example, some individuals may live cancer-free for the remainder of their life after initial treatment, while others may live with cancer as a chronic disease or experience recurrence or subsequent cancer"(ACS, 2019). A report that was solely focused on female breast cancer survivors defined the term "Breast cancer survivor" as "women who have received a diagnosis of breast cancer-from the point of diagnosis, through and after treatment" (WCRFI, 2014). Almost 90% of women with breast cancer can expect to live a minimum of five years, and many of them are achieving an equal age-matched life span to those without breast cancer (Siegel et al., 2021). However, from getting over the horrific experience of being diagnosed with malignancy and the treatment-related side-effects, they need long-term care and wellness support (Ng et al., 2017). Thus, this rising healthcare demand has enhanced the necessity of digital solutions to address the need of survivors. Breast cancer survivors are often enthusiastic about getting wellness support to improve their treatment outcome and quality of life (Szuhany et al., 2021). However, time (82%) seems to be the greatest challenge identified by an anonymous survey with 187 breast cancer survivors (Szuhany et al., 2021). Additionally, they also identified expenses related to wellness service (64%) as a major obstacle along with other professional (65%) and household-related responsibilities (Szuhany et al., 2021). Digital solutions can offer the convenience of scheduling and flexibility, as well as location selection, with minimal disruption to their daily responsibilities (Cox et al., 2017).

Yoga, a structured healing process culturally rooted in the East ((Singleton, 2010), has become quite popular in the West. It is also a well-accepted healing practice among American breast cancer survivors for addressing multiple health and wellness objectives (Hammersen et al.,

2020). They often take yoga for managing different health issues, e.g., stress and anxiety (Prakash & Saini, 2018), sleep (Rao et al., 2017), fatigue (Bower et al., 2012; Yi et al., 2020), lymphadenopathy (Wei et al., 2019), menopausal symptoms (Holger et al., 2018; Cramer et al., 2015), and gastrointestinal symptoms (Pan et al., 2017).

Learning yoga in a yoga studio or gym is a popular choice for people who have enthusiasm for yoga. However, yoga practice in an in-person setting can be interrupted by some identified barriers like time (Atkinson & Permuth-Levine, 2009; Dayananda et al., 2014), transportation, cost, and appropriate yoga class (Atkinson & Permuth-Levine, 2009). In addition, the recent pandemic has made a dramatic change in people's lives; the fear of having a COVID-19 infection and a "stay at home order" is limiting the day-to-day physical activities of adults in the United States (Bhutani et al., 2020; Dunton et al., 2020). As a result, our society faces a sudden increase in the need for remote exercise services while gyms and yoga studios are closed (Nyenhuis et al., 2020). Therefore, addressing some of the usual barriers (scheduling, transportation, etc.) and the sudden barriers that arise due to pandemic exploration of more accessible and cost-effective alternative ways to provide seamless yoga support to breast cancer survivors is necessary.

Survey findings on 279 post-treatment breast cancer survivors reported that almost 70% of their participants believed that breast cancer survivors should practice yoga or pilates, and almost 80% of them expressed their interest in having exercise support via different digital devices (mobile, tablet, internet) (Phillips et al., 2017). On a 4 -week post-intervention follow-up, the yoga group reported a significant reduction in menstrual pain, sleep disturbance, anxiety, and dysphoria as opposed to the control group at their 4-week post-intervention follow-up (Sakuma et al., 2012). In this study, participants received yoga intervention via a pre-recorded DVD for two weeks (Sakuma et al., 2012). The success of yoga service via remote telehealth yoga teaching was also

observed in a study with veterans, and 92% of the respondents (11 out of 12) rated the quality of the yoga classes as “excellent” (Schulz-Heik et al., 2017).

Based on the survey by Philips et al., 66% of participants have acknowledged the app as a useful medium of exercise support (Phillips et al., 2017). Findings of a randomized control trial with 114 women with breast cancer observed significantly better health outcomes in three domains (self-efficacy, symptom interference, and quality of life) among the intervention group (n = 57; who were receiving app-based support along with usual care) compared to their counterpart (n = 57; who were only receiving usual care) after three months (Zhu et al., 2018). In another cross-sectional study, 197 adult breast cancer survivors indicated mobile apps as the second most popular medium after websites to receive information and communication technology-based exercise and diet intervention (Chen et al., 2021). The findings of a pilot study observed some benefits of using yoga apps to make study participants active after eye-opening in the morning and reducing their sleepiness (Sugano & Ueno, 2013). However, this study also points towards the insufficiency of content and the need for design improvement of mobile yoga apps (Sugano & Ueno, 2013).

According to the existing studies, mobile apps are a feasible and popular choice among breast cancer survivors with an optimistic future to provide exercise support (Chen et al., 2021; Chung et al., 2020; Lloyd et al., 2016; Phillips et al., 2017). However, there is an existing discrepancy between interest in a digital exercise system and the actual use of the system (Phillips et al., 2017), which indicates further exploration improves adherence with, and acceptance of the system. Hence, the importance of this study is its potential to explain elements of the usability and acceptance of mobile apps for yoga practice. A study that assessed available apps from the Google Play Store and Apple App Store (that was dedicated to breast cancer survivorship support) highlighted the need to involve breast cancer survivors to create a better user-friendly app version

while considering their unique needs due to their disease status (Kapoor et al., 2020). Hence, the importance of our investigation lies.

Objective

The objective of this study is to assess the potential of commercial yoga apps to support the yoga practice of breast cancer survivors and assess the acceptance and use of the technology. The adoption of a mobile application is evaluated using the Health Technology Acceptance and Use (HTAU) scale to measure usefulness, usability, and relationship with actual use.

Method

Study Design

This is a brief intervention study using a validated tool to measure short-term technology acceptance and technology use. The intervention included using a commercial yoga app (Track Yoga) for seven days. The app is a commercially available free yoga app available for both Apple (Rating: 4.2 on 7/31/2020) and Android (Rating: 4.8 on 7/31/2020) devices; both have an average above 4-star rating on both platforms. Participants complete two questionnaires, the first after seven days and the second 30 days after the first questionnaire.

According to a finding of a large-scale study with 213,667 apps and a large user community of 339,842 people, the number of app downloads or installations is not an accurate predictor of the actual number of users who continue using the app in the long run (Sigg et al., 2019). Often users uninstall the app if they don't find it useful (Sigg et al., 2019). On average, an app fails to retain 65% of its users within the first seven days (Sigg et al., 2019). Very popular apps have a better user-retention capability, and they usually lose only 35% of their users in the first seven days after installation (Sigg et al., 2019). For addressing the purpose of our study, we allowed a 7-day brief

intervention so that our participants could become familiar with the app. At the end of 30 days, we wanted to check if our participants were interested in continuing their app use, although using the app a minimum of once in seven days to practice yoga was mandatory. We left the decisions about the time and duration of app use on our participants to see their spontaneous adherence and app use frequency in a seven-day period.

Health Technology Acceptance and Use Scale

There are numerous theoretical models applicable to user adoption and acceptance: theory of reasoned action (TRA), technology acceptance model (TAM), motivational model (MM), theory of planned behavior (TPB), a combined theory of planned behavior/technology acceptance model (C-TPB-TAM), model of PC utilization (MPCU), innovation diffusion theory (IDT), and social cognitive theory (SCT) (Dwivedi et al., 2011). We relied on the unified theory of acceptance and use of technology (UTAUT) model as it was the synthesis of and extension of prior models. In this model, Venkatesh et al. assimilated constructs from the eight models and found four key constructs: 1) performance expectancy; 2) effort expectancy; 3) social influence; and 4) facilitating conditions behind the user's intention to use a specific technology (Dwivedi et al., 2011; Venkatesh et al., 2003).

Figure 3.1 *UTAUT-2 Model(Venkatesh et al., 2012). Image courtesy: Creative Commons Attribution-Noncommercial-No Derivatives 4.0 International*

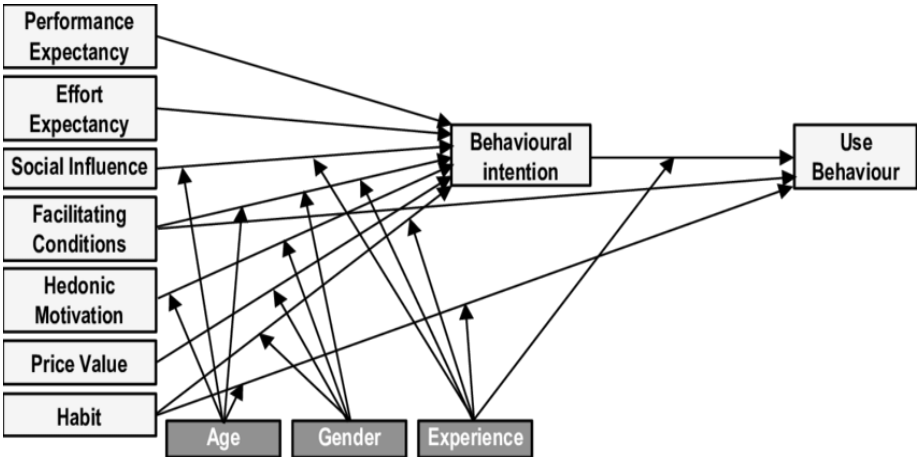

Table 3.1

Constructs of UTAUT2 Model (Slade et al., 2013; Venkatesh et al., 2012)

Constructs of UTAUT 2 Model	Definition
Performance Expectancy (PE)	The degree to which technology or system is improving the intended work quality and performance.
Effort Expectancy (EE)	The degree to which a technology is easy to use
Social influence (SI)	The degree to which individuals believe that their loved ones or near ones think that the individual should use a particular technology.
Facilitating Condition (FC)	This defines the availability of the technical infrastructure and resources to support or promote technology or systems for the users to enhance their adoption.
Hedonic Motivation (HM)	It is related to self-perceived enjoyment while using technology by users.
Price Value (PV)	It is the cost of a technology that users believe is reasonable to pay for the services they are receiving from the system.

Habit (HT)	Habit is the user's daily practice or schedule to use a technology or system.
Behavioral intention (BI)	It determines the intention or wishes to continue using technology or system.

An updated version of the UTAUT model was introduced (called UTAUT2) as a more comprehensive model to explain user acceptance and use. Three new concepts, hedonic motivation, price value, and habit, were introduced in the UTAUT2 model (Venkatesh et al., 2012). The addition of three constructs into the UTAUT2 model has increased the explanation of behavioral intention by 18% and technology use by 12% in comparison to the earlier version of UTAUT (Venkatesh et al., 2012). This theoretical model explains the behavioral intention and actual use of a technology (Venkatesh et al., 2012). The eight constructs depicted in the picture above showed their influence over the behavioral intention, and the behavioral intention also motivates actual use of the technology (Venkatesh et al., 2012). The HTAU scale was adapted from UTAUT2 for the healthcare technology context and validated among cancer patients (Kim et al., 2018). The HTAU scale was validated among cancer patients measuring the acceptance and use of a patient electronic health record portal in an urban academic medical center (Kim et al., 2018). We used the HTAU scale to explain the usability and acceptance of our participants following a brief intervention with the yoga app.

Setting and Recruitment

Participants were recruited via social media platforms from anywhere in the United States. We used social media (Facebook and Twitter) to recruit participants between March 10, 2020, to July 22, 2020. We created a study information website to provide study information. Our target population was breast cancer survivors.

Participants

Inclusion criteria were a) Breast cancer survivors who were currently not on active treatment. Participants who were only getting endocrinal therapies were eligible; b) Breast cancer survivors who had completed their surgery/chemotherapy at least two months (eight weeks) before enrollment or completed a minimum of four weeks after radiotherapy; c) Physically capable of doing yoga. We did not include newly diagnosed breast cancer survivors who had not started treatment yet in our study; d) adults (age 18 years or older); e) owners of, or had access to, an Android or Apple smartphone; f) residents of the United States; and g) able to read and converse in English. We paid for a monthly subscription ($3.29) to the yoga app so that our participants could get full access to the app.

Sample Size

Ninety-two interested candidates who met the inclusion criteria and consented were enrolled in our study. Sixty participants returned the survey. Among those 60 participants, 12 participants reported they did not use the app. Thus, the total sample for analysis included 48 participants who used the app and completed the seven-day questionnaire. (See Figure 3.2)

Ethical Considerations

The study was reviewed and approved by the UC Davis Comprehensive Cancer Center Scientific Review Committee (Study no: CCSN013) and the UC Davis IRB (IRB ID: 154241-9).

Data Source and management

Participants completed a brief demographic questionnaire covering gender, age, education, family income, insurance, relationship status, physical and mental health, and whether or not they were currently practicing yoga (see Appendix E).

Post-7-day Survey

At the end of seven days after enrollment, participants were asked to complete a post-study survey to capture their experience with the yoga app. Here participants were asked about the frequency of their yoga app use in the last seven days and the total time spent doing yoga with the yoga app. We gave instructions to the participants to fill out the frequency and duration of using the app. We also asked participants to rate the installation process of the yoga app on a 7-point scale (0 = Extremely easy to 6 = Extremely difficult). We asked our participants to fill out the HTAU scale, where we modified questions based on the yoga app (see Appendix: D, F). Each construct of the HTAU scale was rated (0 = not at all to 6 = a great deal).

30-day Post Study Survey

After 30 days, we sent a second survey to check if our study participants had intentions to continue using the yoga app after our study (see Appendix G). Survey data were collected online using Qualtrics.

Variables

1) Our main outcome variables include the response 'yes' (intention to continue app use beyond study) or 'no' (intention not to continue app use beyond study) in the post-30-day survey. Our predictor variables included duration and frequency of app use and the total HTAU score (raw HTAU score).
2) Another outcome variable is the total HTAU score or Raw HTAU score. Predictor variables include frequency and duration of app use.

Statistical methods

The data were analyzed using descriptive statistics, and relationships among HTAU and use variables were assessed using t-tests and Pearson correlation coefficients. A two-sample *t*-test

was used to determine differences between people who intended to continue app use and those who did not. Exploration of these relationships included HTAU total and construct scores and self-reported actual use of the app. The total HTAU score was the sum of scores from all constructs. Logistic regression is a common model in medicine or health-research-related fields and is used to describe the relationship between binary or categorical outcome variables and dependent variables (irrespective of continuous, ordinal, categorical) (Czepiel, 2002; Smith & McKenna, 2013). Therefore, we used a logistic regression model to describe the relationship between the total time (in minutes) spent in seven days with the app (duration) and the probability of saying 'yes' in the continued use of the app on the post-30-day survey. All the statistical analysis was completed using Stata 17 (College Station, TX).

Results

Participants

Out of 92 enrolled participants, 60 participants (65.21%) completed the first survey (seven-day post-survey). However, 12 participants never used the app (see Appendix H: demography; Appendix I: reasons for not using the app). Thus, 48 participants were included in the final sample (See Fig 3.2). Among these study participants, 39 people also responded in the 30-day post-study survey.

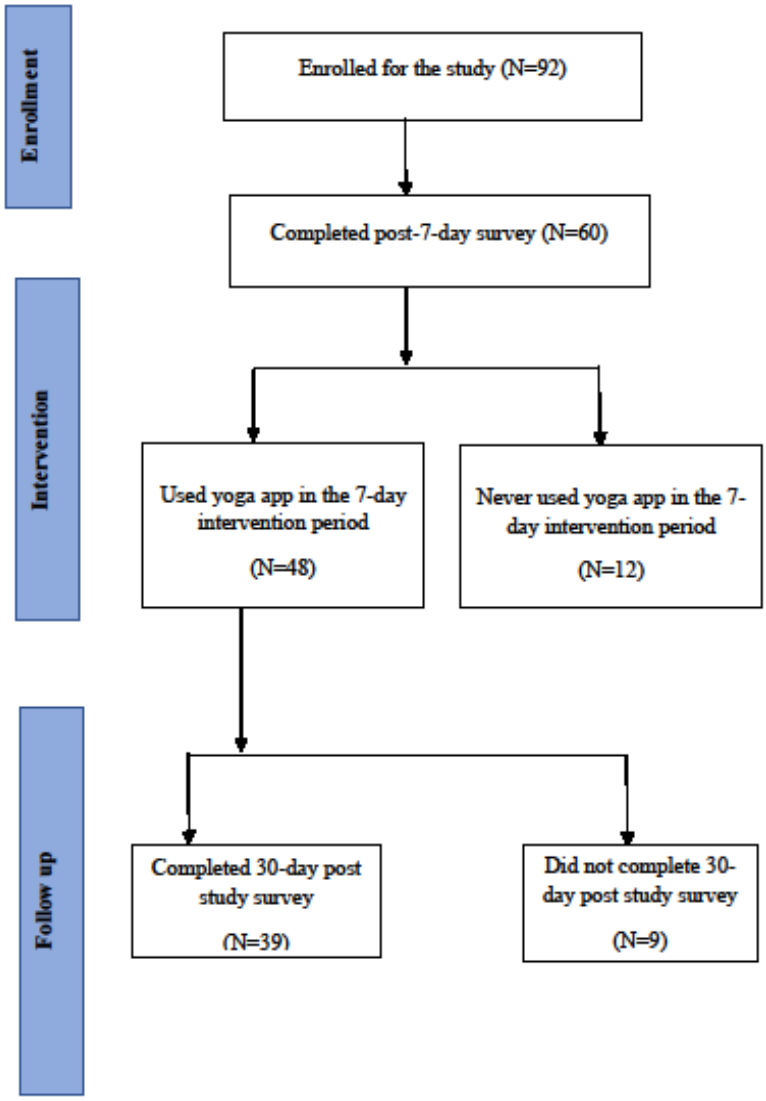

Figure 3.2 *Diagram Describing Participant Enrollment*

Descriptive data

Most of our participants (85%) were white and married (73%). Forty-eight percent of the participants reported having a minimum family income of $90,000 per year. (See Table 3.2.) All

of our participants had a college education and health insurance (See Table 3.2). Most of our participants (67%) said “no” to the current practice of yoga (See Table 3.2).

Table 3.2

Demographic Characteristics of Participants (n=48)

Characteristics	n	%
Age		
Below 35	2	4.16
35 to 55	22	45.83
56 to 78	24	50.00
Race		
White	41	85.42
Asian	2	4.17
Native Hawaiian or Pacific Islander	1	2.08
Hispanic or Latino/ Hispanic or Latino, White*	2	4.16
White, Other	2	4.17
Education		
Some college	5	10.42
College Graduate	22	45.83
Post-Graduate	21	43.75
Insurance		
Medicare**	7	14.58
Medi-Cal	1	2.08
Private health insurance	38	79.17
Another type of health insurance	2	4.17
Marital Status		
Single	6	12.50
Married	35	72.92
Unmarried but living with partner	2	4.17
Divorced/Separated	3	6.25
Widow	2	4.17
Family income		
Less than $40,000	6	12.50
$40,000 to below $90,000	12	25.00
$90,000 and above	23	47.92
Prefer not to State	7	14.58
Other Questions		
Mental Health		
Excellent	6	12.50

Very good	33	68.75
Fair	9	18.75
Physical Health		
Excellent	3	6.25
Very good	26	54.17
Fair	19	39.58
Current Yoga Practice		
Yes	16	33.33
No	32	66.67

Note. * Hispanic or Latino, White = 1; Hispanic or Latino = 1

** Medicare = Medicare only + Medicare with another type of health insurance = 4+3

Outcome data

Technology Use

On average, participants reported using the app for practicing yoga 3.89 times (SD = 1.45) in a week and 64.48 minutes (SD = 44.47) in total (see Table 3.3). There were 46 respondents who reported duration. Four of them reported the same frequency and duration (for example, six times in a week and the total duration of six minutes), which may be due to error or misunderstanding the question. Another person could not remember the duration. Therefore, those five responses were eliminated from duration analysis.

Table 3.3

Mobile Application Seven-day Use

Variable name	n	*M*	Median	*SD*	Minimum	Maximum
Frequency (number of sessions)	46	3.89	4	1.45	1	7
Total Duration (minutes)	41	64.48	58	44.47	10	180

Installation of yoga app

Respondents found the installation of the yoga app on their devices very easy (M = .70; SD = 1.21). 65.21% (30 out of 46 respondents) rated this process as extremely easy (0) on a 7-point Likert scale. Highest reported installation effort reported as 4.

Health Technology Acceptance and Use Score

The table below (Table 3.4) describes the HTAU scale normalized mean construct score. Here, the total construct score is divided by the number of items reported by a participant.

Table 3.4

Health Technology Acceptance and Use Scale Normalized Mean Construct Score

Construct name	n	Mean*	*SD*	Minimum	Maximum	Maximum possible score
Performance Expectancy	47	2.80	1.31	0	5.37	6
Effort Expectancy	47	4.26	1.45	0	6	6
Social Influence	47	1.95	1.86	0	6	6
Facilitating Condition	47	4.30	1.04	1.75	6	6
Hedonic Motivation	47	3.70	1.67	0	6	6
Price Value	44	3.87	1.70	.33	6	6
Habit	47	2.03	1.42	0	4.33	6
Behavioral Intention	47	3.04	1.89	0	6	6

Note. *construct score divided by the number of items in the construct.

Among all the constructs of the HTAU scale (see Table 3.4), the highest score was facilitating conditions (*M*= 4.30; *SD* = 1.04) followed by effort expectancy (*M* = 4.26; *SD* = 1.45), price value (*M* = 3.87; *SD* = 1.70), hedonic motivation (*M* = 3.70; *SD* = 1.67), behavioral intention

(*M* = 3.04; *SD* = 1.89), performance expectancy (*M* = 2.80; *SD* = 1.31), and habit (*M* = 2.03; *SD* = 1.42). The lowest mean score was observed in the social influence construct (*M* = 1.95; *SD* = 1.86).

Table 3.5

Health Technology Acceptance and Use Scale Raw Score by Construct

Construct name	n	*M*	*SD*	Minimum	Maximum	Maximum possible score
Performance Expectancy	43	22.21	10.48	0	43	48
Effort Expectancy	47	17.06	5.84	0	24	24
Social Influence	46	9.48	9.17	0	30	30
Facilitating Condition	47	17.21	4.17	7	24	24
Hedonic Motivation	47	11.11	5.02	0	18	18
Price Value	43	11.77	5.11	1	18	18
Habit	47	6.11	4.28	0	13	18
Behavioral Intention	47	9.15	5.67	0	18	18
Total	39	106.08	38.80	15	183	198

Note. *Responses with missing items are eliminated from the HTAU total count.

Out of the maximum possible total HTAU score of 198 (calculated by adding the total scores of eight constructs), the range was 15 to 183 and the mean 106.08 (SD = 38.80) (see table 3.5). In the six constructs, at least one person reported a minimum score of 0 (not at all). Except for the constructs (performance expectancy, habit), at least one respondent recorded the maximum possible score in all other six constructs.

Follow up

Among 39 participants who completed the final follow-up questionnaire (see Appendix G) after 30 days of enrollment, 23 (58.97%) reported their intention to continue yoga app use after finishing the study.

Main results

Table 3.6 *Two-Sample t-Test Results between Two Groups (People Who Said 'Yes' and 'No' to the Post-30-Day Survey)*

Construct total score	Group	*M*	*SE*	*SD*	*t*	*df*	Sig (2-tailed)	95% *CI*	
								LL	UL
Performance Expectancy (PE) total	No	16.73	3.04	11.76	-2.64	33	.0125*	10.22	23.24
	Yes	25.6	1.81	8.10				21.81	29.39
Social Influence (SI) total	No	6.06	2.30	9.21	-2.20	37	.034*	1.15	10.97
	Yes	12.26	1.72	8.24				8.70	15.82
Hedonic Motivation (HM) total	No	8.75	1.47	5.89	-2.68	37	.011*	5.60	11.89
	Yes	12.87	.78	3.73				11.26	14.48
Behavioral Intention (BI) total	No	5	1.46	5.83	-4.07	37	.0002*	1.89	8.11
	Yes	11.22	.78	3.73				9.60	12.83
Habit (HT) total	No	3.5	1.03	4.11	-3.41	37	.0016*	1.31	5.69
	Yes	7.65	.72	3.46				6.16	9.15
Effort Expectancy (EE) total	No	16.19	1.63	6.52	-1.27	37	.2129	12.71	19.66
	Yes	18.48	.1.00	4.78				16.41	20.54

Facilitating Condition (FC) total	No	17.75	1.10	4.39	0.31	37	.7561	15.41	20.09
	Yes	17.30	.91	4.36				15.42	19.19
Price Value (PV) total	No	11.38	1.46	5.25	_0.23	33	.8212	8.21	14.56
	Yes	11.77	.99	4.64				9.72	13.83
HTAU Score***	No	94	11.71	42.21	-1.58	30	.13	68.49	119.51
	Yes	115.47	7.96	34.68				98.76	132.19
HTAU mean construct score ***	No	20.68	2.78	11.10	-2.73	37	.0097*	14.76	26.59
	Yes	29.01	1.67	8				25.55	32.47

Note. CI = confidence interval; LL = lower limit; UL = upper limit
***HTAU score = PE total + EE total + SI total + HM total + BI total + HT total + FC total + PV total HTAU mean construct score total = PE average + EE average + SI average + HM average + BI average + HT average + FC average + PV average
*P<.05

There were significant differences in the performance expectancy, social influence, hedonic motivation, behavioral intention, and habit construct score between those who intend to continue app use and those who do not. Findings of our two-sample *t*-test show that those who intend to continue had a higher performance expectancy, social influence, hedonic motivation, habit, and behavioral intention construct scores. (See Table 3.6). No significant differences were observed in the facilitating condition, effort expectancy, and price value construct score between these two groups). There was no significant difference in the total HTAU score, but there was in the HTAU mean construct score

Correlation

There was a weak positive correlation (r =.26) between the frequency of app use (number of times participants used the app in seven days) and the total HTAU score (PE total + EE total +

SI total + HM total + BI total + HT total + FC total + PV total). There is no statistically significant relationship between the frequency of app use and the HTAU score. However, a medium positive correlation (r = .34) was found between the frequency of app use and the HTAU mean construct score (PE average + EE average + SI average + HM average + BI average + HT average + FC average + PV average) and this relationship is statistically significant (p = .02) at 95% confidence interval. The total duration of app use and the HTAU mean construct score are very weakly correlated (r = .20). There is no statistically significant relationship between the total duration of app use and the HTAU mean construct score.

Similarly, two variables (HTAU score and the duration of app use) are moderately correlated with each other (r = .34). However, this relationship is not statistically significant. There is a strong positive relationship (r = .67) between the frequency (total number of times in seven days the participant used the app) and the duration (total minutes the participant spent in seven days with the app). This relationship is statistically significant (P<.001) at 95% confidence interval.

Table 3.7

Logistic Regression Model for Ongoing Use of App at 30 days

30-day app use (Yes)	N	Coefficient	*SE*	*Z*	*P>Z*	*Pseudo R2*	*Prob>chi2*	Log-likelihood	*95% CI*
HTAU mean construct score	33	.10	0.05	2.02	.043*	0.14	0.05	-18.63	[0.003, 0.20]
Duration		.002	0.01	0.16	.87				[-.02, 0.02]
Constant		-2.29	1.38	-1.66	.10				[-5.006, .42]

Note. CI = Confidence Interval; HTAU mean construct score total = PE average + EE average + SI average + HM average + BI average + HT average + FC average + PV average
**p<.05*

For addressing multi-collinearity, which denotes the influence between predictor variables and their impact on the outcome variable, it is common to eliminate predictor variables that are highly correlated with each other (Menard, 1995). Since duration and frequency are highly correlated with each other (r = .67, p <.001), the frequency was not used in the logistic regression model to predict post-30-day app use (Yes/No) to avoid multi-collinearity. The model (See Table 3.7) shows a statistically significant positive relationship between the HTAU mean construct score and the probability of saying 'yes' in the post-30-day app use survey (p = .043).

Discussion

Key results

HTAU Constructs

The definition of facilitating condition includes the availability of a support system or resource to utilize a system (Venkatesh et al., 2003; Venkatesh et al., 2012). In our findings (see Table 3.3), the facilitating conditions score may indicate that users felt either familiarity with the system or felt adequate support from the app authorities whenever needed. Facilitating condition seems to be a highly influential factor to determine the behavioral intention, and simultaneously, actual use of the app as determined by the previous studies (Palau-Saumell et al., 2019). The second highest construct score was observed in the effort expectancy, which denotes easiness associated with app use. The UTAUT original paper defines effort expectancy as the degree of effort needed to operate a system (Venkatesh et al., 2003; Venkatesh et al., 2012). A high effort expectancy mean score (see Table 3.4) denotes that the selected Yoga app was easy to use. The mean score of price value indicates the medium price value construct score (see Table 3.4). Many

of our participants reported that the Yoga app is reasonably priced. According to the UTAUT2 model, price value positively impacts behavioral intention if a consumer perceives benefits associated with a system outweigh its expenses (Venkatesh et al., 2012). Our participants did not pay anything during the first 30 days after enrollment as the study covered their expenses. After 30 days, if participants wanted to continue app use with all the features, they had to pay for the app. I collected a price value score after seven days of enrollment, which was within a period of 30 days when participants did not pay anything for the app. It might be possible that some of our participants did not observe the actual cost of the app and answered based on their momentary free status of the app. There is a possibility that the cost of the app might have influenced participants' decisions regarding their continued app use after 30 days.

Moderate joy with the yoga app is noted from the mean score, and it seemed to be enjoyable to many of our users. The moderate behavioral intention score implies the intention to use the app. The word 'habit' implies the addition of technology in the user's daily life (Venkatesh et al., 2012). Habit is perceived as a crucial predictor which can influence behavioral intention and use in many studies (Palau-Saumell et al., 2019; Tak & Panwar, 2017). A lower habit mean score (see Table 3.4) also implies that many of our participants do not perceive app use as a habit. However, habit formation often requires approximately 18 to 254 days (Lally et al., 2010), which is not attainable in such a short duration study. The lowest score was for social influence. There were no data collected directly from these individuals or from participants about their social circles, so we are unable to speculate on this result.

Participants with a higher HTAU mean construct score (See Table 3.7) expressed their interest in continuing the yoga app use beyond the study. However, when we applied the logistic regression model with the variables (predictor variables: duration of app use and HTAU score;

outcome variables: post-30-day app use), we did not find any statistically significant relationship between the total HTAU score and the future intention of continuing app use. The HTAU score is calculated as an aggregated total score of eight constructs. Therefore, if any item is missing, we had to delete the whole response. Therefore, we had only 39 responses that we considered for the HTAU score count. Originally, actual responses we collected from our 47 respondents. In the HTAU mean-construct score count, we also considered the construct with missing items as it is calculated as a mean. Therefore, no responses got eliminated, and we got a comparatively large sample size. Ideally, if the HTAU score, which denotes acceptance and use of participants, increases, their intention to continue the app use should go up as this scale is built upon the theory of UTAUT-2. In our situation, the small sample size is probably a big limitation. Here, we also want to note that consideration of an average score of the construct instead of the total can maximize the scope of including a majority of participants within the study. However, our findings should be considered with caution. Although 59% of our participants expressed their interest to continue app use after our study at the post-30-day survey, some of them might not actually continue the app use. Also, it is noted that studies have found that some users lose interest with time if the app lacks enough motivating factors for long-term use (Sigg et al., 2019).

Difference in behavioral intention

Although our total HTAU score did not differ significantly between the two groups (people who said ‘yes’ to the post-30-day app use and the people who said ‘no’ to the post-30-day app use), we observed statistically significant differences in performance expectancy, social influence, hedonic motivation, behavioral intention, and habit construct score (See Table 3.6). People who reported a high behavioral intention score after a one-week intervention have a tendency to keep their enthusiasm after 30 days. This also bodes well for ongoing app use. Performance expectancy,

effort expectancy, and hedonic motivation are also considered important factors to predict people's intention of the future use of a system (Alalwan et al., 2017). A China-based study that assessed the physical activity app use behavior of the 1704 University students noticed a significant positive association between the intention of physical activity app use and the three constructs of the UTAUT model (performance expectancy, effort expectancy, and social influence) (Liu et al., 2019).

Other studies (Alalwan et al., 2017; Baptista & Oliveira, 2015) have found that hedonic motivation (which implies joy) positively motivates the adoption of a system and increases the user's intention to use the system (behavioral intention). A meta-analysis of 79 studies (where a UTAUT2 model is used) noticed hedonic motivation as a construct of interest among 58% of their selected studies. The overall result from this meta-analysis found a significant statistical relationship between their predictor variable hedonic motivation and their outcome variables (behavioral intention, effort expectancy, and performance expectancy) at a 95% confidence interval (Tamilmani et al., 2019).

The study showed a positive relationship (p = .043) between the mean HTAU construct score and peoples' affirmative response in terms of app use in the future (See Table 3.7). This result indicates that the people who showed acceptance and satisfaction with the app at the post-7-day survey have a higher probability of holding the same enthusiasm of using the app after 30 days.

Retention

Thirty-two participants from the total 92 enrolled participants never completed their post-7-day survey, so the overall attrition rate in this phase was 34.78%. Fifty-two percent of those respondents used the app at least once in seven days, and 81.25% completed the 30-day survey.

The overall attrition rate in this study is in line with chronic illness and mobile studies. A meta-analysis of 17 app-based intervention studies (nine RCTs, eight observational trials) with a population with chronic diseases observed an overall 43% (95% CI 29-57) drop-out rate (Meyerowitz-Katz et al., 2020). In contrast, a systematic review and meta-analysis of yoga intervention studies found that the usual dropout rate was between 15-20% or less (Cramer et al., 2016). They also stated demography, disease status, and several other situational factors may contribute to a much higher participant drop-out rate (Cramer et al., 2016). Some participants who dropped out of the study informed us via text or email that they were affected by COVID-19. We conducted our data collection between 3/10//2020 to 10/11/2020 when the pandemic was at a very severe stage in the United States, which may have contributed to attrition.

Reasons for Use or not Use (see Appendix H and I)

People who expressed their interest to continue the app use beyond our study reported that they enjoyed doing yoga with the yoga app. Those participants identified it as a simple, easy, convenient, and flexible option to practice yoga. One of the participants who self-reported continued use highlighted the benefits of using it during work breaks; however, this participant made it clear that it cannot be a replacement for an in-person class. Similarly, some of the participants who said that they were not willing to continue the yoga app use provided positive feedback about the app. However, the cost of the app was also a de-motivating factor for some of the participants. Some of the participants also mentioned the necessity of incorporating some guidance to modifying poses if users could not achieve the exact poses.

Limitations

Some of the limitations of our study are as follows: small sample size and lack of representativeness of sample (mostly white, highly educated, English speaking), which limits the

generalizability of our findings. There is a high possibility that this small intervention study with a commercial mobile yoga application could suffer from selection bias. Findings of a national survey also indicated that educated white females have a higher tendency to practice yoga (Birdee et al., 2008). Another cross-sectional survey with breast cancer survivors also observed similar findings; white and educated participants have higher yoga utilization than non-white and less-educated counterparts (Desai et al., 2010). Despite the rising number of yoga users among racial or ethnic minorities, a recent study also agreed with the fact that yoga practice is higher among highly educated non-Hispanic white females who typically have health insurance (Zhang et al., 2021).

There was an unintentional typing mistake on a specific survey question that is based on the social influence construct (SI2. People who influence my health behavior think that I should use the Track Yoga). Instead of the Track Yoga, some of our participants got this question as mobile internet, which might have misguided them. Since HTAU is a validated instrument, we could not eliminate this particular construct sub-scale to maintain the integrity of the purpose of the scale. However, randomness answering survey questions is very common (Osborne & Blanchard, 2011), so we can't tell how many of our participants actually consciously scored this specific subscale while all other questions were based on the yoga app. However, from a research point of view, this error might compromise the data quality of the social influence construct score or possibly the HTAU score as a whole.

As we relied on self-reported usage, there is a high chance of reporting bias and social desirability bias (Coughlan et al., 2009) which might limit the data accuracy. We received potentially incorrect responses on the reporting of the duration of use of the app in seven days from four participants. These participants reported the same number in both frequency and duration of

app use (for example, frequency of app use in seven days: six times and total duration of app use in seven days (in minutes): six minutes). Therefore, I eliminated those four responses from the duration estimation. We also got a response from a participant that she forgot about the time she spent with the app even though the app keeps a record of the duration and frequency of app use. I did not have any direct access to the app data, enhancing the reporting bias from the participant's perspective. Future researchers might be benefitted by having direct access to the app data to eliminate a similar kind of recall bias.

Interpretation and Generalizability

To our best knowledge, this is the first study that used a commercial yoga app to study acceptance and use from breast cancer survivors' perspectives. An increasing number of tech-savvy consumers (Lewis, 2017) in developing and developed countries are encouraging the rapid transition of health care from traditional hospital-based settings to smartphone-based health apps (Barak & Grohol, 2011; Koch, 2006). This preliminary investigation will encourage further research in this field and help future developers to develop a more personalized mobile yoga tool for breast cancer survivors.

CHAPTER 5: CONCLUSION

Our findings from app review studies show that the information and engagement domain require more attention from developers. Adding more evidence-based research findings might improve the knowledge base within the app. Adding more links to the outside resources or research articles might strengthen the access to the information from a user's perspective. User engagement can be facilitated by adding different interactive features (ex: gamification) within the app. However, considering the limitations of our findings, a further vigorous investigation is required to bring insight into these aspects. We did not find the set of qualities that defines an app as a 'yoga app.' For this, we relied on the app description to see if the app provided some content related to yoga. Since yoga is broad and versatile, future investigators might focus on defining and categorizing apps that have yoga support components. We only reviewed free yoga content, which has limited our findings. Therefore, we will recommend that future studies should focus on both free and premium content related to yoga within the app. In the end, we want to highlight that this kind of app review study cannot be a replacement for randomized clinical trials or human-centered design research. However, our preliminary investigation findings will be helpful to the developers, and it will further encourage investigators to research this topic.

The main findings of our non-randomized intervention study support the acceptance and usability of a commercial yoga app. Although limitations exist, our findings indicate that similar commercial apps that support yoga practice can be helpful to some breast cancer survivors. Our findings highlight the potential of these apps in breast cancer survivorship. Furthermore, we noticed a statistically significant relationship between the self-declared HTAU mean construct score and the intention of using the app in the future from our intervention study. It further validates the role of the HTAU scale in predicting user behavior. It also shows the areas requiring further

improvement within our selected yoga app and a similar app. Our brief intervention noted that participants reported lower scores in the habit and performance expectancy construct, and the lowest score was noted in the social influence construct. It emphasizes certain aspects that future app developers should be careful about while designing similar app types for a better user experience.

Further clinical trials with a large sample will better report the acceptance and usability of this kind of app. A participatory design approach or any other kind of human-centered design approach will be helpful to create a more comprehensive yoga support tool for breast cancer survivors. Breast cancer survivorship is complex, and the needs of the survivors vary widely depending on the treatment or disease status. Future researchers might consider segregating survivors into different groups and observing their acceptance. Our investigation had a very homogeneous group of participants in terms of education, insurance, language, and gender. A large portion of our participants were white and belonged to an affluent income group. Future studies might benefit by involving a more diverse group of breast cancer survivors.

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Appendix A: Mobile Application Rating Scale *(Stoyanov et al., 2015)*

App Quality Ratings:

The Rating scale assesses app quality on four dimensions. All items are rated on a *5-point scale from "1. Inadequate" to "5. Excellent."*

Section A:

Engagement – fun, interesting, customizable, interactive (e.g., sends alerts, messages, reminders, feedback, enables sharing), well-targeted to audience

1. *Entertainment:* Is the app fun/entertaining to use? Does it use any strategies to increase engagement through entertainment (e.g., through gamification)?

1 Dull, not fun or entertaining at all

2 Mostly boring

3 OK, fun enough to entertain user for a brief time (< 5 minutes)

4 Moderately fun and entertaining, would entertain user for some time (5-10 minutes total) 5 Highly entertaining and fun, would stimulate repeat use

2. *Interest:* Is the app interesting to use? Does it use any strategies to increase engagement by presenting its content in an interesting way?

1 Not interesting at all

2 Mostly uninteresting

3 OK, neither interesting nor uninteresting; would engage user for a brief time (< 5 minutes)

4 Moderately interesting; would engage user for some time (5-10 minutes total)

5 Very interesting, would engage user in repeat use

3. *Customization:* Does it provide/retain all necessary settings/preferences for apps features (e.g. sound, content, notifications, etc.)?

1 Does not allow any customization or requires setting to be input every time

2 Allows insufficient customization limiting functions

3 Allows basic customization to function adequately

4 Allows numerous options for customization

5 Allows complete tailoring to the individual's characteristics/preferences, retains all settings

4. *Interactivity:* Does it allow user input, provide feedback, contain prompts (reminders, sharing options, notifications, etc.)? Note: these functions need to be customizable and not overwhelming in order to be perfect.

1 No interactive features and/or no response to user interaction

2 Insufficient interactivity, or feedback, or user input options, limiting functions

3 Basic interactive features to function adequately

4 Offers a variety of interactive features/feedback/user input options

5 Very high level of responsiveness through interactive features/feedback/user input options

5. *Target group:* Is the app content (visual information, language, design) appropriate for your target audience?

1 Completely inappropriate/unclear/confusing

2 Mostly inappropriate/unclear/confusing

3 Acceptable but not targeted. May be inappropriate/unclear/confusing

4 Well-targeted, with negligible issues

5 Perfectly targeted, no issues found

Engagement mean score =----------

Section B:

Functionality – app functioning, easy to learn, navigation, flow logic, and gestural design of app

6. *Performance:* How accurately/fast do the app features (functions) and components (buttons/menus) work?

1 App is broken: no/insufficient/inaccurate response (e.g. crashes/bugs/broken features, etc.)

2 Some functions work, but lagging or contains major technical problems

3 App works overall. Some technical problems need fixing/Slow at times

4 Mostly functional with minor/negligible problems

5 Perfect/timely response; no technical bugs found/contains a 'loading time left' indicator

7. *Ease of use:* How easy is it to learn how to use the app; how clear are the menu labels/icons and instructions?

1 No/limited instructions; menu labels/icons are confusing; complicated

2 Useable after a lot of time/effort

3 Useable after some time/effort

4 Easy to learn how to use the app (or has clear instructions)

5 Able to use app immediately; intuitive; simple

8. *Navigation:* Is moving between screens logical/accurate/appropriate/ uninterrupted; are all necessary screen links present?

1 Different sections within the app seem logically disconnected and random/confusing/navigation is difficult

2 Usable after a lot of time/effort

3 Usable after some time/effort

4 Easy to use or missing a negligible link

5 Perfectly logical, easy, clear, and intuitive screen flow throughout, or offers shortcuts

9. *Gestural design:* Are interactions (taps/swipes/pinches/scrolls) consistent and intuitive across all components/screens?

1 Completely inconsistent/confusing

2 Often inconsistent/confusing

3 OK with some inconsistencies/confusing elements

4 Mostly consistent/intuitive with negligible problems

5 Perfectly consistent and intuitive

Functionality mean score =----------

Section C:

Aesthetics –graphic design, overall visual appeal, color scheme, consistent style

10. *Layout:* Is arrangement and size of buttons/icons/menus/content on the screen appropriate or zoomable if needed?

1.Very bad design, cluttered, some options impossible to select/locate/see/read device display not optimized

2.Bad design, random, unclear, some options difficult to select/locate/see/read

3. Satisfactory, few problems with selecting/locating/seeing/reading items or with minor screen size problems

4. Mostly clear, able to select/locate/see/read items

5. Professional, simple, clear, orderly, logically organized, device display optimized. Every design component has a purpose

11. *Graphics:* How high is the quality/resolution of graphics used for buttons/icons/menus/content?

1. Graphics appear amateur, very poor visual design –disproportionate, inconsistent style

2. Low quality/low resolution graphics; low quality visual design –disproportionate, stylistically inconsistent

3. Moderate quality graphics and visual design (generally consistent in style)

4. High quality/resolution graphics and visual design –mostly proportionate, stylistically consistent

5. Very high quality/resolution graphics and visual design -proportionate, stylistically consistent throughout

12. *Visual appeal:* How good does the app look?

1. No visual appeal, unpleasant to look at, poorly designed, clashing/mismatched colors

2. Little visual appeal –poorly designed, bad use of color, visually boring

3. Some visual appeal –average, neither pleasant, nor unpleasant

4. High level of visual appeal –seamless graphics –consistent and professionally designed

5. As above + very attractive, memorable, stands out; use of color enhances app features/menus

C. ***Aesthetics mean score*** = _____

Section D

Information –Contains high quality information (e.g., text, feedback, measures, references) from a credible source. Select N/A if the app component is irrelevant.

13. Accuracy of app description (in app store): Does app contain what is described?

1. Misleading. App does not contain the described components/functions. Or has no description.

2. Inaccurate. App contains very few of the described components/functions.

3. OK. App contains some of the described components/functions.

4. Accurate. App contains most of the described components/functions.

5.Highly accurate description of the app components/functions.

14. Goals: Does app have specific, measurable, and achievable goals (specified in app store description or within the app itself)?

0. N/A Description does not list goals, or app goals are irrelevant to research goal (e.g., using a game for educational purposes).

1.App has no chance of achieving its stated goals.

2. Description lists some goals, but app has very little chance of achieving them.

3. OK. App has clear goals, which may be achievable.

4. App has clearly specified goals, which are measurable and achievable.

5. App has specific and measurable goals, which are highly likely to be achieved.

15. *Quality of information:* Is app content correct, well written, and relevant to the goal/topic of the app?

0. N/A There is no information within the app.

1. Irrelevant/inappropriate/incoherent/incorrect

2. Poor. Barely relevant/appropriate/coherent/may be incorrect

3. Moderately relevant/appropriate/coherent/and appears correct

4. Relevant/appropriate/coherent/correct

5. Highly relevant, appropriate, coherent, and correct

16. *Quantity of information:* Is the extent coverage within the scope of the app; and comprehensive but concise?

0. N/A There is no information within the app.

1. Minimal or overwhelming

2. Insufficient or possibly overwhelming

3. OK but not comprehensive or concise

4. Offers a broad range of information, has some gaps or unnecessary detail; or has no links to more information and resources

5. Comprehensive and concise; contains links to more information and resources.

17.*Visual information:* Is visual explanation of concepts –through charts/graphs/images/videos, etc. –clear, logical, correct?

0. N/A There is no visual information within the app (e.g., it only contains audio, or text).

1. Completely unclear/confusing/wrong or necessary but missing

2. Mostly unclear/confusing/wrong

3. OK but often unclear/confusing/wrong

4. Mostly clear/logical/correct with negligible issues

5. Perfectly clear/logical/correct.

18.*Credibility:* Does the app come from a legitimate source (specified in app store description or within the app itself)?

1. Source identified but legitimacy/trustworthiness of source is questionable (e.g., commercial business with vested interest).

2. Appears to come from a legitimate source, but it cannot be verified (e.g., has no webpage).

3. Developed by small NGO/institution (hospital/centre, etc.) /specialized commercial business, funding body.

4. Developed by government, university or as above but larger in scale.

5. Developed using nationally competitive government or research funding (e.g., Australian Research Council, NHMRC).

19. *Evidence base:* Has the app been trialed/tested; must be verified by evidence (in published scientific literature)?

0. N/A The app has not been trialed/tested.

1. The evidence suggests the app does not work.

2. App has been trialed (e.g., acceptability, usability, satisfaction ratings) and has partially positive outcomes in studies that are not randomized controlled trials (RCTs), or there is little or no contradictory evidence.

3. App has been trialed (e.g., acceptability, usability, satisfaction ratings) and has positive outcomes in studies that are not RCTs, and there is no contradictory evidence.

4. App has been trialed and outcome tested in 1-2 RCTs indicating positive results.

5. App has been trialed and outcome tested in >3 high-quality RCTs with positive results.

D. Information mean score = _____

* * Exclude questions rated as “N/A” from the mean score calculation.

App subjective quality

Section E:

Would you recommend this app to people who might benefit from it?

Not at all–I would not recommend this app to anyone. There are very few people I would recommend this app to.

Maybe–There are several people whom I would recommend it to. There are many people I would recommend this app to.

Definitely–I would recommend this app to everyone.

How many times do you think you would use this app in the next 12 months if it was relevant to you?

None.

1–2

3–10

11–50

>50

Would you pay for this app?

No

3 Maybe

5 Yes

What is your overall star rating of the app?

★*One of the worst apps I’ve used*

★★

★★★*Average*

★★★★

★★★★★*One of the best apps I've used*

Scoring

App quality scores for Section F

A: Engagement mean score =_____

B: Functionality mean score =_____

C: Aesthetics mean score =_____

D: Information mean score =_____

App quality mean score =_____

App subjective quality score =_____

Appendix B: Table for Android Apps (List for 4 or above star rating apps with reason for exclusion)

SL no	Title	Rating	No of raters	Target population	Last Year of update	Included/Excluded in final review	Reason for Exclusion
1	Daily Yoga - Yoga Fitness Plans	4.4	86761	Everyone	2019	Included	
2	Asana Rebel	4.2	15050	Everyone	2019	Excluded	Paid/ Free portion of the app did not provide enough yoga pose content to evaluate
3	Sadhguru - Yoga, Meditation & Spirituality	4.8	14232	Everyone	2019	Excluded	Free portion of this yoga app lacks step by step guidance to yoga poses at the time of evaluation. It contained excellent philosophical discussion. We decided to exclude the app from the MARS evaluation after discussion.
4	Keep Yoga - Yoga & Meditation, Yoga Daily Fitness	4.7	12698	Everyone	2019	Included	
5	5 Minute Yoga	4.5	10618	Everyone	2018	Included	
6	Yoga - Poses & Classes	4.3	10536	Everyone	2018	Included	
7	Yoga - Track Yoga	4.5	9338	Everyone	2019	Included	

8	Yoga for weight loss - Â lose weight programÂ at home	4.6	7070	Everyone	2018	Included	
9	Simply Yoga - Fitness Trainer for Workouts & Poses	4.1	6995	Everyone	2018	Included	
10	Daily Mudras (Yoga) - for health	4.8	6532	Everyone	2018	Excluded	Focused on only finger poses
11	Yoga Challenge App	4.4	6230	Everyone	2019	Included	
12	Yoga daily fitness - Yoga workout plan	4.6	6088	Everyone	2019	Included	
13	Yoga Studio: Mind & Body	4.3	6030	Everyone	2019	Included	
14	Gaia: Stream mindfulness, yoga & astrology videos	4.6	6026	Everyone	2019	Excluded	Paid/ Free portion of the app did not provide enough yoga pose content to evaluate
15	Yoga Workout - Yoga for Beginners - Daily Yoga	4.7	4413	Everyone	2019	Included	
16	Yoga for Beginners	4.3	4407	Everyone	2018	Included	
17	7pranayama: Yoga Daily Breath Fitness Habit - Calm	4.6	4082	Everyone	2019	Included	

18	Yoga Flexibility for Beginners	4.1	4039	17 +	2018	Included	
19	Yoga for Kids	4.4	2783	Everyone	2019	Included	
20	Yoga for Weight Loss	4.2	2676	17+	2017	Included	
21	Complete Yoga Guide	4.2	2672	Everyone	2018	Included	
22	Yoga Challenge App	4.6	2633	Everyone	2017	Included	
23	Alo Moves - Yoga Classes	4.7	2407	Everyone	2019	Excluded	Paid/ Free portion of the app did not provided enough yoga pose content to evaluate
24	Yoga Morning Routine	4.4	1464	17+	2018	Excluded	No of raters below 1824
25	Yoga for Complete Beginners	4.2	1396	Everyone	2018	Excluded	No of raters below 1824
26	Hatha Yoga for beginners - poses and asanas	4.7	1304	Everyone	2018	Excluded	No of raters below 1824
27	Yoga for Beginners â€“ Daily Yoga Workout at Home	4.5	1301	Everyone	2019	Excluded	No of raters below 1824
28	Kids Fitness - Yoga	4.3	1271	Everyone	2019	Excluded	No of raters below 1824
29	Yoga For Kids	4.3	1077	Everyone	2019	Excluded	No of raters below 1824

30	Find What Feels Good	4.8	1008	Everyone	2019	Excluded	No of raters below 1824
31	Yoga for Beginners | Workouts for the mind & body!	4.6	960	Everyone	2019	Excluded	No of raters below 1824
32	Yoga Plus - Asanas & Classes	4.4	894	Everyone	2019	Excluded	No of raters below 1824
33	YOGOM - Yoga free for beginner	4.3	806	Everyone	2017	Excluded	No of raters below 1824
34	Bihar Yoga	4.6	747	Everyone	2018	Excluded	No of raters below 1824
35	7 Minute Yoga workout	4.3	742	Everyone	2019	Excluded	No of raters below 1824
36	Yoga International: Daily Yoga	4.2	653	Everyone	2019	Excluded	No of raters below 1824
37	Yoga 108	4.6	579	Everyone	2018	Excluded	No of raters below 1824
38	10 Min Daily Yoga	4.3	496	Everyone	2018	Excluded	No of raters below 1824
39	Yoga daily workout for flexibility and stretch	4.6	444	Everyone	2018	Excluded	No of raters below 1824
40	Yoga Poses :Yoga asanas videos	4.5	410	Everyone	2018	Excluded	No of raters below 1824
41	Weight Loss Yoga Sequence	4.3	403	17+	2017	Excluded	No of raters below 1824

42	Yoga for Weight Loss	4.1	388	Everyone	2017	Excluded	No of raters below 1824
43	Yoga to Lose Belly Fat	4.5	365	17+	2018	Excluded	No of raters below 1824
44	Pregnancy yoga Exercises	4	360	17+	2019	Excluded	No of raters below 1824
45	Yoga for Kids and Family fitness - Easy Workout	4.3	344	Everyone. Targeted for Ages 9-12Ages 9-12	2019	Excluded	No of raters below 1824
46	Yoga Fitness - Daily Yoga Poses and Stretches	4.3	305	Everyone	2018	Excluded	No of raters below 1824
47	Yoga Poses for Lower Back Pain Relief	4.5	303	Everyone	2018	Excluded	No of raters below 1824
48	Daily Yoga - Yoga Poses & Fitness Plans	4.5	288	Everyone	2018	Excluded	No of raters below 1824
49	Yoga For You	4.7	268	Everyone	2019	Excluded	No of raters below 1824
50	Yoga for Life - The Health Secret In Your Pocket.	4.4	254	Everyone	2018	Excluded	No of raters below 1824
51	Yoga workout - Free yoga videos and workouts	4.2	251	Everyone	2018	Excluded	No of raters below 1824

52	Nadi Shuddhi Yoga	4.9	251	Everyone	2017	Excluded	No of raters below 1824
53	Indian Yoga by Shilpa Shetty	4.4	246	Everyone	2017	Excluded	No of raters below 1824
54	yoga exercises	4.1	216	Everyone	2017	Excluded	No of raters below 1824
55	Yoga Asanas - Perfect Yoga for Beginners	4.2	201	Everyone	2018	Excluded	No of raters below 1824
56	Yoga mini - Poses	4.2	193	Everyone	2018	Excluded	No of raters below 1824
57	Yoga Flexibility	4	182	17+	2018	Excluded	No of raters below 1824
58	Yoga Workout - Fitness Girls	4.4	181	Everyone	2019	Excluded	No of raters below 1824
59	7 Yoga Poses to Stop Hair Loss	4.1	178	Everyone	2017	Excluded	No of raters below 1824
60	Yoga Poses for beginners - Easy Yoga Trainer	4.2	154	Everyone	2018	Excluded	No of raters below 1824
61	Life of Yoga	4.5	149	Everyone	2019	Excluded	No of raters below 1824
62	Yoga for Anxiety	4.2	147	Everyone	2018	Excluded	No of raters below 1824
63	Celebrating Yoga	4.7	141	Everyone	2019	Excluded	No of raters below 1824
64	Yoga Lessons - Meditation	4.6	121	Everyone	2019	Excluded	No of raters below 1824

65	YOGA FOR BEGINEER	4.3	120	Everyone	2018	Excluded	No of raters below 1824
66	Morning Yoga Sequence	4.4	115	17 +	2018	Excluded	No of raters below 1824
67	YogaTrail - Follow Your Yoga	4.4	115	Everyone	2018	Excluded	No of raters below 1824
68	Yoga Mudras(Hand Yoga)	4.3	101	Everyone	2018	Excluded	No of raters below 1824
69	Mudras [YOGA 2018]	4.2	97	Everyone	2018	Excluded	No of raters below 1824
70	Lower Back Pain Yoga	4.5	85	Everyone	2019	Excluded	No of raters below 1824
71	Sarah Beth Yoga	4.2	85	Everyone	2017	Excluded	No of raters below 1824
72	Yoga for Core Strength	4.4	83	Everyone	2018	Excluded	No of raters below 1824
73	Daily Yoga For Weight Loss -Yoga Fitness Plans	4.5	83	Everyone	2018	Excluded	No of raters below 1824
74	Yoga Power	4.8	82	Everyone	2017	Excluded	No of raters below 1824
75	Arhatic Yoga Journal	4.8	82	Everyone	2017	Excluded	No of raters below 1824
76	Learn Yoga	4.1	81	Everyone	2019	Excluded	No of raters below 1824

77	Daily Yoga Pose Offline	4.7	77	Everyone	2017	Excluded	No of raters below 1824
78	Free Yoga classes for beginners at home & Trainer	4.5	77	Everyone	2018	Excluded	No of raters below 1824
79	Flow Yoga - Learn and Practice Yoga Asana	4.4	73	Everyone	2019	Excluded	No of raters below 1824
80	FitReady : Fitness & Yoga App - Home Workouts	4.4	70	Everyone		Excluded	No of raters below 1824
81	Yoga For Weight Loss	4.1	65	Everyone	2018	Excluded	No of raters below 1824
82	Prana Yoga Ashram	4.8	65	Everyone	2018	Excluded	No of raters below 1824
83	Yoga for Relief of Anxiety, Stress and Depression	4.1	63	Everyone	2018	Excluded	No of raters below 1824
84	Full Body Yoga Workout	4.2	62	Everyone	2018	Excluded	No of raters below 1824
85	Yoga Poses & Asanas for Butt, Thighs and Legs	4.3	62	Everyone	2018	Excluded	No of raters below 1824
86	Yoga Poses & Asanas for Spine, Neck and Back	4.6	61	Everyone	2018	Excluded	No of raters below 1824

87	Yoga Poses for Men's Health & Impotence Treatment	4.5	60	Everyone 10+	2018	Excluded	No of raters below 1824
88	Yoga Asanas Daily : Yoga Asana Book & Yoga Guide	4.6	59	Everyone	2018	Excluded	No of raters below 1824
89	Yoga and Exercises to Increase Height Naturally	4.2	57	Everyone	2018	Excluded	No of raters below 1824
90	Satyam Yoga Prasad	4.5	56	Everyone	2019	Excluded	No of raters below 1824
91	Yoga for beginners	4+	56	Everyone	2018	Excluded	No of raters below 1824
92	Yoga for Relaxation	4.2	55	Everyone	2018	Excluded	No of raters below 1824
93	Yoga & Fitness	4.2	55	Everyone	2019	Excluded	No of raters below 1824
94	Yoga exercises for beginners	4.1	54	Everyone	2018	Excluded	No of raters below 1824
95	Yoga For Kids	4.2	52	Everyone	2018	Excluded	No of raters below 1824
96	Baba Ramdev Yoga : Complete Guide	4.6	50	Everyone	2018	Excluded	No of raters below 1824
97	Yoga Point	4.8	49	Everyone	2018	Excluded	No of raters below 1824
98	Yoga and Therapy	5	49	Everyone	2017	Excluded	No of raters below 1824

99	Yoga Poses For Beginner - Weight Loss Yoga Dance	4.3	48	Everyone	2018	Excluded	No of raters below 1824
100	20 Daily Yoga – Offline	4.1	48	Everyone	2018	Excluded	No of raters below 1824
101	10 Yoga For Back Pain	4.3	47	Everyone	2018	Excluded	No of raters below 1824
102	Yoga For Stress Relief	4.2	46	Everyone	2019	Excluded	No of raters below 1824
103	Kids Fitness â€“ Yoga	4.3	46	Everyone	2018	Excluded	No of raters below 1824
104	Best Daily Yoga - Yoga Poses & Daily Workouts	4.6	41	Everyone	2019	Excluded	No of raters below 1824
105	Daily Yoga Postures for Office and Workplace	4.3	41	Everyone	2018	Excluded	No of raters below 1824
106	Accupressure Yoga Point Tips	4.6	37	Everyone	2019	Excluded	No of raters below 1824
107	10 Yoga Poses High Blood Pressure	4.1	33	Everyone	2018	Excluded	No of raters below 1824
108	Modo Yoga	4.2	33	Everyone	2018	Excluded	No of raters below 1824
109	7 Yoga For Improving Memory Power	4.1	27	Everyone	2019	Excluded	No of raters below 1824

110	10 Yoga Poses For Growth And Stop Hair Loss	4.1	27	Everyone	2018	Excluded	No of raters below 1824
111	Pilates Anytime Yoga Fitness Workouts at Home	4.3	26	Everyone	2018	Excluded	No of raters below 1824
112	Yoga Teacher Training Program	4.3	23	Everyone	2018	Excluded	No of raters below 1824
113	Yoga For Kids - Fun Kids Yoga Workout	4.3	21	Everyone	2018	Excluded	No of raters below 1824
114	Women Yoga Health & Fitness - Yoga Fitness Plans	4.7	19	Everyone	2019	Excluded	No of raters below 1824
115	Yoga For Kids	4.6	18	Everyone	2018	Excluded	No of raters below 1824
116	Yoga For Kids - Easy Yoga Poses for Kids Fitness	4.2	18	Everyone. Targeted for Ages 6-12Ages 6-12	2019	Excluded	No of raters below 1824
117	Best Yoga App - Yoga Poses & Fitness Training	4.6	18	Everyone	2018	Excluded	No of raters below 1824
118	Yoga Plus by Psychetruth	4.2	16	Everyone	2019	Excluded	No of raters below 1824

119	Yoga Mudras	4.4	16	Everyone	2019	Excluded	No of raters below 1824
120	aerial yoga	4.2	16	Everyone	2018	Excluded	No of raters below 1824
121	Stress Relief Yoga and Exercise Fitness App	4.7	15	Everyone	2018	Excluded	No of raters below 1824
122	yoga	4.5	13	Everyone	2018	Excluded	No of raters below 1824
123	Easy Yoga - For Physical and Mental Fitness	4.5	13	Everyone	2018	Excluded	No of raters below 1824
124	Office Yoga	4.3	12	Everyone	2018	Excluded	No of raters below 1824
125	Yoga Trainer For Beginners	4.3	9	Everyone	2018	Excluded	No of raters below 1824
126	Cosmic Kids Yoga	4.6	9	Everyone	2019	Excluded	No of raters below 1824
127	5 Yoga Poses for Constipation	4.4	8	Everyone	2017	Excluded	No of raters below 1824
128	Yoga Videos	5	7	Everyone	2018	Excluded	No of raters below 1824
129	My Yoga Poses	5	7	17+	2018	Excluded	No of raters below 1824
130	Hatha Yoga	4.3	7	Everyone	2018	Excluded	No of raters below 1824
131	Yoga Poses For Beginners	4.7	6	Everyone	2019	Excluded	No of raters below 1824

132	The Best Yoga Classes	4	6	Everyone	2018	Excluded	No of raters below 1824
133	Yoga Steps	4.8	6	Everyone	2017	Excluded	No of raters below 1824
134	YOGA ASANAS - THE BENEFITS OF THESE POSES	5	5	Everyone	2019	Excluded	No of raters below 1824
135	Yoga Guide for Beginners	4	5	Everyone	2018	Excluded	No of raters below 1824
136	Yoga Pod	5	5	Everyone	2018	Excluded	No of raters below 1824
137	Yoga eBook	4.2	4	Everyone	2019	Excluded	No of raters below 1824
138	Daily Yoga - Poses for weight lose	4.2	4	Everyone	2019	Excluded	No of raters below 1824
139	KUNDALINI YOGA - IS ACCESSIBLE TO ALL	4.3	3	Everyone	2019	Excluded	No of raters below 1824
140	Beginner Yoga Gymnastics	5	3	Everyone	2018	Excluded	No of raters below 1824
141	Kuuma Yoga	5	2	Everyone	2018	Excluded	No of raters below 1824
142	Yogi Wajahat Yoga Videos	5	2	Everyone	2017	Excluded	No of raters below 1824

Appendix: C: Table for Apple apps which were downloaded for final selection for MARS evaluation

App name	Average user rating	No of Raters	Included/Excluded	Reason for Exclusion
Nike Training Club	4.5	161721	Included	
Beachbody® On Demand	5	119102	Excluded	Paid/ Free portion of the app did not provide enough yoga pose content to evaluate
LivingSocial - Deals & More	4	74372	Excluded	Class Scheduling or finding app/ Shopping app
Class Pass	5	71419	Included	
Down Dog | Great Yoga Anywhere	5	60675	Included	
Aaptiv: #1 Audio Fitness App	4.5	50774	Excluded	Paid/ Free portion of the app did not provide enough yoga pose content to evaluate
Daily Yoga - Workout & Fitness	4.5	50045	Included	
Yoga Studio: Mind & Body	4.5	37563	Included	
Sworkit Fitness	4.5	36243	Excluded	Paid/ Free portion of the app did not provide enough yoga pose content to evaluate
Gaia TV Discover Mindful Yoga	5	34824	Excluded	Paid/ Free portion of the app did not provide enough yoga pose content to evaluate

Asana Rebel	4.5	28182	Excluded	Paid/ Free portion of the app did not provide enough yoga pose content to evaluate
Udemy Online Courses & Classes	4.5	26303	Excluded	Online learning platform
Peloton Digital	5	25631	Excluded	Paid/ Free portion of the app did not provide enough yoga pose content to evaluate
MINDBODY: Gym, spa & wellness	4.5	22219	Excluded	Class Scheduling or finding app (helps to find yoga, spa and other wellness and beauty services)
Sweat: Kayla Itsines Fitness	4.5	19023	Excluded	Paid/ Free portion of the app did not provide enough yoga pose content to evaluate
Yoga for Beginners | Mind+ Body	4.5	13637	Included	

Appendix D: Health Technology Acceptance and Use (HTAU) Scale (Kim et al., 2018)

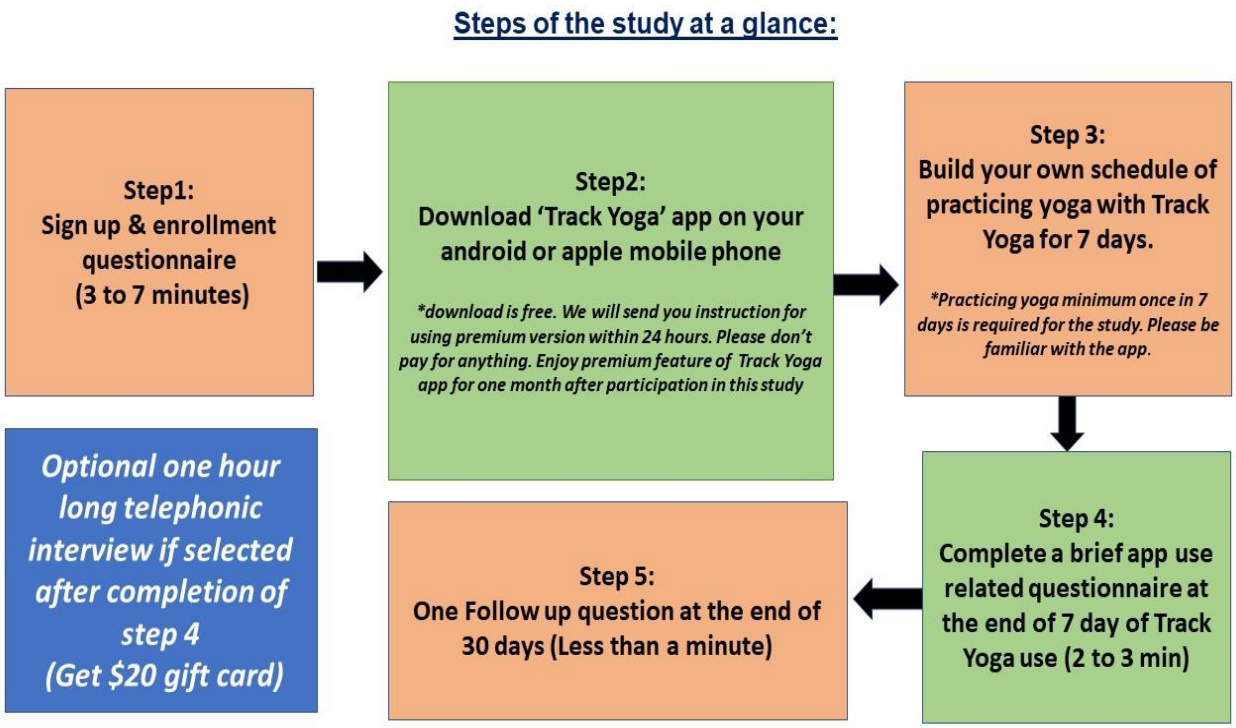
[*Unpublished work. HTAU scale is used with author's permission*]

Health Technology Acceptance and Use	Circle one number for each question: 0 (not at all) to 6 (a great deal)						
Performance Expectancy							
PE1. I find Track Yoga useful in my daily life.	0	1	2	3	4	5	6
PE2. Using Track Yoga helps me to accomplish things more quickly.	0	1	2	3	4	5	6
PE3. I find Track Yoga useful in managing my health condition.	0	1	2	3	4	5	6
PE4. Using Track Yoga saves me time in managing my health condition.	0	1	2	3	4	5	6
PE5. Using Track Yoga increases my productivity.	0	1	2	3	4	5	6
PE6. Using Track Yoga improves my effectiveness in managing my health condition.	0	1	2	3	4	5	6
PE 7. Using Track Yoga helps me get the information I need.	0	1	2	3	4	5	6
PE 8. Track Yoga improves my ability to keep in touch with my health care provider	0	1	2	3	4	5	6
Effort Expectancy							
EE1. Learning how to use Track Yoga is easy for me.	0	1	2	3	4	5	6
EE2. My interaction with Track Yoga is clear and understandable.	0	1	2	3	4	5	6
EE3. I find Track Yoga easy to use.	0	1	2	3	4	5	6
EE4. It is easy for me to become skillful at using Track Yoga.	0	1	2	3	4	5	6
Social Influence							
SI1. People who are important to me think that I should use Track Yoga.	0	1	2	3	4	5	6
SI2. People who influence my health behavior think that I should use the mobile Internet.	0	1	2	3	4	5	6
SI3. People who influence my health decisions think that I should use Track Yoga.	0	1	2	3	4	5	6
SI4. My health care provider thinks that I should use Track Yoga.	0	1	2	3	4	5	6
SI5. People whose opinions that I value prefer that I use Track Yoga.	0	1	2	3	4	5	6
Facilitating Conditions							
FC1. I have the resources necessary to use Track Yoga.	0	1	2	3	4	5	6
FC2. I have the knowledge necessary to use Track Yoga.							

	0	1	2	3	4	5	6
FC3. Track Yoga is compatible with other technologies I use.	0	1	2	3	4	5	6
FC4. I can get help from others when I have difficulties using Track Yoga.	0	1	2	3	4	5	6
Hedonic Motivation							
HM1. Using Track Yoga is fun.	0	1	2	3	4	5	6
HM2. Using Track Yoga is enjoyable.	0	1	2	3	4	5	6
HM3. Using Track Yoga is entertaining.	0	1	2	3	4	5	6
Price Value							
PV1. Track Yoga is reasonably priced.	0	1	2	3	4	5	6
PV2. Track Yoga is a good value for the money.	0	1	2	3	4	5	6
PV3. At the current price, Track Yoga provides a good value.	0	1	2	3	4	5	6
Habit							
HT1. The use of Track Yoga has become a habit for me.	0	1	2	3	4	5	6
HT2. I use Track Yoga automatically	0	1	2	3	4	5	6
HT3. I must use Track Yoga.	0	1	2	3	4	5	6
Behavioral Intention							
BI1. I intend to continue using Track Yoga in the future.	0	1	2	3	4	5	6
BI2. I will always try to use Track Yoga in my daily life.	0	1	2	3	4	5	6
BI3. I plan to continue to use Track Yoga frequently.	0	1	2	3	4	5	6
Use	0	1	2	3	4	5	6
I have logged into Track Yoga…	Never						many times a day

Appendix E: Enrollment Questionnaire

Welcome to our project "User-centered design considerations of mobile yoga applications for challenges of breast cancer survivors"! Please complete the brief screening questionnaire attached below!



Q1 Are you at least 18 years of age or older?

Yes

No

Q2 Have you been ever diagnosed with breast cancer?

Yes

No

Q3 Are you a resident of the United States?

Yes

No

Q5 Are you able to read, write and speak English?

Yes

No

Q6 What mobile devices you have access to?

Android

Apple

Both Android and Apple

None/ I have no access to the mobile device

Q7 Are you willing to try yoga with an app at least once for a week?

Yes

No

Q8 Are you physically capable of doing yoga?

Yes

No

Q9 I am not on active treatment (exception: hormonal therapy)

Yes

No

Q10.b I got my chemotherapy/ surgery within last 8 weeks

Yes

No

Q10.c I got my radiotherapy within last 4 weeks

Yes

No

Q.10.d Newly diagnosed and have not received any treatment yet

Yes

No

** Please read the consent form carefully (attached below) and other relevant documents (Guidelines for participants for track yoga app download and use and Disclaimer). Please read relevant documents and consent form before proceeding.

Q11 What is your age?

Insert your age in years (example: 39) _____

Q12 Which gender describes you?

Female

Male

Other

Prefer not to state

Q13 When you read the following list, please tell me if the category describes your ethnicity/race. (You may choose 1 or more)

Hispanic or Latino

Black or African American

White

Asian

Native Hawaiian or Pacific Islander

American Indian or Alaskan Native

Other

Prefer not to state

Q14 What is the highest grade or level of school that you completed?

Less than a High School Graduate

High School Graduate

Some College

College Graduate

Post-Graduate

Prefer not to state

Q15 What kind of medical insurance coverage do you have? Select all that are true for you.

Medicare

Medi-Cal

Tri- Care

Private health insurance

No health insurance

Another type of health insurance

Q16 What is your marital status?

Single

Married

Unmarried but living with a partner

Divorced/ Separated

Widow

Prefer not to state

Q17 What was your total combined income (for you & your family) in the last calendar year?

Less than $40,000

$40,000 to $80,000

$90,000 and above

Prefer not to state

Q18 In general, how would you rate your overall mental health? Would you say that it is

Excellent

Very Good

Fair

Poor

Q19 In general, how would you rate your overall physical health? Would you say that it is

Excellent

Very Good

Fair

Poor

Q20 Are you currently practicing yoga?

Yes

No

Q21 *Please write down your email address

(*Required)

_____

Q22 *Please write down your phone number

(*Required)

“+1 (xxx) xxx–xxxx” _____

Q23 Will you be interested in participating in an hour-long optional telephonic interview session with us?

(Remember participation of the interview session is optional. If you are interested, you will get an email invitation after completion of the online survey. The selection of the willing participants for the interview will be dependent on entirely investigator’s decision.)

Yes

No

Q24 Your interview with the researcher will be audio recorded. Are you willing to allow us to record your conversation with the researcher?

Yes

No

Appendix F: Post-7-day Questionnaire

Q1 Did you use the Track yoga app in the last 7 days?

Yes

No

If no,

Q2.a Please write down in your word why you have not used the Track yoga app in the last 7 days.

_____

If yes,

Q2.b How many times in the last 7 days have you practiced yoga?

(write down the total number of use in the box, please refer to app data to fill out this number)

[Example: 5 times in a week]

_____

Q3 In total, how much time did you participate in yoga practice with this Track Yoga app in the last 7 days? (Please refer to the app data) [Example: 12 min, 20 min, 30 min etc.]

_____

Q4 How easy or hard was the process of downloading and installing the Track Yoga app? Please rate it in the following 0 to 6 scale

Installation of Track Yoga app (1)	Extremely easy (0)	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	Extremely difficult (6)

Q10 Performance Expectancy

	not at all (0)	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	A great deal (6)
PE1. I find Track Yoga useful in my daily life. (1)							
PE2. Using Track Yoga helps me to accomplish things more quickly. (2)							
PE3. I find Track Yoga useful in managing my health condition. (3)							
PE4. Using Track Yoga saves me time in managing my health condition. (4)							
PE5. Using Track Yoga increases my productivity. (5)							
PE6. Using Track Yoga improves my effectiveness in managing my health condition. (6)							
PE 7. Using Track Yoga helps me get the information I need. (7)							
PE 8. Track Yoga improves my ability to keep in touch with my health care provider (8)							

Q19 Effort Expectancy

	Not at all (0)	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	A great deal (6)
EE1. Learning how to use Track Yoga is easy for me. (1)							
EE2. My interaction with Track Yoga is clear and understandable. (2)							
EE3. I find Track Yoga, easy to use. (3)							
EE4. It is easy for me to become skillful at using Track Yoga. (4)							

Q9 Social Influence

	Not at all (0)	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	A great deal (6)
SI1. People who are important to me think that I should use Track Yoga. (1)							
SI2. People who influence my health behavior think that I should use the mobile Internet. (2)							
SI3. People who influence my health decisions think that I should use Track Yoga. (3)							
SI4. My health care provider thinks that I							

should use Track Yoga. (4)	
SI5. People whose opinions that I value prefer that I use Track Yoga. (5)	

Q13 Facilitating Condition

	Not at all (0)	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	A great deal (6)
FC1. I have the resources necessary to use Track Yoga. (1) FC2. I have the knowledge necessary to use Track Yoga. (2) FC3. Track Yoga is compatible with other technologies I use. (3)							
FC4. I can get help from others when I have difficulties using Track Yoga. (4)							

Q14 Hedonic Motivation

	Not at all (0)	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	A great deal (6)
HM1. Using Track Yoga is fun. (1) HM2. Using Track Yoga is enjoyable. (2)							

HM3. Using Track Yoga is entertaining. (3)	

Q15 Price

	Not at all (0)	1 (1)	2 (2)	3 (3)	5 (4)	6 (5)	A great deal (6)
PV1. Track Yoga is reasonably priced. (1) PV2. Track Yoga is a good value for the money. (2)							
PV3. At the current price, Track Yoga provides a good value. (3)							

Q16 Habit

	Not at all (0)	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	A great deal (6)
HT1. The use of Track Yoga has become a habit for me. (1) HT2. I use Track Yoga automatically (2)							
HT3. I must use Track Yoga. (3)							

Q17 Behavioral Intention

	Not at	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	A great deal (6)

	all (0)	
BI1. I intend to continue using Track Yoga in the future. (1) BI2. I will always try to use Track Yoga in my daily life. (2)		
BI3. I plan to continue to use Track Yoga frequently. (3)		

Appendix G: 30 day-post-study Questionnaire

Q1 Are you still interested in using the Track Yoga app after completion of our study?

Yes

No

Q2 Please add free text to inform why you want to use this app in future

_____

Q3 Please add free text to inform why you do not wish to use this app in future

_____

Appendix H: Demographic characteristics of participants who never used the app

Demographic table of the participants who have never used the app (N=12) but they have returned post-7-day- study survey

Age	n	%
35 to 55	8	66.66
56 to 75	4	33.33
Race		
White	9	75
Asian	1	8.33
Hispanic or Latino	1	8.33
Black or African American	1	8.33
Education		
College Graduate	4	33.33
Post-Graduate	7	58.33
Some College	1	8.33
Insurance		
Medicare	2	16.67
Private health insurance	5	41.67
No health insurance	2	16.67
Another type of health insurance	2	16.67
Medicare, Private Health insurance	1	8.33
Marital Status		
Single	2	16.67
Married	6	50.00
Divorced/Separated	3	25.00
Widow	1	8.33
Family income		
Less than $40,000	3	25.00
$40,000 and below $90,000	2	16.67
$90,000 and above	6	50.00
Prefer not to State	1	8.33
Other Questions		
Mental Health		
Excellent	2	16.67
Very good	8	66.67
Fair	2	16.67
Physical Health		

Excellent	2	16.67
Very good	4	41.67
Fair	5	45.45
Poor	1	8.33
Current Yoga Practice		
Yes	2	16.67
No	10	83.33
App Use		
Yes		
No	12	100%

Appendix I: Reasons for not using the Yoga App in participant's own words (N=12)

No of responses	Reason for not using Yoga App in the 7-day intervention period of the study
1	"I used it once and did not like it"
2	"I haven't been able to participate in the yoga because of COVID 19."
3	"Need longer time. I looked at the app, but it looked daunting. I would have liked to try one or two shorter versions to get started. I have done meditation for years, so I didn't try that one. It seemed overwhelming."
4	"Sorry! I did not get to complete the yoga activity."
5	"Could not access the app."
6	"I downloaded the app. I found that I could not see it adequately on my phone to follow."
7	"I forgot all about the study."
8	"I was injured so could not complete."
9	"I just lost track of time and never got app downloaded."
10	"Completely forgot. I have 3 kids, and life is just hectic!"
11	"I am sorry but never took classes! Life has been too hectic. I had good intentions."
12	"no electricity in my area"

Appendix J: Reasons for continuation/discontinuation of Yoga App Use in participant's own words

(People who used the app and completed both post-7-day survey and post-30-day survey)

No of responses	The intention of continued app use after study (Yes/No)	Reasons (participant's own words)
1	Yes	"It is a great way to keep me on track."
2	Yes	"I like it as a quick break from work, but it certainly doesn't take the place of a class. I have a good understanding of yoga and like the instruction of a class. I also do a certain type of yoga, Svaroopa, which is quite precise and supportive but still like all kinds of yoga."
3	Yes	"The routines are a good length, voice and music are calming. Can adjust length on workout based on your needs."
4	Yes	"It is convenient, and I feel so much better after doing the sessions."
5	Yes	"Yoga is a wonderful way to slow down, center and quiet my thoughts, relax, and build strength."
6	Yes	"Easy to use"
7	Yes	"Because I like yoga."
8	Yes	"Easy to use and follow. Useful to me in my overall health."
9	Yes	"It was helpful to keep me moving, and it was helpful to keep me centered. I practiced yoga until my surgery in November and haven't had the opportunity to continue. When I recovered, covid started, and that was the end of my yoga sessions."
10	Yes	"I like the voice of the woman leading the classes. "
11	Yes	"I would only use if it contained information on how to modify poses for people with mobility issues."
12	Yes	"I enjoy it."
13	Yes	"It's short and simple enough to use every day."

14	Yes	"It is convenient. I can do yoga on my own schedule."
15	Yes	"Classes are short and very beneficial to body and mind."
16	Yes	"I enjoy being able to just turn in on and get started whenever it is convenient for me."
17	Yes	"I tend to injury the tissue where I was radiated, and it felt like I had completely torn everything up right before using the yoga app. I tried using it but after a few days I couldn't take the pain. Now that I am starting to feel better, I would like to try it again."
18	Yes	"Good to use in between my other workouts."
19	Yes	"i enjoy being able to do yoga and meditation at home."
20	Yes	"One thing I am not sure about is how long the subscription will last and whether I will get an email to renew it?"
21	Yes	"It is convenient whenever I think I want a yoga session rather than following a class schedule."
22	Yes	"It was simple to use, self-explanatory, and it had great videos so I can see the correct poses."
23	No	"I liked it, but I don't want to pay to use it. There are plenty of yoga videos that are free."
24	No	"The poses in the app are far too advanced for me"
25	No	"Did not fit my needs. too fast and did not account for people with decreased range of motion.
26	No	"Enjoy other yoga sites more. yoga with Y (name changed)
27	No	"Using a yoga app that feels more comprehensive."
28	No	"The yoga practice moved too fast and had poor translations. There is another app that is better suited for my fatigue and post-treatment limitations. Really did not like this particular app!"
29	No	"I found the Yoga app quite interesting. I liked the detailed directions and videos that accompanied the

		directions. I did not like all the music, which I found distracting. Having never tried yoga, I was open to new ways to get in shape and stay healthy. However, I found that the many poses that required me to keep my upper torso in a downward-facing position caused me to have a headache. I tried 4 or five of the sessions and found that the headaches continued. I realized that even though I am fully cleared by my oncologist to get back to exercising, yoga is not for me. Thank you for the opportunity to participate in your study. Much success in what you discover for results."
30	No	"frustrating"
31	No	"Daughter bought a new app with cardio, weights, and yoga. We have been using it together. I really enjoyed the music on your yoga app"
32	No	"Too slow"
33	No	"I haven't been using it, and so, cost of continuing is an issue. I loved the app, and it was very informative, but during this time it's not feasible.
34	No	"I continue to do yoga on my own with the yoga studio I go to as well as the YLSA (name changed). Perhaps if I were not already committed to doing yoga, I would use it"
35	No	"I really like the app. It's still on my phone, and I get alerts to do yoga daily. I have chemo-related cognitive dysfunction, which causes me to forget logistics and plans, including making time for yoga. It is tough."
36	No	"image too small, no explanation of modifications and goals of postures, no music."
37	No	"I prefer Yoga with Y (name changed) videos

Appendix K: Consent form

University of California at Davis

Consent to Participate in Research

Title of study:

User-centered design considerations for mobile yoga applications: A mixed-method study

Investigator: Sayantani Sarkar

Introduction and Purpose

You are being invited to join a research study.

The purpose of this study is to see if whether mobile yoga apps are beneficial for breast cancer survivors and explore user perspectives or opinion regarding the yoga practice by a mobile app

If you agree to participate in this research, you will be asked to practice yoga for 7 days with a given app. We will pay for the app, and you can choose your own schedule of practice and place of practice at your convenience. You will be asked questions about app use and your acceptance. It will take about 3 to 7 minutes to complete the online survey following one week of yoga practice, and you will get another questionnaire with just one question (To see if want to continue using the app after one month) which will take less than 15 sec to complete after 30 days.

There is no direct benefit to you from taking part in this study. We hope that the research will add to the scientific knowledge and findings of the study will be helpful to understand some useful

strategies to develop mobile app-based yoga services in the future, specifically for breast cancer survivors. Yoga practice may bring some physical and psychological wellbeing among some people according to the findings of the previous studies. However, we cannot promise any potential benefits following the participation of this study

The risks of this research are minimal. Some of the questions might make you feel uncomfortable or upset. You do not have to answer any of the questions you do not want to answer.

Confidentiality

As with all research, there is a chance that confidentiality could be compromised; however, we are taking precautions to minimize this risk. Your responses to the survey will include information (email, phone number) that identifies you. This identifiable information will be handled as confidentially as possible.

As with all research, there is a chance that confidentiality could be compromised; however, we are taking precautions to minimize this risk. Your responses to the survey involve email addresses, phone number and demographic information that may identify you. However, we will not collect your name and zip code for this study. All the de-identified data will be stored in a secured cloud system authorized by UC Davis, and we will keep your identification information under proper encryption. However, individuals from UC Davis who oversee research may access your data during audits or other monitoring activities. We don't have any control over the commercial app that we are using for the study. The app, which is a part of this study, is monitored and regulated

by a commercial organization that is not a part of UC Davis, and we will not take any responsibility for the data collected by the app. There is no potential conflict of interest between the commercial app developers and us.

To minimize the risks of breach of confidentiality, we will keep all identifiable information under proper encryption, and only researchers will handle the survey data.

While this study does not involve banking the data we collect with your identifiable information (e.g., your email address, phone number) for future use, we may still use your data to answer additional research questions or share them with other investigators for additional research. If we do so, we will remove all identifiable information before use or sharing. Once identifiers have been removed, we will not ask your consent for the use of the sharing of your data in additional research.

Compensation

You will not be paid for taking part in this study. However, we will pay for the commercial app that we are using for the survey, which will allow you to enjoy premium service for up to one month. There will be no compensation for any injury or side effect that may occur due to the yoga practice.

Rights

Participation in research is completely voluntary. You are free to decline to take part in the project. You can decline to answer any questions, and you can stop taking part in the project at any time.

Whether or not you choose to participate, or answer any question, or stop participating in the project, there will be no penalty to you or loss of benefits to which you are otherwise entitled.

Questions

If you have any questions about this research, please feel free to contact the investigator at [530-220-3338] or [tsarkar@ucdavis.edu].

If you have any questions about your rights or treatment as a research participant in this study, please contact the University of California Davis, Institutional Review Board, at 916 703 9158 or HS-IRBEducation@ucdavis.edu.

If you agree to take part in the research, please "print a copy of this page to keep for future reference, then click on the "Accept" button below."

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Appendix L: IRB approval letter

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OFFICE OF RESEARCH
IRB Administration
TELEPHONE: 916 703-9151
FAX: 916 703-9160

SACRAMENTO, CALIFORNIA 95817

March 10, 2020

Sayantani Sarkar, B.Sc. Nursing
Department: School of Nursing
Phone: 5307609989/ 5302203338
Email: tsarkar@ucdavis.edu

Dear Dr. Sarkar:

On March 10, 2020 the UC Davis IRB reviewed the following protocol:

Type of Review:	Amendment/Modification
Title:	User-centered design considerations for mobile yoga applications for challenges of breast cancer survivors: A mixed-method study
Investigator:	Sarkar, Sayantani, B.Sc. Nursing
IRB ID:	1542419-2
Documents Submitted:	• Advertisement - clean mod flyer 2.25.2020.docx • Advertisement - Marked mod flyer.docx • Amendment/Modification - HRP-213-FORM-Modification.docx • Other - Clean guideline for participation track yoga.docx • Other - Marked guideline for participation track yoga.docx • Protocol - Marked mod 2.25.20 IRB protocol 2.3.2020 initial.docx • Protocol - clean mod 2.25.20 IRB protocol 2.3.2020 initial.docx • Questionnaire/Survey - clean 30 day post study follow up question.docx • Questionnaire/Survey - Marked 30 day post study follow up question.docx • Questionnaire/Survey - Marked app use and HTAU questionnaire.docx • Questionnaire/Survey - clean app use and HTAUquestionaire.docx • Questionnaire/Survey - Marked ONLINE QUALTRICS ENROLLMENT QUESTIONAIRE.docx • Questionnaire/Survey - Clean ONLINE QUALTRICS ENROLLMENT QUESTIONAIRE.docx • UC Davis - Initial Review Application
Determination:	Exempt *[Minor Modifications]*
Comments/Conditions:	This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are being considered and there are questions about whether IRB review

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SACRAMENTO, CALIFORNIA 95817

June 3, 2020

Sayantani Sarkar, B.Sc. Nursing
Department: School of Nursing
Phone: 5307609989/ 5302203338
Email: tsarkar@ucdavis.edu

On June 3, 2020 the UC Davis IRB reviewed the following protocol:

Type of Review:	Amendment/Modification
Title:	User-centered design considerations for mobile yoga applications for challenges of breast cancer survivors: A mixed-method study
Investigator:	Sarkar, Sayantani, B.Sc. Nursing
IRB ID:	1542419-3
Funding:	Departmental
Grant ID and Title:	None
Documents Submitted:	• Amendment/Modification - 5.18.2020 HRP-213-FORM-Modification.docx • Protocol - Clean 5.18.2020 mod 2.25.20 IRB protocol 2.3.2020 initial.docx • Protocol - Track changes 5.18.2020 mod 2.25.20 IRB protocol 2.3.2020 initial.docx • UC Davis - Initial Review Application

Determination:	Exempt *2, 3*
Comments/Conditions:	This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are being considered and there are questions about whether IRB review is needed, please submit a modification request to the IRB for another determination. In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

This Assurance, on file with the Department of Health and Human Services, covers this determination:

Appendix M: Participant Email and Text message Example

Enrollment email

Dear Participant,

Thank you very much for enrolling in our study “Experience of breast cancer survivors regarding mobile yoga application". I hope that you have successfully downloaded the Track Yoga app. Here is the instruction of using coupon code which will allow you to unlock all the premium features of the app.

Instructions for becoming a premium Track Yoga user:

1. Download the Track yoga app and signup with email/password.
   (Do not signup using Facebook, and do not make any payments within the app)
2. Go to the coupon URL and
   - Enter the email address, the same one used for Track Yoga.
   - Enter the coupon code - XXXXXXX
3. Open the track yoga app now, and the app is fully unlocked!

After 7 days, we are going to send you a survey to know your feedback about this app. Please feel free to email at tsarkar@ucdavis.edu if you have any questions.

with regards,

Post-7-day survey email

Dear Participant,

Congratulations on the completion of the 7-day use of the Track Yoga app! Please complete a brief survey here [link] and help us to know about your experience of yoga practice with the Track Yoga app. Please try to complete this questionnaire within 48 hours. Please enter the same email and phone number to complete this survey.

Please remember, there will be only one follow up question which will take less than 15 seconds at the end of 30 days. We appreciate your enormous contribution to our study "Experience of breast cancer survivors regarding mobile yoga application".

With regards,

Post-30-day survey email

Dear Participant,

Please take a moment to complete a single follow-up question regarding Track Yoga app use by clicking the [link] and let us know your intent to use the Track Yoga app in the future.

This is the final survey of this study " Experience of breast cancer survivor regarding mobile yoga application".

Thank you very much for completing the whole study and for supporting us.

with regards,

Enrollment Text

Dear Participant,

Thank you very much for participating in our study “Experience of breast cancer survivors regarding mobile yoga application.” PLEASE DO NOT PAY FOR ANYTHING. Please check your email for the directions of access to the full features of the app. If you face trouble accessing the premium features of the Track Yoga app, please don’t hesitate to contact us. We will send you a brief 2–3-minute survey at the end of the 7 day of app use. Please feel free to contact us with any questions or concerns.

Thank you very much!