Emre Sezgin · Soner Yildirim
Sevgi Özkan Yildirim · Evren Sumuer
*Editors*

# Current and Emerging mHealth Technologies

## Adoption, Implementation, and Use

Springer

# Current and Emerging mHealth Technologies

Emre Sezgin • Soner Yildirim
Sevgi Özkan Yildirim • Evren Sumuer
Editors

# Current and Emerging mHealth Technologies

## Adoption, Implementation, and Use

Springer

*Editors*
Emre Sezgin
The Research Institute
Nationwide Children's Hospital
Columbus, OH, USA

Sevgi Özkan Yildirim
School of Informatics
Middle East Technical University
Cankaya, Ankara, Turkey

Soner Yildirim
Department of Computer Education and
Instructional Technology
Middle East Technical University
Cankaya, Ankara, Turkey

Evren Sumuer
Faculty of Education
Department of Computer Education and
Instructional Technology
Kocaeli University
Kocaeli, Turkey

ISBN 978-3-319-73134-6 ISBN 978-3-319-73135-3 (eBook)
https://doi.org/10.1007/978-3-319-73135-3

Library of Congress Control Number: 2018935274



Printed on acid-free paper

This Springer imprint is published by the registered company Springer International Publishing AG part of Springer Nature.
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

# Contents

# Chapter 1
# Introduction to Current and Emerging mHealth Technologies: Adoption, Implementation, and Use


**Emre Sezgin**

The proliferation of smart mobile devices and increase in Internet access enabled many of the populations to reach many services with minimum efforts. The reports presented that the economic impact of the mobile market is estimated to reach to 14-digit numbers and over 100% annual growth rate. Mobile devices provide accessibility, reachability, and availability regarding exchanging information. In this context, mobile health (mHealth) is an important factor as a major component of electronic health services.

## 1.1 Mobile Health

Today, mobile health can be considered as an umbrella term for mobile information communication and network technologies accessing to the systems and services of healthcare (Adibi 2015). It includes the mobile devices and peripherals which are used by healthcare providers, patients, and customers in order to gather, store, and analyze data in the decision-making process. It was reported that health services adopted the mobile technologies and promoted its use by the healthcare professionals (Deloitte 2013; WKH 2013). Thus, there were a number of mobile healthcare services in particular use for diagnostic stages and health management, such as smartphone applications, emergency services, echography, and telemedicine applications (Istepanian et al. 2010; Hussain et al. 2015). Similarly, there were studies in the literature about the use of mobile devices and applications in healthcare services (Istepanian et al. 2010; Hampton 2012).

E. Sezgin (✉)
The Research Institute, Nationwide Children's Hospital, 575 Children's Crossroad, 43215, Columbus, OH, USA
e-mail: esezgin1@gmail.com



E. Sezgin et al. (eds.), *Current and Emerging mHealth Technologies*,
https://doi.org/10.1007/978-3-319-73135-3_1

However, in the light of these developments, there has been a puzzle that the mobile healthcare services might not have reached the expected level of quality (Visvanathan et al. 2011; Munos et al. 2016). By the growth of the market, security, regulations, transformation, costs, and technology use were identified as key issues which affect the quality of service and effective dissemination of mobile health. For instance, increasing use of mobile communication technologies may reveal multifaceted risk issues, such as electromagnetic risks, patient security risk, confidentiality and data security risk, and distraction and safety issues (Visvanathan et al. 2011).

It is a fact that mobile health significantly reduces the cost and increases the accessibility, yet the use of the technology may also depend on many other factors that cannot be easily quantified. In this context, a sociotechnical perspective stands as an important indicator toward understanding the use of the technology by the end users. For the success of the technologies, it is critical to develop an understanding about existing mobile health opportunities and what influences on the users' decisions to use these technologies. Otherwise, lack of sociotechnical knowledge may impede the potential success of the technologies. The adoption decision of users (i.e., patients, healthcare providers) may show changes over the time considering the change in technologies and culture. Thus, there is no golden standard to assess user intentions, but a continuous investigation is required to understand the mobile health technologies as well as the influencing factors to use these technologies.

## 1.2 Our Contribution

Regarding the sociotechnical perspective in mobile health, we believe it is significant to report the knowledge on the implementation, adoption, and use of mobile health technologies. In this book, authors mirrored the current state of mobile health from a sociotechnical perspective in four parts, which are "Behavioral Change," "Monitoring and Tracking with mHealth," "Use and Adoption in Healthcare Delivery," and "Global Perspectives and Issues." The first part, "Behavioral Change in mHealth," covered three chapters about persuasion strategies, technologies, and behavioral change techniques. The second part, "Monitoring and Tracking with mHealth," has four chapters reporting mHealth use in tracking during pregnancy, physical activity, weight loss, and emergency services. The third part is "mHealth Use and Adoption in Healthcare Delivery." This part has five chapters about usability of mHealth, physicians' mHealth app use trends and their adoption, and mobile patient assistance technology in healthcare delivery. The last part, "Global Perspectives and Issues with mHealth," included four chapters. In this part, mobile access to healthcare in Africa, big data use in mHealth, use of sensors, and IoT in mobile health were outlined.

In the second chapter, "Use of Persuasion Strategies in Mobile Health Applications," Nurcan Alkış and Duygu Fındık-Coşkunçay conducted a literature review. Their chapter reported suggestions and implications for behavior change theories and persuasion strategies that were used for mobile health applications. These theories included elaboration likelihood model, social cognitive theory, theory of planned behavior, cognitive behavioral therapy, transtheoretical model of

behavioral change, Cialdini's six principles of persuasion, and Fogg's behavior model. The chapter also summarized how these applications were used to change health-related behaviors.

The third chapter, "Behavior Change Techniques Used in Mobile Applications Targeting Physical Activity: A Systematic Review" by Hakan Kuru, presented an overview of behavioral change techniques used in physical activity applications. The author reported a taxonomy including 26 different behavior change techniques and 7 different health behavior theories. The chapter summarized that providing feedback on performance, prompting specific goal setting, and providing instructions for users are the most frequently used behavior change technique.

In the fourth chapter, "Exploring Intention on Continuous Use of Mobile Health Applications Designed by Persuasive Technology: 'Adımsayar' Case Study" by Seray Öney Doğanyiğit, an integrated research model based on theory of planned behavior and Fogg's captology was used to understand the intention to use a mobile app. The name of the app is "Adimsayar," which is a health tracking and motivation application designed by persuasive technology techniques. The data for the study was collected from over 200 participants and analyzed using multiple regression models. The author reported significant findings on behavioral attitude, subjective norms, perceived behavioral control, trust, and persuasive features.

In the fifth chapter, "Mobile Health Integration in Pregnancy," Aslı Günay and Çiğdem Erbuğ investigated the impact of mobile health during pregnancy. To understand pregnant women's interactions with mobile pregnancy applications, they conducted a user study with 33 pregnant women in different trimesters. The study reported that needs, concerns, and expectations change according to different pregnancy trimesters and pregnant women types. Their chapter highlights that the acceptance, adoption, and integration of mobile health into the daily lives of pregnant women; technologies should go beyond that by making expectant mothers feel happy and enhancing their wellness holistically.

In the sixth chapter, "Utilizing mHealth Applications in Emergency Medical Services of Turkey," Görkem Sarıyer and Mustafa Gokalp Ataman presented an exploratory study, providing an overview of the current state of mHealth interventions in emergency medical services (EMS) in Turkey. They outlined the most commonly used technologies in EMS, as well as the challenges and suggestions in EMS use. Utilization of mobile health was reported not being achieved successfully due to several issues as use priorities, costs, legal issues, lack of knowledge, logistics, and problems with technology literacy.

In the seventh chapter, "User Adoption and Evaluation of Mobile Health Applications: The Case for Physical Activity Monitoring," Perin Unal and her colleagues explored the mobile applications that have behavior change support features to encourage physical activity, and they investigated the relationship between user ratings and applications. An empirical analysis of 78 physical activity applications from Google Play store was conducted to extract the features that support behavior change. Minimum redundancy maximum relevance methodology was used to find the most relevant features. The study reported that user downloads are highly related to the features including voice coach, visualization of activity statistics, self-reports,

reminders, sharing activity statistics, social platform support, and sharing with community friends.

In the eighth chapter, "Unintended Users, Uses, and Consequences of Mobile Weight Loss Apps: Using Eating Disorders as a Case Study," Elizabeth V. Eikey sought for an answer for "What do we know about the users of weight loss apps?" and "How do the apps affect users?" In this context, the chapter discussed the unintended users, uses, and consequences of weight loss apps by using eating disorders as a case study. The unintended users of weight loss apps, and then the unintended uses of these apps and the unintended consequences of weight loss apps using qualitative data, including forum posts and interviews, previous work, and popular media articles, were reported.

In the ninth chapter, "Understanding Cross-Cultural Requirements in mHealth Design: Findings of a Usability Study of Indian Health Professionals," Joyram Chakraborty and his colleagues reported a usability study conducted over 6 months with the participation of eight Indian public health professionals. Their user preferences in their interactions with an mHealth application were investigated using a qualitative analysis approach as a requirement analysis tool to identify cross-cultural factors that might influence usability, accessibility, and interaction challenges and affect mHealth acceptance. In the study, technology familiarity, navigation, language, feedback mechanisms, cognitive overload, and background preferences were reported to be the key factors affecting performance and user acceptance.

In the tenth chapter, "Intention vs. Perception: Understanding the Differences in Physicians' Attitudes Towards Mobile Health Applications," Emre Sezgin, Sevgi Özkan Yildirim, and Soner Yildirim reported a comparative analysis for understanding the perception and intention of physicians about mobile health app use. Two different physician groups (mHealth application users and nonusers) were reported outlining the differences in intentions of users and perceptions of nonusers toward actual use of mHealth applications. They pursued a secondary research on a survey data collected from 137 mHealth user physicians and 122 nonuser physicians. Considering the findings, the authors listed a number of suggestions (from psychological, clinical, technological, and regulatory perspectives) to guide developers, researchers, and authorities to identify different factors influencing mHealth app use.

In the 11th chapter, "HealthGuide: A Personalized Mobile Patient Guidance System," Erhan Eren and Ebru Gökalp presented a mobile application, HealthGuide, which was designed by using a pervasive workflow management system. The authors also regarded the critical technology adoption factors in the mHealth literature. They argued HealthGuide helps improve the user experience and satisfaction by providing personalized services in a timely manner. They featured the app with a case and discussed the benefits and challenges for further implications.

In the 12th chapter, "Mobile Applications User Trend Analysis of Turkish Physicians in Digital Environments," Elgiz Yılmaz Altuntaş reported the preliminary findings from an online health communication survey about mobile app use trends of Turkish physicians. The study also focuses on discovering the behavior of physicians and the applications they download with respect to healthcare, medical

information, and their patient's health history. The findings revealed that the adoption of mHealth is dramatically growing. The author suggested that the improvements in health communication have the potential to play a significant role in the development of a promising new platform for patients/consumers and healthcare providers.

In the 13th chapter, "Acceptance of Mobile Homecare Technologies: An Empirical Investigation on Patients with Chronic Diseases" by Ayşegül Kutlay, Ünal Erkan Mumcuoğlu, and Sevgi Özkan Yildirim, the authors reported the factors affecting the acceptance of mobile homecare system employing unified theory of acceptance and use of technology (UTAUT) as a theoretical model. A survey was conducted and analyzed by using structural equation model. The chapter summarized that performance expectancy was the most significant predictor of patients' intention to use the homecare system. The UTAUT model was also able to explain user acceptance of mobile homecare technology with a variance of 68%.

In the 14th chapter, "Improving Access to Health Services in Sub-Saharan Africa Using Mobile and Wireless Technologies," Emmanuel Eilu presented a literature overview, investigating the use of mobile and wireless technologies in the prevention, surveillance, management, and compliance of disease epidemic in sub-Saharan Africa. The author also summarized the challenges and suggestions about mobile phone technology use and accessibility to health services. This chapter was argued to be resourceful for the authorities to plan and deploy mHealth technologies in sub-Saharan Africa.

In the 15th chapter, "Big Data in mHealth," Mert Onuralp Gökalp and his colleagues investigated the relationship between mHealth and big data concept from a sociotechnical perspective. They reported the opportunities of using big data technologies in the mHealth domain, as well as social and economic implications of using big data technologies. Their study outlined that there are social challenges including privacy, safety, and a false sense of confidence; there are also technical challenges such as security, standardization, correctness, timely analysis, and domain expertise. Finally, the authors proposed a solution framework to facilitate widespread user adoption.

In the 16th chapter, "Adoption of Sensors in Mobile Health," Haluk Altunel reported the use of sensors in mobile health applications. He categorized the sensors as built-in and add-in and investigated the adoption of sensors by different user groups (non-patients and patients) employing usability and user acceptance methods. The author used multiple data collection methods, collecting responses from more than 300 participants. The chapter reported that learnability (the level of ease to accomplish basic tasks the first time they encounter the sensors) was highly correlated with built-in sensors and the use of non-patients. Efficiency was highly correlated with add-in sensors and use of patients.

In the 17th chapter, "Adoption of Internet of Things in Healthcare Organizations," Halil Cicibas and Sevgi Özkan Yildirim addressed Internet of things (IOT) and mobile health adoption in healthcare. They conducted a literature review and identified main variables which affect adoption decision among top-level managers, healthcare professionals, technical staff, and patients. Finally, they presented a

number of recommendations for decision-makers to improve the adoption process of its devices in their healthcare organizations. Authors reported that the number of articles addressing radio-frequency identification (RFID) tag adoption is higher than the ones which focus on the other IoT technologies. Thus, they identified the gap in the literature, which needs to be addressed to explain the adoption of healthcare applications by specifically addressing the unique characteristics of IoT technology.

All chapters of this book demonstrate a novel collection of studies presenting the recent research on healthcare and mobile technologies. It covers the adoption and implementation of mobile health technologies for different user groups (e.g., healthcare professionals, patients, and consumers). The book encompasses significant arguments and contributions about the use of mobile technologies, behavioral change, monitoring and tracking, adoption, and different perspectives in mHealth use. The outstanding feature of the book is its perspective toward mobile health. The authors followed a sociotechnical approach in their chapters. Thus, rather than sole technicality, the book also focuses on the users' perspective. Readers who are interested in intention, perception, attitudes, and adoption in mobile health would be interested in this book. The editors believe that this book will be useful for developers, decision-makers, academics, and healthcare providers.

## References

Adibi S (2015) Mobile health: a technology road map, 1st edn. Springer International Publishing, Cham

Deloitte (2013) Physician adoption of health information technology: implications for medical practice leaders and business partners. https://www2.deloitte.com/content/dam/Deloitte/us/Documents/life-sciences-health-care/us-lshc-physician-adoption-10012014.pdf. Accessed 15 July 2017

Hampton T (2012) Recent advances in mobile technology benefit global health, research, and care. Am Med Assoc 307:2013–2014

Hussain M, Al-Haiqi A, Zaidan AA et al (2015) The landscape of research on smartphone medical apps: coherent taxonomy, motivations, open challenges and recommendations. Comput Methods Prog Biomed 122:393–408. https://doi.org/10.1016/j.cmpb.2015.08.015

Istepanian RSH, Laxminarayan S, Pattichis CS (2010) M-health: emerging mobile health systems. Springer-Verlag, London

Munos B, Baker PC, Bot BM et al (2016) Mobile health: the power of wearables, sensors, and apps to transform clinical trials. Ann N Y Acad Sci 1375:3–18. https://doi.org/10.1111/nyas.13117

Visvanathan A, Gibb AP, Brady RRW (2011) Increasing clinical presence of mobile communication technology: avoiding the pitfalls. Telemed J E Health 17:656–661

WKH (2013) Wolters Kluwer Health 2013: Physician outlook survey. http://wolterskluwer.com/binaries/content/assets/wk-health/pdf/company/newsroom/white-papers/wolters-kluwer-health-physician-study-executive-summary.pdf. Accessed 15 July 2017

# Part I
# Behavioral Change in mHealth

# Chapter 2
# Use of Persuasion Strategies in Mobile Health Applications


**Nurcan Alkiş and Duygu Findik-Coşkunçay**

## 2.1 Introduction

Health-related behaviors have been traditionally influenced through different channels such as television, radio, and newspaper (Michael and Cheuvront 1998). Today, with the advances in the computing technologies, the Internet, e-mail, and mobile applications have become the tools for influencing health-related behaviors. According to Fogg (2007), mobile phones are as powerful as personal computers due to their advantages of providing easy access to the internet and having GPS sensors and other useful instruments such as accelerometers. Therefore, mobile applications present modern opportunities to promote healthy behavior by offering real-time monitoring and detection of a change in health status. The challenge here is to efficiently integrate mobile technologies into daily life to motivate individuals to adopt specific health-related behavior. This could be accomplished by using persuasive technologies.

In the context of social sciences, persuasion refers to changing human behaviors toward a system, an idea, or other people. Simons et al. (2001) defined persuasion as "human communication designed to influence the autonomous judgments and actions of others." Individuals have been trying to influence each other's behaviors

N. Alkiş
Başkent University, Ankara, Turkey
e-mail: nalkis@baskent.edu.tr

D. Findik-Coşkunçay (✉)
Atatürk University, Erzurum, Turkey
e-mail: duygu.findik@atauni.edu.tr



E. Sezgin et al. (eds.), *Current and Emerging mHealth Technologies*,
https://doi.org/10.1007/978-3-319-73135-3_2

and attitudes unintentionally or intentionally; thus, impact of persuasion can be observed in every part of our lives. For example, marketers use persuasion techniques to increase awareness, charities use for fundraising, and health service providers for healthy behavior. The term persuasion has been introduced to the information systems domain to explain the behavior changes of humans toward computing systems (Fogg 2002). Computing products have been considered as social actor that could trigger behavior change.

In the literature, different persuasion strategies and behavior change theories are employed for mobile health applications. In this study, a literature survey was conducted to identify the theories of behavior change that have been used in mobile health applications. The most common behavior change theories or persuasion approaches were determined as the elaboration likelihood model (ELM), social cognitive theory (SCT), theory of planned behavior (TPB), cognitive behavioral therapy (CBT), transtheoretical model of behavior change, and Cialdini's six principles of persuasion and motivation. Furthermore, the study identified that personalization of applications improves the effectiveness of the applications and increases the success rates of the target behavior. In addition, mobile phone use, e-mail, short message service (SMS) and multimedia message service (MMS) interventions, mobile diaries, mobile phone applications, and mobile games were found to be the commonly used tools to change individuals' health-related behavior in the mobile health domain.

## 2.2 Review Procedure

A search procedure was defined for a systematic literature review. First of all, English was selected as the only language since the most of the studies in this context were written in English. *Mobile health*, *mobile health applications*, *persuasive technology*, *behavior change*, *behavior change theories*, *behavior change in health*, *persuasion principles*, and *persuasion theories* keywords and their combination were used. The papers were searched using scholar.google.com and the institutional online libraries (i.e., lib.metu.edu.tr and lib.baskent.edu.tr which have access to international databases, such as Scopus, Sciencedirect, and Web of science). In order to reach relevant studies, references of the papers were followed. A total of 76 studies were reached that consisted of journal papers and conference proceedings. The studies that were not focusing on persuasion or behavior change theory and not covering mobile applications were excluded. Finally, 22 of the studies were included for analysis. The next section presented our findings about the theories and mobile applications.

## 2.3 Persuasion and Behavior Change Theories and Use in Mobile Health Applications

### *2.3.1 Elaboration Likelihood Model of Persuasion (ELM)*

ELM is an attitude change theory. It explains decision-making and persuasion with two parallel processes, of a central and a peripheral route (Cacioppo and Petty 1984; Oinas-Kukkonen and Harjumaa 2008; Petty and Cacioppo 1986). The main idea behind ELM is to decide whether a person will be persuaded from the central or the peripheral route. Central route to persuasion refers to processes, in which elaboration likelihood is high, while peripheral route involves processes with low elaboration likelihood.

ELM has been applied in physical activity interventions in the mobile health domain. In one of the studies, Hurling et al. (2007) proposed a system including the use of the internet, mobile phone, and e-mail to promote physical activity based on the social comparison, decisional balance, elaboration likelihood, and goals. The system used a Bluetooth-connected wrist accelerometer to measure physical activity. In addition, the users were asked to enter their weekly physical exercises, and feedback and a comparison of their performance with other users were provided. The system also provided a schedule for the following week trainings and e-mail or mobile message reminders. Hurling et al. (2007) reported that the system was effective in increasing the physical activity of the users.

Zuercher (2009) integrated ELM into an SMS intervention to increase the physical activity performance of young women. Using this application, the participants sent information about their daily physical activities to a central database via SMS, and they received personal feedback about the exercises and their target goals. The study measured the elaboration likelihood using a scale on the users' motivation, ability, and favorable thoughts. Although a significant correlation was not reported between these constructs and behavior change, the author concluded that SMS was found acceptable intervention method for young women.

### *2.3.2 Social Cognitive Theory (SCT)*

Social cognitive theory (SCT) is a widely accepted and empirically validated model of individual behavior (Compeau et al. 1995). SCT is based on the reciprocally determined factors consisting of environmental influences, cognitive, and other personal factors and behavior. Environmental influences refer to people selecting the environment in which they exist and being influenced by those environments. Furthermore, environmental factors, situational characteristics, cognitive, and other personal factors affect the behavior of individuals. The relations between these three factors, environment, and behavior have been related as "triadic reciprocality" by Bandura (1977) . In addition, Bandura (1986) considered self-efficacy to be a

cognitive factor in his theory and defined it as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances. It is concerned not with the skills one has but with judgments of what one can do with whatever skills one possesses." Based on Bandura's theory, Compeau et al. (1999) focused on information systems and developed a model concerning computer usage. The SCT model was used to examine the relations among factors including computer self-efficacy, outcome expectations (performance), outcome expectations (personal), affect, anxiety, and usage. The model shows that self-efficacy directly influences affect, anxiety, and usage, and also it impacts the usage over outcome expectations and effect.

In the literature, it was observed that SCT has been used in the design of health applications, such as using the constructs of SCT on mobile phone intervention (Yoganathan and Kajanan 2013). Zuercher (2009) also used the self-efficacy construct of SCT, alongside with ELM, to assess the positive health behavior change in young women. The author concluded that significant behavior improvement in self-efficacy was not observed.

In another SMS intervention study, Fjeldsoe et al. (2010) implemented SCT in an application called MobileMums to promote physical activity. In this intervention, the researchers developed the content of the SMS considering the constructs of SCT that are effective in changing individual behavior (self-efficacy, goal setting skills, outcome expectancy, social support, and perceived environmental opportunity for physical activity).

### *2.3.3 Theory of Planned Behavior (TPB)*

TPB extended the theory of reasoned action (Ajzen and Fishbein 1975) in order to understand the complexities of human social behavior. The key factor in TPB is the individual's intention to perform a behavior, which means that an individual's behavior is determined by his/her intention to perform that behavior (Ajzen and Fishbein 1975; Chang 1998). Ajzen and Fishbein (1975) theorized that behavioral intention is a function of two conceptually distinct sets of attitude towards behavior and subjective norms of behavior. Attitude is considered a collection of behavioral beliefs, and thus attitude toward behavior refers to the "degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior in question" (Ajzen 1991). Subjective norm indicates the normative belief and is defined as "the perceived social pressure to perform or not to perform the behavior" (Ajzen 1991). TPB introduced a third independent expositive factor of intention, perceived behavior control, which refers to beliefs that underlie the level of control over behavior and "people's perception of ease or difficulty of performing the behavior of interest" (Ajzen 1991).

Sirriyeh et al. (2010) proposed that the effective components of attitude (such as finding the behavior enjoyable and pleasant) influence engaging in physical activity. They conducted an SMS intervention with adolescents and found that the SMS

content was successful in increasing the physical activity of inactive participants. This study demonstrated enjoyment as an influencing factor in promoting physical activity by taking the attitude construct of TPB as the theoretical base.

### *2.3.4 Cognitive Behavioral Therapy (CBT)*

CBT is a kind of psychotherapy involving processes cognitive restructuring, stress inoculation training, problem-solving, skills training and relaxation training (Butler et al. 2006). CBT targets groups to solve their problems and change their behaviors. Self-monitoring is one of the key methods in CBT (Mattila et al. 2008). With this approach, the subjects can be taught the ways that they could observe their actions, emotional reactions, thoughts, and other health-related variables. Through these observations, individuals can identify their behavioral lifestyle changes (Mattila et al. 2008). In the literature, CBT has been implemented in a number of studies as clinical trials and cognitive-behavioral interventions (Butler et al. 2006).

In this context, a mobile phone application, The Patient-Centered Assessment and Counseling Mobile Energy Balance (PmEB),was developed to monitor caloric balance in real time for weight management (Lee et al. 2006; Tsai et al. 2007). The application aimed to increase self-efficacy of self-monitoring in dietary and exercise behavior and helped people to change their nutrition habits. PmEB was developed with a four-phase iterative approach. The first three phases were designed using human-computer interaction methodologies. The users enter their daily consumption of food and the physical activities they undertake into the system, which then calculates the caloric balance. The system also sends reminder SMS messages to motivate the users to update their caloric and exercise information. In the last phase, the researchers assessed the feasibility of the application with 15 clinically overweight and obese participants using two key methods, ubiquitous computing evaluation (attention, trust, conceptual degree, interaction, invisibility, and impact) and feasibility evaluation (compliance and satisfaction). The results of the study demonstrated that self-monitoring increased the level of awareness in all participants. Paper diaries were found to be inconvenient leading to bias and lower compliance, whereas PmEB was easy to use and effective in motivating users in a variety of ways. This application helped users to develop emergent weight management practices. However, the researchers added that PmEB users found food entry challenging and disliked the prompts.

Mattila et al. (2008) developed the wellness diary (WD) for the management of personal wellness and weight based on the philosophy of CBT. WD was used for self-monitoring and embedded in an existing calendar application for life and time management. The focus of the research was on the usage, usability, and acceptance of the concept and its implementations. The study showed that WD was well accepted and actively used by the participants.

Wylie and Coulton (2008) presented a health-monitoring software, Heart Angel, which was developed for mobile phones to monitor, record, and improve individuals'

level of fitness. The software included built-in cardiorespiratory tests, a tracking software to provide information about heart rate exertion over time and location. It also provided mobile game called Health Defender, which measures the players' real-time heart rate and informs them about heart rate exertion during game play that triggers bonus points. These bonuses are used to encourage users to undertake a physical exercise to increase their heart rate.

Denning et al. (2009) introduced a wellness management system, BALANCE, which automatically detects the user's caloric expenditure via a sensor from a Mobile Sensing Platform unit worn on the hip for long-term health monitoring. The researchers conducted initial validation experiments to measure oxygen consumption during treadmill walking and jogging. The results showed that the system estimates caloric output within 87% of the actual value. The researchers concluded that this system would facilitate behavioral change for weight loss and weight control.

Morris et al. (2010) aimed to investigate the potentials of mobile phone technologies to increase access using CBT techniques and provide instant support. The researchers developed a mobile phone application, Mood Map, which allowed users to report their moods and the therapeutic exercises they undertook for cognitive reappraisal and physical relaxation. A one-month field study was conducted with eight participants who were prompted to report their moods several times a day using the Mood Map by selecting from mood scales. In addition, the participants were able to activate mobile therapies when needed. The researchers emphasized that use of Mood Map was successful in increasing self-awareness and coping with stress.

Lathia (2012) stated that people use their mobile phones in the lavatory to pass the time; therefore, this is an ideal idle moment to use health applications. The researchers introduced the design of The Poo mobile phone application to examine user feedback about their gastrointestinal health in an idle moment. This application allows users to input data to monitor and review their current bowel movement.

### *2.3.5 Transtheoretical Model of Behavior Change*

The transtheoretical model was derived from theories of psychotherapy and behavior change. This model proposed that health behavior change depends on the progress that occurs in six stages: precontemplation, contemplation, preparation, action, maintenance, and termination (Prochaska and Velicer 1997). In the precontemplation stage, people do not intend to take action in the near future (for 6 months) (Prochaska and Velicer 1997). Persuasive technology should target precontemplators to focus on education (Consolvo et al. 2009). In the contemplation stage, people intend to change their behaviors in the next 6 months (Prochaska and Velicer 1997). For contemplators, persuasive technology should be designed in a way to provide techniques for overcoming barriers and rewards for encouraging desired behaviors (Consolvo et al. 2009). In the preparation stage, people are anticipated to take action in the immediate future (next month) (Prochaska and Velicer 1997). In this case, persuasion technology should focus on rewarding behaviors even if the behavior is

not consistent (Consolvo et al. 2009). In the action stage, people have made specific explicit modification in their lifestyles usually within the past 6 months (Prochaska and Velicer 1997). For the people in this stage, the best strategy is to focus on keeping track of progress and consider the elements of social influence (Consolvo et al. 2009). In the maintenance stage, people try to prevent relapse; however, they cannot undergo the change process as frequently as people who are in the action stage (Prochaska and Velicer 1997). For maintainers, persuasion technology should provide strategies for problems encountered previously and help them to realize how they become "the kind of person one wanted to be" (Consolvo et al. 2009; Prochaska et al. 1992, p. 12). In the termination stage, individuals do not have any temptation and have 100% self-efficacy (Prochaska and Velicer 1997). The researchers identified ten processes of change to achieve decisional balance, self-efficacy, and temptations: Consciousness raising, dramatic relief, self-reevaluation, environmental reevaluation, self-liberation, social liberation, counterconditioning, stimulus control, contingency management, and helping relationships (Prochaska and Velicer 1997).

Grimes et al. (2010) created a casual nutrition game called OrderUP!, in which players learn how to make healthier meal choices. The researchers used the transtheoretical model of behavior change to characterize four processes of change, namely, consciousness raising, self-reevaluation, engaging in helping relationships, and counter-conditioning. The researchers assessed the experiences of 12 participants with the game, and they observed that playing OrderUP! helped people to demonstrate behavior change and encouraged them to adopt a healthier lifestyle.

### *2.3.6 Cialdini's Six Principles of Persuasion*

To understand how people influence others' attitudes and actions, Cialdini proposed six principles of influence that triggers the behavior of people (Cialdini 1993, 2001, 2004). According to Cialdini, these basic principles can be taught, learned, and applied to change human behavior in different contexts. These principles were defined as followings:

- The principle of reciprocation: According to this principle, "People repay in kind." This strategy can be applied by giving gifts, doing favors, and making concessions (Cialdini 2003).
- The principle of scarcity: This is based on the assumption that "People want more what they have less." When something is scarce, people have a tendency to value it more. This principle can be applied by explaining the unique benefits of the target behavior, opportunities, and using deadlines. For example, Kaptein and Eckles (2012) applied this strategy in their online bookstore by mentioning that there were only limited copies of the books on sale.
- The principle of authority: People are inclined to follow those who have power. This principle is based on the idea that "people defer to authorities." When a

request is made by a legitimate authority, people have a tendency to follow/believe the request. This principle can be applied by referring to expert opinions in applications.

- The principle of commitment and consistency: "People align with their clear commitments." People do what they are told to do. This strategy can be applied encouraging target users to make public commitments since they will be consistent with their previous commitments.
- The principle of social proof (consensus): This principle depends on people's tendency to follow other people that are similar to them when making a decision. In other words, "People follow the lead of similar others". To apply this principle, examples from similar individuals' behaviors can be given.
- The principle of liking: According to this principle, people are influenced more easily from those they like. This principle can be applied by considering similarity and praise since people like who likes them and behave similarly to those. Groves et al. (1992) identified the factors that increased liking as the similarity of attitude, background, dress, praise, cooperation, and physical attractiveness.

Cialdini's persuasion principles are implemented in different domains to change human behavior. In the mobile health domain, these principles have mostly been used in e-mail and SMS interventions and mobile phone applications. Kaptein et al. (2010) conducted two experiments, in which the participants were asked to join a lunch walk exercise and consume fruit. The researchers employed Cialdini's following persuasion strategies in e-mail messages: authority, scarcity, and consensus. Authority was employed by giving recommendations from the physicians, general practitioners, and the World Health Organization. Scarcity was employed by mentioning the limited slots to join the activity, and consensus was employed by giving examples from similar individuals. The results of the study showed that these strategies increased people's compliance to health-related activities.

Kaptein et al. (2012) used personalized short SMS to reduce snacking. The researchers developed and validated the Susceptibility to Persuasive Strategies scale (STPS) based on the six principles of Cialdini (1993). The researchers performed an experiment with 73 participants. The test group received personalized text messages, and the control group received non-tailored messages. It was observed that, based on the participants' score on STPS, the personalized messages resulted in a higher decrease in the consumption of snacks.

Van Dantzig et al. (2013) aimed to reduce sedentary behavior with the SitCoach application, which encourages office workers to have regular breaks from sitting. This application monitors physical activity and sedentary behavior, and it sends timely persuasive messages suggesting active breaks. The messages were based on the social influence strategies of Cialdini (1993). To evaluate the effectiveness of persuasive text messages, the researchers conducted an experiment with 86 participants from different health companies in the Netherlands. The study showed that there were significant differences between the control group, not receiving any persuasive messages, and the intervention group, receiving advising messages to take a

break. However, no significant change was observed in the physical activity of the participants.

Alkiş and Temizel (2015) investigated the relationship between Big Five Personality (BFP) traits and six influence strategies of Cialdini and found that different types of personalities are influenced differently from persuasion strategies which will guide the use of persuasion strategies according to personality type. The study showed that data related to personality is crucial for implementing effective influence strategies for a given personality type. As suggested by Hirsh et al. (2012), persuasive messages are more effective when they are framed according to the personality traits of people. In addition, Halko and Kientz (2010) investigated the relationship between BFP traits and persuasive technologies in the context of health-mobile applications. They found correlations between these traits and cooperative, competitive, positive reinforcement, negative reinforcement, intrinsic, extrinsic, authoritative, and non-authoritative persuasion instruction styles. The results of the study contributed to the personalization of health applications according to the personality types.

### *2.3.7 Fogg's Behavioral Model (FGM)*

FGM was proposed by Fogg (2009) to understand the drivers of human behaviors. There are three factors in this model to determine behavior: motivation, ability, and trigger. According to this model, to achieve a target behavior, the person should be motivated enough, have the ability to accomplish the target behavior, and be triggered to perform the behavior. Therefore, a persuasive design should focus on increasing the motivation for the target behavior, consider the ability of audience, and use effective triggers.

Gasser et al. (2006) compared the usage and acceptance of a mobile lifestyle coaching application with that of an equivalent traditional web application. In the study, the researchers administered a set of health questionnaires that incorporated social facilitation features to enhance motivation. The implications of the study provided a guideline to strengthen the persuasiveness of health applications on mobile devices. The researchers emphasized the importance of using social facilitation features, such as aliases and avatars or functionalities, as instant messaging, for strengthening the persuasive effect of the system.

When the mobile health applications were examined, it was seen that some of these applications aimed to improve users' motivation to reach the target behavior, which is a dimension in FBM. For example, Patrick (2009) performed an SMS and MMS intervention by assessing the motivation progress in order to help individuals improving their dietary behaviors (to lose or maintain their weight over 4 months). The experiment was conducted with age- and a gender-adjusted sample of 65 participants, and it was found that the intervention group that received personalized SMS and MMS messages two to five times a day lost more weight than the control group.

Ahtinen et al. (2009) evaluated user experiences in three mobile wellness applications, namely, Wellness Diary (WD), Mobile Coach (MC), and SelfRelax (SR). In their study, the researchers concentrated on motivational factors. The results indicated that the participants positively responded to the applications. In the study, the participants used the applications to find the solution for given problems. The rate of using the applications increased once the participants understood the purpose of the functions and perceived them as being personally relevant. WD was perceived being easy to use, which means that its purpose and functionalities were understandable. On the other hand, MC was more challenging to understand and to learn. However, it provided persuasive and motivating solutions that can be adaptable for training programs, goals, and coaching. MC triggered curiosity, challenge, and control factors of intrinsic motivation. SR was perceived as being intuitive to use, and it was considered beneficial for helping participants to fall asleep and relax.

Pollak et al. (2010) created the Time to Eat mobile game to motivate children to develop healthy eating habits. The researcher examined the role of the motivational feature of a mobile phone in supporting and encouraging healthy eating habits in seventh and eighth graders. The game allows participants to care for a virtual pet by sending photos of the food they consume. The researcher evaluated the experience of 53 seventh and eighth graders. According to the results, the children who played the game consumed a healthy breakfast more frequently than those who did not play the game.

Buttussi and Chittaro (2010) created a fitness game called Monster & Gold to increase physical exercise. In the game, users gain or lose points according to their level of exercise. This study showed that games have motivational effects on people, which is a dimension of persuasion in FBM.

## 2.4 Discussion and Implications

With the improvements in technology, health-related behaviors have been promoted in using mobile systems and applications. The extensive use of mobile phones is an evidence of their acceptance as well as an advantage in supporting the adoption of a healthy lifestyle. In the reviewed studies, ten mobile phone applications, six SMS-MMS interventions, four games, and two e-mail interventions cases were investigated. This showed that mobile phone applications are becoming a common medium to promote health behavior. These applications were effective in managing weight, encouraging physical activities and exercises, preventing and managing chronic diseases, self-monitoring, and self-awareness for long-term wellness. Furthermore, promoting physical activities and wellness management were the common target behaviors for the applications.

In order to increase the effectiveness of these applications, behavior change, and persuasion theories were employed. In this study, the following theories and models were identified from the literature review: traditional behavioral theories, specifically ELM, SCT, TPB, CBT, the transtheoretical model of behavior change,

Cialdini's six principles of persuasion, and FBM. Among these theories CBT and motivation are frequently implemented.

In addition, the mobile applications that were reported in the studies were revealed that the personalization feature was effective to promote health-related behaviors. For example, Halko and Kientz (2010) listed the persuasive health technology design strategies (authoritative, non-authoritative, cooperative, competitive, extrinsic, intrinsic, negative reinforcement, and positive reinforcement) and suggested that different types of personalities required different strategies to be considered in designing effective personalized applications. Similarly, the personalized feature of mobile game increases its effectiveness as a persuasive application.

For example, a mobile game called MoviPill was designed to increase medication adherence for elder people in that regard (De Oliveira et al. 2010). In the game, users gain points when they take their bills on time and at the right amount, and they compete against other users.

This study revealed that health behavior change was difficult to measure and quantify. Therefore, it was not always possible to determine whether the applications were successful solutions in achieving the intended behavior (Klasnja et al. 2011). Thus, regardless of the platform (mobile phones, web applications, or social networking tools), health-related applications should be carefully designed and implemented to reach the target behavior.

## 2.5 Conclusion

In this chapter, the studies on mobile health applications, behavior change, and persuasion theories were investigated. ELM, SCT, TPB, CBT, transtheoretical model of behavior change, Cialdini's six principles of persuasion, and FBM were the theories employed in mobile health applications. Persuasive technology, including SMS-MMS intervention, e-mail intervention, mobile health applications, and games, encourages individuals to adopt a healthy lifestyle by helping them track their physical activities, moderate their diet, reduce the consumption of snack food, learn how to make healthier meal choices, and prevent and manage chronic diseases. This chapter provides an overview for (1) researchers to guide their future research and (2) persuasive technology designers to develop effective mobile health systems to promote behavior change.

## References

Ahtinen A, Mattila E, Vaatanen A et al (2009) User experiences of mobile wellness applications in health promotion: user study of wellness diary, mobile coach and SelfRelax. In: 2009 3rd international conference on Pervasive Computing Technologies for Healthcare, IEEE, pp 1–8

Ajzen I (1991) The theory of planned behavior. Organ Behav Hum Decis Process 50(2):179–211

Ajzen I, Fishbein M (1975) Belief, attitude, intention and behavior: an introduction to theory and research. Addison-Wesley, Boston

Alkiş N, Temizel TT (2015) The impact of individual differences on influence strategies. Pers Individ Dif 87:147–152

Bandura A (1977) Self-efficacy: toward a unifying theory of behavioral change. Psychol Rev 84(2):191–215

Bandura A (1986) Social foundations of thought and action: a social cognitive theory. Prentice-Hall, Upper Saddle River

Butler AC, Chapman JE, Forman EM et al (2006) The empirical status of cognitive-behavioral therapy: a review of meta-analyses. Clin Psychol Rev 26(1):17–31

Buttussi F, Chittaro L (2010) Smarter phones for healthier lifestyles: an adaptive fitness game. IEEE Pervasive Comput 9(4):51–57

Cacioppo JT, Petty RE (1984) The elaboration likelihood model of persuasion. Adv Consum Res 11(1):673–675

Chang MK (1998) Predicting unethical behavior: a comparison of the theory of reasoned action and the theory of planned behavior. J Bus Ethics 17(16):1825–1834

Cialdini RB (1993) Influence: the psychology of persuasion. Morrow, New York

Cialdini RB (2001) Harnessing the science of persuasion. Harv Bus Rev 79(9):72–81

Cialdini RB (2003) The power of persuasion putting the science of influence to work in fundraising. Stanf Soc Innov Rev 1:8–27

Cialdini RB (2004) The science of persuasion. Sci Am Mind 14(1):70–77

Compeau DR, Higgins CA, Huff S (1995) Computer self-efficacy: development of a measure and initial test. MIS Q 19(2):189–211

Compeau DR, Higgins CA, Huff S (1999) Social cognitive theory and individual reactions to computing technology: a longitudinal study. MIS Q 23(2):145–158

Consolvo S, McDonald DW, Landay JA (2009) Theory-driven design strategies for technologies that support behavior change in everyday life. In: Proceedings of the SIGCHI conference on human factors in computing systems, ACM, pp 405–414

De Oliveira R, Cherubini M, Oliver N (2010) MoviPill: improving medication compliance for elders using a mobile persuasive social game. In: Proceedings of the 12th ACM international conference on ubiquitous computing, ACM, pp 251–260

Denning T, Andrew A, Chaudhri R et al (2009) BALANCE: towards a usable pervasive wellness application with accurate activity inference. In: Proceedings of the 10th workshop on mobile computing systems and applications, ACM, p 5

Fjeldsoe BS, Miller YD, Marshall AL (2010) MobileMums: a randomized controlled trial of an SMS-based physical activity intervention. Ann Behav Med 39(2):101–111

Fogg BJ (2002) Persuasive technology: using computers to change what we think and do. Ubiquity 2002:5

Fogg BJ (2007) The future of persuasion is mobile. In: Fogg BJ, Eckles D (eds) Mobile persuasion, 20 perspectives on the future of behavior change. Stanford Captology Media, Stanford, pp 5–11

Fogg BJ (2009) A behavior model for persuasive design. In: Proceedings of the 4th international conference on persuasive technology, ACM, p 40

Gasser R, Brodbeck D, Degen M et al (2006) Persuasiveness of a mobile lifestyle coaching application using social facilitation. In: International conference on persuasive technology, Springer Berlin Heidelberg, pp 27–38

Grimes A, Kantroo V, Grinter RE (2010) Let's play!: mobile health games for adults. In: Proceedings of the 12th ACM international conference on ubiquitous computing, ACM, pp 241–250

Groves RM, Cialdini R, Couper MP (1992) Understanding the decision to participate in a survey. Public Opin Q 56(4):475–495

Halko S, Kientz JA (2010) Personality and persuasive technology: an exploratory study on health-promoting mobile applications. In: International conference on persuasive technology, Springer Berlin Heidelberg, pp 150–161

Hirsh JB, Kang SK, Bodenhausen GV (2012) Personalized persuasion tailoring persuasive appeals to recipients' personality traits. Psychol Sci 23(6):578–581
Hurling R, Catt M, De Boni M et al (2007) Using internet and mobile phone technology to deliver an automated physical activity program: randomized controlled trial. J Med Internet Res 9(2):e7
Kaptein M, Eckles D (2012) Heterogeneity in the effects of online persuasion. J Interact Mark 26(3):176–188
Kaptein M, Lacroix J, Saini P (2010). Individual differences in persuadability in the health promotion domain. In: International conference on persuasive technology, part of the lecture notes in computer science, vol 6137, pp 94–105
Kaptein M, De Ruyter B, Markopoulos P et al (2012) Adaptive persuasive systems: a study of tailored persuasive text messages to reduce snacking. ACM Trans Interact Intell Syst 2(2):10–25
Klasnja P, Consolvo S, Pratt W (2011) How to evaluate technologies for health behavior change in HCI research. In: Proceedings of the SIGCHI conference on human factors in computing systems, ACM, pp 3063–3072
Lathia N (2012) Using idle moments to record your health via mobile applications. In: Proceedings of the 1st ACM workshop on mobile systems for computational social science, ACM, pp 22–27
Lee G, Tsai C, Griswold WG et al (2006) PmEB: a mobile phone application for monitoring caloric balance. In: CHI'06 extended abstracts on human factors in computing systems, ACM, pp 1013–1018
Mattila E, Pärkkä J, Hermersdorf M et al (2008) Mobile diary for wellness management-results on usage and usability in two user studies. IEEE Trans Inf Technol Biomed 12(4):501–512
Michael M, Cheuvront CCJB (1998) Health communication on the Internet: an effective channel for health behavior change? J Health Commun 3(1):71–79
Morris ME, Kathawala Q, Leen TK et al (2010) Mobile therapy: case study evaluations of a cell phone application for emotional self-awareness. J Med Internet Res 12(2):e10
Oinas-Kukkonen H, Harjumaa M (2008) Towards deeper understanding of persuasion in software and information systems. In: Advances in computer-human interaction, 2008 first international conference, IEEE, pp 200–205
Patrick K (2009) A text message-based intervention for weight loss: randomized controlled trial. J Med Internet Res 11(1):e1
Petty RE, Cacioppo JT (1986) Communication and persuasion: central and peripheral routes to attitude change. Springer-Verlag, New York
Pollak J, Gay G, Byrne S et al (2010) It's time to eat! Using mobile games to promote healthy eating. IEEE Pervasive Comput 9(3):21–27
Prochaska JO, Velicer WF (1997) The transtheoretical model of health behavior change. Am J Health Promot 12(1):38–48
Prochaska JO, DiClemente CC, Norcross JC (1992) In search of how people change: applications to addictive behaviors. Am Psychol 47(9):1102–1114
Simons HW, Morreale J, Gronbeck B (2001) Persuasion in society. Sage Publications, Thousand Oaks
Sirriyeh R, Lawton R, Ward J (2010) Physical activity and adolescents: an exploratory randomized controlled trial investigating the influence of affective and instrumental text messages. Br J Health Psychol 15(4):825–840
Tsai CC, Lee G, Raab F et al (2007) Usability and feasibility of PmEB: a mobile phone application for monitoring real time caloric balance. Mob Netw Appl 12(2–3):173–184
Van Dantzig S, Geleijnse G, van Halteren AT (2013) Toward a persuasive mobile application to reduce sedentary behavior. Pers Ubiquit Comput 17(6):1237–1246
Wylie CG, Coulton P (2008) Persuasive mobile health applications. In: International conference on electronic healthcare, Springer Berlin Heidelberg, pp 90–97
Yoganathan D, Kajanan S (2013) Persuasive Technology for Smartphone Fitness Apps. In: Proceedings of PACIS (Pacific Asia conference on information systems), p 185
Zuercher JL (2009) Developing strategies for helping women improve weight-related health behaviors. University of North Carolina at Chapel Hill, Chapel Hill

# Chapter 3
# Behavior Change Techniques Used in Mobile Applications Targeting Physical Activity: A Systematic Review


**Hakan Kuru**

## 3.1 Introduction

Most of the individuals today are health-care consumers, and with the advances in technology, e-health is changing the delivery of health care. mHealth has emerged as a component of e-health, and it was defined as the use of information and communication technology (ICT) such as smartphones, personal computers, global positioning services (GPS), and vital sign monitors for health care and health services (World Health Organization 2011). mHealth apps serve for two primary purposes: disease management and wellness/fitness. The wellness-focused mobile applications (mApps) facilitate health-promoting behaviors. In 2015, 38% of the mHealth applications in the Apple Store and Google Store were grouped under the fitness category (Ventola 2014). For disease management, mApp features allow health professionals to maintain low-cost interventions. These interventions include reminders and motivational messages. Moreover, the interventions can target different ages, sexes, occupations, motivational stages, and physical abilities. The major function of mApps, therefore, is to encourage and support consumers to adopt healthy behaviors (Free et al. 2013). Furthermore, mApps enable self-monitoring, health tracking, and creating social connection (Klasnja and Pratt 2012).

The need for technologies that promote physical activity behavior was a result of physical inactivity. According to the World Health Organization report, the lack of physical activity was related to 3.2 million deaths annually, which was the reason for increased mortality risk by 20–30% (World Health Organization 2009). In 2010, it was reported that one in four adults participated less than the recommended 150 min of moderate physical activity per week (World Health Organization 2010). In order to overcome this problem, public health researchers have been focusing on novel approaches to change physical activity behavior.

H. Kuru (✉)
Middle East Technical University, Ankara, Turkey
e-mail: hkuru@metu.edu.tr



E. Sezgin et al. (eds.), *Current and Emerging mHealth Technologies*,
https://doi.org/10.1007/978-3-319-73135-3_3

The impact of apps on changing the physical activity behavior is currently unknown (Yang et al. 2015). Besides, most apps have not been designed on grounded health behavior theories and evaluated using scientific methods (Cowan et al. 2013; Direito et al. 2014; Middelweerd et al. 2014). Thus, identifying the BCTs would illuminate the way of adopting mApps for modifying physical activity behavior. Besides, understanding the way of adoption will provide insight on developing and designing mHealth interventions. Physicians and practitioners who seek low-cost interventions would also benefit from the findings of BCTs used in mApps. This systematic review aimed to examine the use of behavior change techniques in smartphone apps that target physical activity based on an established taxonomy of behavior change techniques.

## 3.2 Background

To be successful in health behavior interventions and to maximize the effectiveness of mobile apps, we need to investigate the effective ways in development. To develop an understanding about how interventions work, Abraham and Michie (2008) studied the BCTs in their taxonomy by investigating different health behavior theories. For instance, the technique that *prompted specific goal setting* was derived from the control theory; or the technique that *provided information about others' approval* was derived from the theory of reasoned action, the theory of planned behavior, and the information-motivation-behavioral skills model. Therefore, in their taxonomy, a variety of health behavior theories were used (i.e., the theory of reasoned action, the theory of planned behavior, social cognitive theory, the information-motivation-behavioral skills model, the control theory, operant conditioning, and theories of social comparison) (Abraham and Michie 2008).

In their taxonomy, the theory of reasoned action proposes that the behaviors are under a person's control and the behavioral intentions predict the actual behavior (Fishbein and Ajzen 1975). Intentions are determined by two factors: attitude toward the behavior and beliefs regarding other people's support of the behavior. The theory of planned behavior explains the behavior as individual's perceived control over the opportunities, resources, and skills that are needed to be performed for affecting behavioral intentions (Ajzen 1991). Social cognitive theory explains human behavior as behavior change, which is caused by the interactions between the environment, personal factors, and attributes of the behavior itself. Also, self-efficacy is explained as one of the most important characteristics that determine the behavior change (Bandura 1997). The information-motivation-behavioral skills model mainly focuses on the cognitive domain by using the information to support behavior change. Control theory, being one of the motivational theories, states that behavior is stimulated by what individuals desire the most: survival, love, power, freedom, or any other needs (Carver and Scheier 1982). The operant conditioning theory focuses on changes in observable behaviors and explains that new or continued behaviors are impacted by new or continued consequences (Skinner 1974).

Theories of social comparison discuss how individuals evaluate their opinions and abilities by comparing themselves to others to reduce uncertainty in these domains and learn how to define the self (Berkman and Syme 1979).

## 3.3 Method

This study aimed to review the empirical literature on the behavior change techniques employed in mobile apps within the physical activity context. This systematic review started with searching combination of keywords: "behavior change technique-related keywords" AND "mobile application-related keywords" AND "physical activity."

More specifically, the keywords of behavior change techniques and mobile applications were combinations of the following: "behavior change" OR "behaviour change techniques" OR "behavior change techniques" OR "BCT" OR "BCT taxonomy" AND "mobile applications" OR "smartphone applications" OR "mApps" OR "mobile apps" OR "smartphone apps." EBSCOhost, Web of Science, and Google Scholar databases were used for the search. The literature research was conducted in August and October 2016. The articles included were only in English. The flowchart of the search process and refinement was given in Fig. 3.1.

### *3.3.1 Inclusion and Exclusion Criteria*

This review includes only the studies focusing on the BCTs used in mobile applications in the context of physical activity. This focus was decided after a preliminary search of the literature about health behavior theories and the efficacy of behavior changing in mobile applications. Reporting an analysis of the behavior change techniques in the context of mobile application development and grounding the method on a developed taxonomy were the main criteria for the study selection.

### *3.3.2 Coding of BCTs*

The selected studies used three different BCT taxonomies: the original Abraham and Michie's taxonomy, the CALO-RE taxonomy, and the behavior change technique taxonomy (v1) (Abraham and Michie 2008; Michie et al. 2011). The numbers and definitions of BCTs differed from each other in these taxonomies, and this led to inconsistencies when investigating differences of the BCTs. To achieve consistency, the first taxonomy of Abraham and Michie's original work, comprising 26 items, was chosen as the reference taxonomy, as shown in Table 3.1 (Abraham and Michie 2008). The reason for the selection of this taxonomy was that the other two

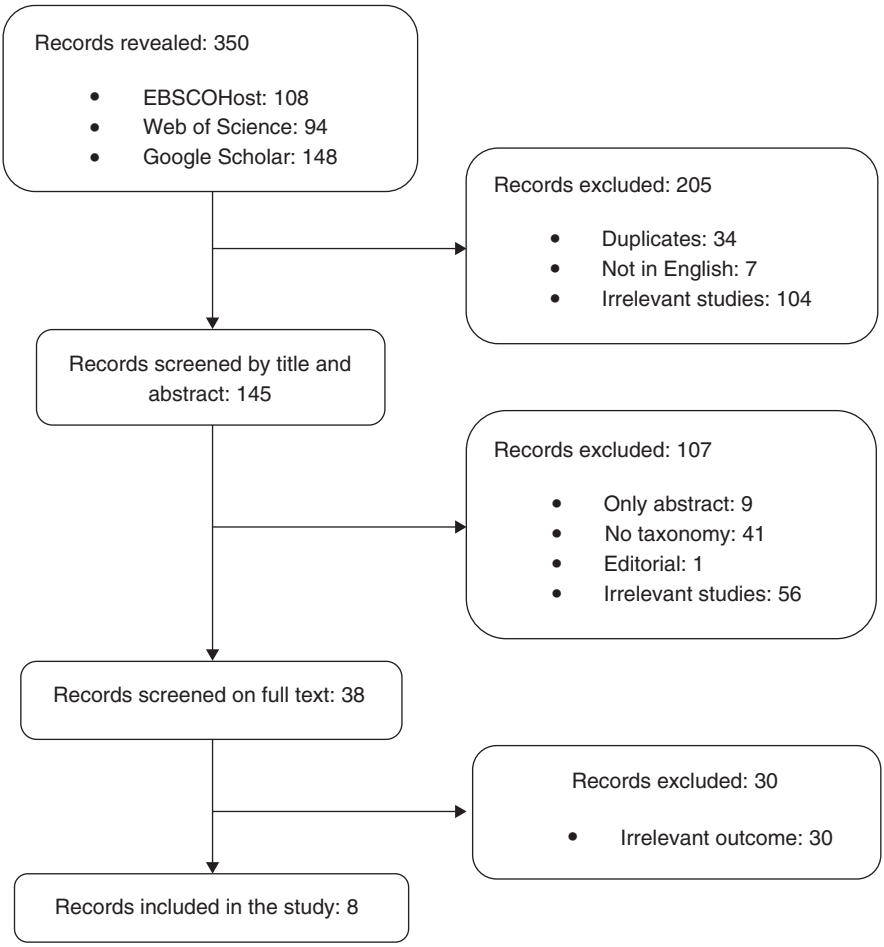


**Fig. 3.1** Selection of the studies

taxonomies, the CALO-RE taxonomy and the behavior change technique taxonomy (v1), were derived from this reference taxonomy and covered more items of BCTs. For example, the CALO-RE taxonomy includes 40 items, and the behavior change technique taxonomy (v1) lists 93 items. This indicates a challenge in terms of standardization. For example, in the CALO-RE taxonomy, technique *goal setting* was explained in two different ways: *goal setting (outcome)* and *goal setting (behavior)*. On the other hand, Abraham and Michie's first taxonomy defined *goal setting* in one item, covering both *goal-setting behavior* and *goal-setting outcomes*. Therefore, the first taxonomy, which is composed of a relatively fewer number of BCT items, was selected for coding.

In the next step, the 93-item taxonomy and 40-item taxonomy were coded in line with the 26-item taxonomy. For example, the techniques in 93-item taxonomy,