The Relationship Between attributes of mHealth App Acceptability and The Likelihood of Mhealth App Adoption in The 18–19-Year-Old College Freshman

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ABSTRACT

THE RELATIONSHIP BETWEEN ATTRIBUTES OF mHEALTH APP ACCEPTABILITY AND THE LIKELIHOOD OF mHEALTH APP ADOPTION IN THE 18–19-YEAR-OLD COLLEGE FRESHMAN

Celeste Rochelle, Ph.D.
College of Health and Human Sciences
Northern Illinois University, 2023
Beverly Henry, Director

Achieving the recommended amount of physical activity (PA) is linked to improved cognitive function, overall physical health, and protection against non-communicable diseases. However, most people surveyed in the United States do not meet the recommendations for PA; especially adolescents between the ages of 17-19. Evidence suggests that interventions for increasing PA must be considered acceptable before the individual will use them. This study explored the relationships between the attributes of acceptability of mHealth apps and adoption intention of mHealth apps in a sample of adolescents (n = 287).

Participants completed a survey with 24 total items: 19 from the Acceptability of Health Apps for Adolescents (AHAA) survey and five additional items assessing response efficacy and adoption intention. Bivariate correlations were completed between each subscale of the AHAA, response efficacy, and adoption intention followed by multiple regression. Correlation coefficients indicated that there were statistically significant relationships between self-efficacy ($\beta = .184, t(264) = 3.41, p < .05$), response-efficacy ($\beta = .209, t(264) = 3.51, p < .05$), attitude ($\beta$
= .392, t(264) = 6.43, p < .05), and adoption intention. The adolescents who demonstrated higher reports of self-efficacy, response-efficacy, and attitude reported an increased likelihood of app adoption for PA, with attitude most strongly predicting adoption intention. Results of this study may be beneficial for PA intervention efforts and mHealth app development for the adolescent population.
NORTHERN ILLINOIS UNIVERSITY
DEKALB, IL

MAY 2023

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ACCEPTABILITY AND THE LIKELIHOOD OF mHEALTH APP ADOPTION
IN THE 18–19-YEAR-OLD COLLEGE FRESHMAN

BY
CELESTE ROCHELLE
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A DISSERTATION SUBMITTED TO THE GRADUATE SCHOOL
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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DEDICATION

To every person finding a path towards complete health
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CHAPTER 1: INTRODUCTION

Background

The benefits of physical activity for mental and physiological health throughout the human lifespan are well-established and include improved physical and cognitive measures. Achieving the recommended amount of physical activity (PA) is associated with establishing protective factors against non-communicable diseases (NCDs), including cardiovascular disease and certain cancers (Piercy et al., 2018; Zhao, 2019). Recent research findings show that even small increases in PA help decrease all-cause mortality risk (Zhao, 2019). Unfortunately, the majority of people surveyed in the United States do not meet the current recommendations for PA, with the most significant decrease in activity levels occurring during adolescence, specifically between the ages of 17-19 (Armstrong et al., 2018; Guthold et al., 2020; van Sluijs, 2021).

Conventional methods of implementing PA in the daily lives of adolescents typically involve physical education classes or organized sports participation (Lowry et al., 2005; van Sluijs, 2021). Little research exists regarding adolescent use of mobile health (mHealth) applications (apps) as a resource for promoting PA. Adolescents are often the earliest and most rapid adopters of technology use, and 95% of high school aged adolescents own a smartphone or have access to one (Giavonelli et al., 2020; Pew Research Center, 2018a; Magis-Weinberg et al., 2021). Existing literature shows that mHealth apps have been successfully used by adolescents for chronic illness management, such as diabetes, HIV, and depression (Holtz et al., 2017;
Goldstein et al., 2022; Hammond et al, 2021; and Shin et al., 2019). Even though these statistics highlight the ubiquitous nature of mobile technology adoption and successful use for disease management in the adolescent population, most existing literature regarding app use by adolescents examines social media adoption and use (Dimock, 2019). While use of digital health interventions in the adolescent population has not been studied prolifically, the potential for exploration and research in this area is significant (Shin et al., 2019).

**Statement of the Problem**

Limited PA, sedentary behavior, and low cardiorespiratory fitness are strong risk factors for the development of chronic diseases with resulting morbidity and mortality, as well as economic burden to society and reduced occupational productivity (Kumar et al., 2015). The lifelong health risks involved with insufficient PA are also well established in the literature, thus reinforcing the need to investigate scalable and accessible means of facilitating PA, especially for adolescents. It is important to address PA practices in adolescents since adolescence has been shown to be a phase of life where health behaviors that track into adulthood are established (Winpenny et al., 2020). Another significant finding regarding PA in adolescents is that the amount of PA declines throughout adolescence and into young adulthood (van Sluijs, 2021). Thus, researching mechanisms that may influence an uptake in PA in the adolescent population is an important focus for public health.
Conceptual Framework

To understand how to facilitate PA, one strategy is to examine the use of mHealth apps by adolescents. It is necessary to first explore factors that influence mHealth app consideration and adoption. Sekhon et al. (2017) examined the concept of acceptability of health interventions as an antecedent to adoption and noted that the more acceptable an intervention is, the more likely it will be used, and the higher likelihood there is of the intervention being successful. In their research, constructs of acceptability were identified and defined as the theoretical framework of acceptability (TFA). Complimentary research by Zhang et al. (2017) suggested that empirical studies of users’ adoption behaviors is limited, especially regarding self-efficacy and response-efficacy. Chen (2019) highlighted the need for research of mHealth app use in adolescents and extended the concept of the TFA through development of a scale specific to the adolescent population. For the purpose of this research, a general definition of acceptability of mHealth apps will follow the definition established by Samkange-Zeem et al. (2015) and used by Chen (2018); the term acceptability refers to the extent to which intended users (adolescents) would use the health app in their everyday lives. Self-efficacy is defined as an individual’s perceptions about being able to regularly perform physical activity, to adopt and maintain regular physical activity even if the conditions are difficult, and to reinitiate it when lapses occur (Bandura, 1997). Response-efficacy is defined as the degree to which an individual believes that a recommended response is effective in averting a health threat (Rogers et al., 1983; Johnston & Warkentin, 2010).
In the study by Sekhon and colleagues (2017), the theoretical framework of acceptability (TFA) was operationally defined through seven component constructs: affective attitude, burden, perceived effectiveness, ethicality, intervention coherence, opportunity costs, and self-efficacy. The constructs were further described by Chen’s research (2019) in the development and use of the Acceptability of Health Apps in Adolescents Scale (AHAA), which resulted in self-efficacy being the most significant predictor of app use. Zhang and colleagues (2017) examined similar constructs of the AHAA in relation to participants’ adoption intentions regarding mHealth apps, but also measured response-efficacy. The study results showed that self-efficacy and response-efficacy were the most significant predictors of mHealth app use in an adult population.

Significance of the Study

Information gained from this study can be used to identify which factors of health app acceptability are the most influential on the likelihood of adolescent mHealth app adoption. In turn, health care providers and educators can use the evidence from this study to formulate interventions and educational methods targeted to the adolescent population for mHealth app adoption and use. Finally, the data from this research can further support the validation of the conceptual framework of the Theoretical Framework of Acceptability (TFA) and the Acceptability of Health Apps in Adolescents (AHAA) scale, as well as provide information regarding the relationship of response-efficacy to mHealth app adoption intention in the adolescent population.
Purpose of the Investigation

The purpose of this dissertation study was to explore and analyze the relationships between constructs related to the acceptability of and the intention to adopt mHealth apps for physical activity (PA) in the adolescent population. The research study was formed from established frameworks and theories, including the TFA and Social Cognitive Theory (SCT), which in turn influenced the use of a validated survey instrument and associated constructs to gather the data of interest. The data gathered is important for use in development of health related interventions for PA, specifically in the adolescent population. The information may also be useful for health technology advancement, which has been shown to be a feasible and scalable avenue for delivering public health interventions.

The existing literature examining mHealth app acceptability and use for PA promotion in the adolescent population is limited. Research by Sekhon et al. (2017), Chen (2019), and Zhang et al. (2017) has established an important set of operationalized definitions and constructs for mHealth app studies; however, there is still a lack of scientific research in mHealth app acceptability and use for PA promotion in the adolescent population. It is important to understand the unique contributions of the operationalized constructs of acceptability of mHealth apps for PA in this population.

Operational Definitions of Variables

Acceptability of health app use in adolescents (AHAA) is defined as the extent to which intended users would use a health app in their everyday lives (Samkange-Zeeb et al., 2015).
Using the framework of acceptability (TFA) established by Sekhon et al. as a guide to define the constructs associated with acceptability pertaining to health-related interventions, Chen developed the AHAA to quantitatively measure the constructs. The constructs were categorized into six domains: affective attitude, burden, ethicality, intervention coherence, perceived effectiveness, and self-efficacy. The final 22-item scale contained four response options coded from 1.00 to 4.00. Acceptability scores were calculated by taking the mean of responses within each of the six subscales and then totaling the six means. Higher scores indicated a greater likelihood of app acceptability; lower scores indicated the opposite.

*Self-efficacy* is defined as the participant’s confidence that they can perform the behavior(s) required to participate in the intervention (Sekhon et al., 2017). Self-efficacy was measured within the AHAA as its own domain with three questions scored from 1.00 to 4.00 and was analyzed as an explicit factor, then correlated with intention to adopt mHealth apps. This was done based on the importance of self-efficacy as a theoretical construct that is predictive in various health behaviors, including intervention adoption likeliness, especially in the adolescent population (Baker et al. 2014, Chen et al., 2022). The remainder of this dissertation will use the definition of self-efficacy as follows: the participant(s) confidence in their ability to use a mHealth app for PA.

Response-efficacy is defined as the degree to which an individual believes a recommended response will effectively avert a threat (Rogers, 1975; Witte, 1992). Response-efficacy was measured by three constructs developed through research and operationalized by Johnston and Warkentin (2012). Each question related to response-efficacy was also measured on a 1.00 to 4.00 scale. The remainder of this dissertation will use the definition of response-
efficacy as follows: the participant(s) belief that using a mHealth app for PA will prevent adverse health conditions.

Adoption intention is defined as a participant’s likelihood of adopting mHealth apps for physical activity. This construct was derived from research completed by Johnston and Warkentin (2010) and was measured on a 1.00 to 4.00 scale with three questions.

The remaining sub-scales of acceptability were also measured individually and cumulatively on a 1.00 to 4.00 scale, with the mean scores used for statistical analysis, including descriptive, correlational, and regression analysis.

Limitations of Study

A limitation of this research is that the subjects were all between the ages of 18 to 19, which means the generalizability of the findings to other adolescent ages is unclear. Another limitation of the study is the accuracy of self-reporting of the research participants, as it is possible that they over or under estimated their use of mHealth apps. An additional study limitation is the population sample consisted of freshman students at one midwestern public university, potentially limiting socioeconomic variability and the influence geographic location may have on participants’ PA levels due to weather or built environments. Finally, the study did not assess the actual use of mHealth apps by the participants but instead measured the intention to adopt mHealth apps in the next three months. A natural extension of this line of research would be comparing intention to adopt data with actual app for PA usage data.
Summary

This chapter introduced background information related to the lack of achievement of recommended PA in the adolescent population and the role of acceptability as defined by its sub-constructs and their predictive values regarding adoption of mHealth app use in adolescents to increase physical activity. A conceptual framework and related constructs were presented to explore the relationships between mHealth app acceptability, self-efficacy, response-efficacy and intention to adopt an mHealth app for PA. After introducing the purpose of this study, the chapter outlined research questions, significance, and limitations. Operational definitions were provided to help with the understanding of key concepts. The following chapter is an in-depth literature review examining the life phase of adolescence, the impact of physical activity (PA), factors that influence adolescents in PA participation, and the use of mHealth apps for increasing PA in adolescents.

Definitions of Terms

- **Adolescent**: Individuals between 10-21 years of age (WHO, 2015; Alderman et al., 2019).
- **Adolescence**: A developmental life stage marking the period from childhood to adulthood (Jaworska & MacQueen, 2015).
- **Application (app)**: Software programs on mobile devices that process data for their users (Maaß et al., 2022).
- **Affective Attitude**: How an individual feels about the intervention (Sekhon, Cartwright, & Francis, 2017).
• **Burden**: The perceived amount of effort that is required to participate in the intervention (Sekhon, Cartwright, & Francis, 2017).

• **Ethicality**: The extent to which the intervention is a good fit with an individual’s value system (Sekhon, Cartwright, & Francis, 2017).

• **Intervention Coherence**: The extent to which the participant understands the intervention and how it works (Sekhon, Cartwright, & Francis, 2017).

• **mHealth**: The use of mobile or wireless devices to support medical and public health practice (Ryu, S. 2012).

• **Perceived Effectiveness**: The extent to which the intervention is perceived as likely to achieve its purpose (Sekhon, Cartwright, & Francis, 2017).

• **Physical Activity**: Any body movement that increases energy expenditure, including activities of daily living, occupation, active transport, play, exercise, and sport (Kumar, 2015).
CHAPTER 2: REVIEW OF LITERATURE

Adolescent Health

Adolescence is a life phase marked by physical and cognitive development between childhood and adulthood. Adolescence is also when future patterns of adult health are established (van Sluijs, 2021). Self-regulation, described as the capacity to deliberately modulate one’s thoughts, feelings, or actions in the pursuit of planned goals, increases linearly and gradually during adolescence before plateauing in adulthood (Harden and Tucker-Drob, 2011). Before adolescence, the young child is dependent upon the care provider for food, health care access, safety, sleep environment, opportunity for exercise, and cues for learning self-regulatory behaviors (Mollborn and Lawrence, 2018). As children transition into adolescence, increased self-agency, decreased adult oversight, and increased peer influence contribute to health behavior choices. The time spent in adolescence is an opportunity for individuals to continue positive, protective health behaviors, acquire new health behaviors, and discontinue unhealthy practices. Enhancing positive health behaviors during adolescence suggests a greater likelihood of health behavior continuity into adulthood (Hoyt et al., 2012; Kumar, 2015).

There is not a universally agreed upon operational definition of adolescence. The Society of Adolescent Medicine (SAM) published a position paper in 1995 within which the recommendation was given for adolescent health research to include ages 10 to 25. The American Academy of Pediatrics (AAP) identifies adolescence as the ages of 11-21 (Hagan et al., 2017). The Center for Disease Control and Prevention’s Youth Risk Behavior Surveillance
System is constructed using a high school sample, grades 9-12, rather than age (CDC, n.d.). The World Health Organization (WHO) defines *adolescents* as individuals between 10 and 19 years (Alderman et al., 2019).

Just as there is no one standardized definition of adolescence, a variety of descriptors are used to define health. The Oxford dictionary defines health as: “the state of being free from illness or injury.” The WHO defines health as a state of “complete physical, mental and social well-being and not merely the absence of disease or infirmity.” The Centers for Disease Control and Prevention, along with a range of WHO partners, endorses this definition (WHO, n.d.). Each definition includes being free from disease or injury, yet the WHO definition emphasizes that health is more than being disease free or injury free. Thus, when considering health in the adolescent population, defining health domains may help direct research. Adolescent health can be described in the following five domains, as first designated in the *American Journal of Health Promotion* by O’Donnell in 1986. The most recent definitions are from 2017:

- **Physical health**: The condition of the body
- **Emotional health**: The ability to cope with or avoid stress and other emotional challenges
- **Social health**: The ability to form and maintain nurturing and productive relationships with family, friends, classmates, neighbors, and others
- **Spiritual health**: Having a sense of purpose, love, hope, peace, and charity
- **Intellectual health**: The necessary skills for academic achievements, career achievements, hobbies, and cultural pursuits. (O’Donnell, 2017)

While the literature indicates varying ideas concerning which domain of health is most important for adolescents, there is consistent agreement that physical health is a key focus for
public health initiatives. Public health initiatives include promoting protective behaviors such as exercise, nutritionally balanced eating, and avoidance of alcohol, tobacco, and other drugs. During the past twenty years, the World Health Organization (WHO) has emphasized the importance of focusing on adolescence as a unique phase of life to target health behaviors for improving health into adulthood. Increased autonomy as well as cognitive development that occurs during adolescence creates a unique opportunity within the life span to address the health factors identified by O’Donnell (2017). Thus, research focusing on behaviors related to physical health in adolescents is important.

One area of interest for public health interventions includes prevention of non-communicable diseases (NCDs). The global burden of NCDs such as obesity, type 2 diabetes, hypertension, and osteoarthritis is staggering in terms of quality life years and the negative economic impact (GBD 2017 Causes of Death Collaborators, 2018). Research has shown that many modifiable risk factors for NCDs start during adolescence, such as sedentary lifestyle, unhealthy food consumption, and smoking (Uddin et al., 2020). Thus, research focusing on the status of physical activity in adolescence is a promising avenue for public health interventions to improve protective factors of NCDs during this phase of life.

**Physical Activity and Physical Health**

The positive effects of physical activity (PA) are well established in the literature and include benefits such as improvement in physical, mental, and cognitive measures and reduction of risk for non-communicable diseases, such as cardiovascular disease, hypertension, and type 2 diabetes mellitus (Kraus et al., 2019). The World Health Organization (WHO) defined physical
activity as “all movement including during leisure time, for transport to get to and from places, or as part of a person’s work” (WHO, n.d.). In addition, WHO guidelines on physical activity and sedentary behavior were developed by using, and systematically updating, the evidence collated for the development of other recent national physical activity guidelines. The recommendations met the following three criteria: (1) the evidence reviews had been conducted according to standard and rigorous systematic processes that were well documented; (2) the assessment of the certainty of the evidence used the Grading of Recommendations Assessment Development and Evaluation (GRADE) method or an equivalent methodology that was clearly described and documented; and (3) the evidence reviews addressed the populations of interest with no restrictions to country or country income level. For these guidelines on children and adolescents, systematic reviews undertaken by the authors were used and updated (Bull et al., 2020).

The current recommendation by the World Health Organization is for children and adolescents (5-17 years) to engage in a daily average of 60 min of moderate-to-vigorous physical activity (MVPA) and for adults (18-64 years) to engage in a weekly average of 150-300 minutes of moderately intense or 75-150 minutes of vigorously intense activity (Bull et al., 2020). Despite recommendations, a survey conducted by WHO in 2018 found that only 1 in 4 adults meets the recommended amount of physical activity, with similar statistics in adolescents. Piercy et al. (2018) also published similar physical activity guidelines for Americans and includes directives for sitting less and moving more, with emphasis placed on the benefit of even small changes in activity; however, quantifiable measurements were difficult to discern. The physical activity guidelines (PAG) were compiled by a committee of academic experts in physical activity
appointed by the United States Health and Human Sciences Department. The committee evaluated, graded, and compiled recommendations from current literature relevant to physical activity. The analysis included answering 38 questions and 104 sub-questions the committee had agreed upon prior to reviewing current literature. A group of federal writers with expertise in physical activity and public health compiled the committee findings into the current PAG document. Similar to the recommendations published by the WHO, Piercy and colleagues determined that children and adolescents (ages 3-17) should participate in at least 60 minutes of MVPA daily. In addition, the American College Health Association uses the PAG established by the US Health and Human Services department for college age students (typically 18-22) that dwell in or commute to college campuses.

The association between increased levels of physical activity and improved observed and self-reported health measures in adolescents and adults is significant, including cardiovascular and metabolic health, bone health, and mental health (Mountjoy et al., 2011). Specific to research findings in the adolescent population, the health benefits of PA include the following: optimizing muscular strength and flexibility, maintaining healthy weight, developing cardiovascular health, developing neuromuscular awareness, benefitting cognition and mental health, mood, sleep, and academic attainment, and improving overall wellbeing and social behavior (Sibley, 2003).

While the health benefits of physical activity in adults and adolescents have been well researched, the accuracy of physical activity reporting is questionable. Typically, research in PA in adolescents involves self-reported measurement, which has shown low to moderate criterion validity of 0.3 and 0.4 (Chinapaw et al., 2010). A significant inconsistency exists between the
self-reported level of physical activity in adolescents, with 40% reporting they have met current PA recommendations, compared to only 25% of the same individuals meeting PA recommendations based on accelerometry data (Troiano, 2008).

An additional challenge exists with current research regarding adolescent PA, and that is the dominance of research in younger adolescents, ages 10-14. While the information from this age group is important, there still exists the need for quality research regarding PA in older adolescents, ages 15-19 (van Sluijs, 2021). Another factor that deserves delineation is that current recommendations for PA are for age categories from 5-17 and 18-64, with a significant change in recommended amounts of MVPA between the ages of 17 and 18 (from 60 minutes daily to an average of 150-300 minutes weekly). The significance of the change in PA recommendations at the age delineation of 17 to 18 is questionable, with no explanation offered in the literature. While the physiologic mechanisms including cardiorespiratory functions of humans between these ages is unremarkable, research findings show that cortical structure maturation and cognitive ability continues into the early 20s (Estrada et al., 2019), thus illustrating the need to further understand why PA recommendations differ so vastly in this age change.

**Determinants of PA in Adolescents**

The determinants of PA in adolescents were summarized in a systematic review of 27 studies (Uijtdewilligen et al., 2011). Insufficient evidence was found for a longitudinal association between parent education and PA in their children; moderate evidence was found for a longitudinal association between intention and PA, where *intention* meant the participant’s plan
to be PA. Older age in adolescence, ethnicity (besides being African American), and planning were considered positive determinants of PA. A well-researched determinant of PA in adolescents included the role of self-efficacy, which is defined as an individual’s perceptions about being able to perform physical activity regularly, to adopt and maintain it even if the conditions are difficult, and to reinitiate it when lapses occur (Bandura, 2001). Bandura postulated that self-efficacy and social support are among the key determinants of physical activity, and a more recent review of reviews supports this assumption for adolescents (Sterdt, Liersch, and Walter, 2014).

A recent analysis of PA in adolescents using mobile health (mHealth) technologies was conducted in a scoping review (Lee et al., 2019). The review included a total of 16 studies of participants ranging in ages 12-18 and included PA related outcomes and five mHealth intervention categories: website, website and wearable device; app; wearable device and app; and website, wearable device and app. Three of the studies revealed an objective improvement in daily moderate to vigorous PA (MVPA), subjective weekly PA, and the number of days per week of 60 min of PA. While there was not significant improvement of PA throughout all the studies, the majority of participants did increase PA during study participation.

The use of mobile health technologies has been researched in several areas of health behavior, including dietary interventions for weight loss. Harris et al. (2011) concluded that interventions via mHealth for changes in dietary behavior do not produce clinically significant changes. However, Davies et al. (2012) concluded that mHealth interventions targeting PA with inactive participants significantly improved PA in the short term (Cohen d effect size 0.14), though long-term maintenance of PA, engagement, and retention of participants was
problematic. A review of literature by Lau et al. (2011), specifically focused on mHealth interventions among children and adolescents, with 7 of 9 such interventions significantly improving PA.

While research of the use of mHealth and PA in adolescents is not prolific, it is important to note the need for further exploration of the topic. Small effect sizes do not relate to the impact that mHealth may have as a public health intervention with adolescents and PA; thus, continued research on the use of mHealth in this population is warranted. For instance, if adolescents are more physically active while using an mHealth app but do not meet recommendations for daily activity, the increase in activity is still beneficial, even though the effect size of the study may not be substantial (Kumar, 2015). It is also a feasible and natural association to consider the use of mHealth interventions with adolescents due to the accessibility of the internet and high level of ownership of mobile technology by adolescents. Finally, adolescents are credited with being the earliest and most prolific adopters of technology, which includes mobile technology and associated platforms (apps, websites, social media) (Pew Research Center, 2018b). These factors contribute to the need for further research in mHealth app adoption by the adolescent population.

The search for current (2016-2022), peer-reviewed articles was conducted via the online library. These databases included PubMed, ProQuest Digital Dissertations, ProQuest Nursing & Allied Health Source, Cochrane Library, MEDLINE, Nature, EBSCO, Science Direct, Scopus, and the Wiley Online Library. Google Scholar was also utilized to locate open access articles. The following search terms were used to locate articles specific to this study: adolescent, adolescence, physical activity, physical activity guidelines, mHealth, mHealth apps, mHealth app
acceptability, and adoption intention, Variations of these terms were used to ensure exhaustive search results.

**Physical Activity and Adolescents**

Current statistics show that there are 1.8 billion adolescents aged 10-24; this is approximately 25% of the world’s total population (Sawyer et al., 2012). A sample of this population’s self-reported health is summarized in the 2017 Youth Risk Behavior Surveillance Survey (YRBSS). High school students in grades 9-12 in the United States were selected through a three-stage cluster sample from 144 schools, for a total of 14,765 usable questionnaires (Kann et al., 2018). The results indicated that 46.5% of students attained 60 minutes or more of PA that increased heart rate and made breathing more challenging at least 5 days per week. Males comprised 56.9% of this group, with females accounting for 36.8% of the total. The survey also included statistics that showed a steady decline in attaining 60 minutes of physical activity in all genders and races from grade 9 to grade 12, with an overall decrease from 54.1% to 41.4%. Theories for the decrease in PA from grade 9 to 12 were not included by the authors.

**Self-reported Outcomes of Physical Health Related to PA**

A cross-sectional survey study by Herman et al. (2015) of 7725 Canadian adolescents (ages 12-17) measured self-rated physical and mental health, screen time, and physical activity via a tool by which participants rated their health sub-optimally (good, fair, or poor), versus optimally (excellent or very good). The high PA group, categorized by self-estimates of using >3kcal/kd/day, reported good health status in 78% of participants compared to 62% of controls,
with no significant difference between genders (P values < 0.001). Conversely, adolescents in this study exceeding 2 hours/day of sedentary time (sitting or reclining posture) had 30% greater odds of sub-optimal self-reported physical health.

A cross-sectional and longitudinal study of 2353 Australian adolescents with a mean age of 12.7 years were surveyed by Gopinath et al. in 2012; after attrition, 1216 of the initial group were resurveyed 5 years later. The survey measured the frequency and duration of outdoor, non-sporting activities and health-related quality of life, and was assessed using the Pediatric Quality of Life Inventory (PedsQL) (Varni, Seid, & Kurtin, 2001). The respondents that reported >2.57 hours total of physical activity a day were in the top tertile, or 3.15 points higher than those in the lower PedsQL lowest tertile (P Values for trend is 0.004), supporting the correlation between physical activity and quality of life.

A study of 3040 Australian adolescents (age range 11.4-18.3; mean age = 14.6), by Lacey et al. (2011), used a physical activity measurement over a five-day period; high PA level was categorized as playing active games during school breaks or participating in PA after school all 5 days of the school week. The PedsQL 4.0 measurement tool was also used by the participants. Boys with high PA scored 3.62 points higher on the PedsQL than their least active counterparts (P values < 0.001); girls with high PA scored 4.08 points higher than their least active counterparts (P values < 0.001).

In contrast, research by Boyle, Jones, & Walters (2010) concluded that there was not a statistically significant relationship between exercise levels and self-reported health status. Self-reported measurement of PA occurred in 1771 English adolescents with an age range of 11-15 years (mean age = 13.2) with health status measurement using the PedsQL 4.0. The high PA
group (≥ 7 hours of moderate to vigorous PA/week) scored -1.5 points lower on the PedQL than the control group.

Additional findings that contradict the literature regarding insufficient PA in adolescents were recently published by the American College Health Association National College Health Assessment. In spring 2022, researchers surveyed 29,131 college students in the United States. The participants were enrolled in college courses and either lived on or commuted to college campuses and included 1st year undergraduates through Doctorate level students. The results of the survey included the following: 68.7% of all respondents achieved the recommended amount of aerobic exercise; 42.9% achieved the recommended amount of strength training and aerobic activity; and 33.9% achieved twice the recommendation for aerobic activity and met the recommendations for strength training. The definitions of recommended activity guidelines provided to the respondents were based on the US Department of Health and Human Services Physical Activity Guidelines for Americans, 2nd edition, and are as follows: Recommendation for aerobic activity is 150 minutes or more of moderate-intensity physical activity per week, or 75 minutes of vigorous-intensity physical activity, or the equivalent combination; recommendation for strength training is 2 or more days a week of moderate or greater intensity activities that involve all major muscle groups. Active Adults met the recommendation for strength training and aerobic activity. Highly Active Adults met the recommendation for strength training and twice the recommendation for aerobic activity (300 minutes or more of moderate-intensity physical activity per week or 150 minutes of vigorous-intensity physical activity or the equivalent combination). Respondents’ activity levels were self-reported.
Objective Reports of Physical Health Related to PA

Weston et al. (2016) conducted an exploratory controlled before-and-after study with 101 adolescents from four schools in the United Kingdom (n = 41 for intervention; n = 60 as control) (mean age 14.0 ± 0.3 years). The intervention required participants to complete 4 to 7 repetitions of 45 second maximal effort exercise interspersed with 90 seconds of rest three times weekly for 10 weeks. Cardiometabolic factors were measured pre- and post-intervention. Measured factors included non-fasting blood lipids, glucose, and resting blood pressure. Significant findings included a reduction of -26% of triglycerides (90% confidence interval -46% to 0%) and reduction of waist circumference (-3.9 cm; CI -6.1 cm to -1.6 cm).

A study published in 2018 by Marin-Puyalto analyzed the relationship of vigorous physical activity and healthy bone development in 140 healthy male adolescents between the ages of 11-13 years. Baseline x-rays of the hip and lumbar spine were taken twice at a 1-year interval between measurements, and one-week accelerometry registers were completed for each participant. The individuals with the highest levels of PA as measured by accelerometry were noted to have the most significant femoral neck and lumbar spine bone mineral density of 0.066 with a 95% CI (0.047-0.085) versus 0.034 (0.021-0.047) g/cm² in the low PA participants (p < 0.05). Generally speaking, bone density is directly related to bone strength, which largely determines a bone’s susceptibility to fracture. Thus, the inference may be made that the group of high PA level and higher bone mineral density are less susceptible to fractures.
Physical Activity Studies in Older Adolescents

While there is a paucity of research regarding PA levels in the 18-19 year old population, other closely related studies revealed the positive correlation of adequate PA to diminished anxiety and depression and improved sleep quality. In a survey-based study of 617 college students ranging from 18-30 years of age in New Delhi, India, participants that reported moderate to high PA levels, showed significantly and inversely associated scores for anxiety (OR = 0.16 and 0.96; \( p = 0.001 \)) and for depression (OR = 0.11 and 0.96; \( p = 0.001 \)) (Ghrouz et al., 2019). The study results support the benefits of MVPA as a protective factor against anxiety and depression.

Memon et al. (2021) conducted a systematic review and meta-analysis of 29 studies with a total of 141,035 participants (43% men and 57% women). A random-effects meta-analysis showed that moderate-to-high intensity PA was associated with better sleep quality \([r = -0.18, 95\% \text{ CI } (-0.37, 0.03), p = 0.100]\); however, the study results did not quantify the age of the participants nor the amount of PA for those reporting adequate levels of MVPA. While the findings of this review were derived from cross-sectional investigations with predominant use of self-reported measures, they further justify the benefit of PA in the older adolescent population.

Uddin et al. (2021) performed a study of 18 to 24 year old university students in Bangladesh to identify correlates of changes in PA and sedentary behavior (SB) in a 1-year prospective study with 2 assessment points (analytical sample = 395). Changes in PA were categorized as: negligible ( < 60 min/week), > 60 min/week decrease, or > 60 min/week increase. Changes in SB were categorized as negligible ( < 60 min/week), >60 min/week decrease, and >
60 min/week increase. Multinomial logistic regression analysis was used to identify the correlates. About three quarters (72%) of participants had insufficient PA at both assessment points. Of those who were sufficiently active at Wave 1, 5% became insufficiently active at Wave 2. One quarter of participants (23%) had high SB at Wave 1 and Wave 2. Of those who had low SB at Wave 1, 16% had high SB at Wave 2. Being male [OR ¼ 2.04 (95% CI: 1.06–3.93)], baseline phone time of > 2 h/day [OR ¼ 3.14 (95% CI: 1.04–7.04)] and not participating in organized sports at baseline [OR ¼ 2.56 (95% CI: 1.24–5.29)] were characteristics associated with a decrease in PA by > 60 min/week. Participants who frequently experienced stress at baseline had higher odds of increasing SB by > 120 min/day [OR ¼ 1.83 (95% CI: 1.04–3.23)]. The study results highlight correlates associated with decreased PA and increased SB, which is another important contribution to the literature on PA in older adolescents.

A recent study cross-sectional study (Cuenca’s Adults Study) involving 296 female Spanish university students aged 18-25 years old assessed total PA through data gathered by the ActiGraph GT1M accelerometer for seven consecutive days. Only 30.3% of participants accumulated 30 min/day at least five days a week of MVPA. A total of 5.4% of participants met the recommendation of 150 minutes/week of MVPA or 75 min/week of vigorous PA (Arias-Palencia et al., 2015). The authors of this study noted that while there was a high incidence of sedentary time in the participants, the number of students meeting PA recommendations significantly differed depending on the recommendation proposed by agencies including the WHO, US Department of Health and Human Services, or the British Association of Sport and Exercise Sciences (BASES).
Summary

Within the literature reviewed, consistent findings included the following: There was an increase in the amount of daily PA in most participating adolescents using mHealth apps, and increased PA diminished after completion of study participation. These findings indicate a potentially important research need, which is exploring the acceptability, adoption, and use of mHealth apps for improving PA. It is important to reiterate that most studies found regarding PA and mHealth app use were performed in younger adolescents (< 18), whereby the studies related to PA in older adolescents were typically correlative studies measuring PA and mental health and sleep.

The definition of optimal health in the adolescent population as described by O’Donnell elucidates the concept that health is not unidimensional, nor can it be defined by one standardized outcome measure. One of the more standardized and objective measures of health is related to physical health. While multiple studies report the correlation between physical activity and physical health, the impact of mHealth interventions and PA in adolescents is still in the nascent phase. This line of research may be valuable when considering physical health in adolescents, especially factors that are known to be influential in the development and/or prevention of non-communicable diseases (NCDs), including obesity, hypertension, and type 2 diabetes. Opportunities for prevention of non-communicable diseases occur during adolescence due to health-related behaviors that begin during this life phase, including obesity and physical inactivity (Beaglehole et al., 2011).
While there is empirical evidence to support mHealth use for PA in the adolescent population, gaps in research include the following: accurately measuring PA in adolescents, the use of mHealth apps for adoption of PA in adolescents, and key factors in acceptability of mHealth app adoption. For adolescents to use mHealth apps for facilitation of PA, they must first find the use of an mHealth app acceptable, then adopt and use the app. Analyzing these steps of adolescents using mHealth apps is an area of research that is relatively new and is not extensive.

**Trends of PA in Adolescents**

The primary settings in which adolescents participate in PA include active transport, such as bike riding, (AT), organized sports, school physical education (PE) participation, and PA during school play periods. Studies of physical activity among adolescents revealed inconsistent magnitudes of change over the last few decades (Booth et al., 2015). One reason for the variance could be that most studies consisted of self-reported amounts of physical activity, which typically reported individuals’ overestimation of the time spent performing PA (Dhurandhar et al., 2015). Methodological inconsistencies and a lack of use of specific PA contexts in research creates a significant gap in the literature and opportunity for focused research in the adolescent population.

It is commonly understood that PA habits established in early life continue into adulthood. Research evidence corroborates this in a review of 4 longitudinal studies by Craigie et al. (2011) that demonstrated the relationship of PA behaviors established in childhood and adolescence tracking into adulthood. Data showed males participating in sports 2-3 times a week at age 14 being 3.2 times as likely at age 31 to be physically active. For females with similar PA
in early adolescence, the odds ratios for later PA habits were also increased (though less than males) at 1.5. It may be important to further research regarding when and where PA in adolescence occurs regarding environment and context; it would also be worthwhile to explore factors that facilitate or impede PA, study temporal trends of PA, and target interventions for PA promotion.

One of the largest studies with objective outcome measures related to PA was completed by Tomkinson et al. (2019). The authors examined the temporal trends in cardiorespiratory fitness (CRF) in children and adolescents from 19 high-income and upper middle-income countries between 1981 and 2014. Data was compiled from 965,264 healthy children and adolescents aged 9-17 years, specifically using studies that reported a 20m shuttle run test. After the estimation of relative peak oxygen uptake (mL/kg/min) as a measure of CRF, sample weighted temporal trends were estimated at the country-sex-age level using best-fitting linear or polynomial regression models relating the year of testing to mean CRF. Post-stratified population-weighted mean changes in absolute and percent CRF were estimated. Pearson’s correlations were used to describe the association between linear temporal trends in CRF and broad socioeconomic and health-related indicators. Collectively, there was a moderate decline of CRF of 7.3% (95% CI -7.8% to -6.7%) over the 33-year time period. Notably, countries with lower levels of income equality demonstrated a larger decline in CRF, whereas countries with closer income equality had less of a decline. The overall trend of a decrease in CRF in children and adolescents indicates the likelihood of diminished population health. While this study analyzed an extremely large data set, it did not include data from low or middle-income
countries, which is necessary to further inform public policy makers and health care providers of actionable strategies for addressing CRF and PA in adolescents and children.

Examining the daily activities of adolescents can indicate how they occupy their time. Adolescence is typically a life phase involving formalized education and opportunities for participating in organized sports and/or employment. A study by Hardy et al. (2010) showed that adolescents spend an average of 35 hours per week at school, making it a potentially optimal place to meet physical activity recommendations. However, several studies note a decrease in days of PE provided for students in the United States. For example, a 21% decrease in boys’ and 7% decrease in girls’ participation in daily PE was noted among 14,000 students between 1981 to 2003 (Lowry et al., 2004). A more recent statistic compiled in the Youth Risk Behavior Surveillance from 2017 (Kann et al., 2018) showed that 72.9% of high school students reported that they did not engage in the recommended 60 or more minutes of daily PA, whereas 45% reported spending three or more hours daily using a computer/electronic device and sitting for non-school work activities.

While temporal trends showed a steady decline in adolescent PA in the past ten years, the recent Covid-19 pandemic and resulting social distancing and lockdown requirements merit examination on the impact to daily living activities around the world. Bates and colleagues found that normal opportunities for physical activity were significantly decreased, particularly those related to recreation, transportation, work, and school (2020). A recent study examining PA in adolescents during the Covid-19 pandemic showed a notable decrease in PA and an increase in sedentary behavior (SB) compared to pre-Covid-19 levels. Dunton et al. (2020) compiled results from a convenience sampling of 325 parents with children ages 5-13 living in the United States.
during the Covid-19 pandemic. Parents reported their child’s previous day’s PA and SB using the “Active Where” survey instrument (Carlson et al., 2012), which includes 11 types of common non-school based PA and 12 common types of non-school-based SB for children. Duration in each activity was reported. The Youth Compendium of Physical Activities was utilized as a guide to calculate metabolic equivalents (METs) for PA completed, with a calculation completed for METs expended in each activity. Parents were asked to indicate how similar their child’s daily level of PA or SB respectively was compared to the prior 7 days. Parents were also asked to compare their child’s current levels of PA and SB to the pre-Covid-19 period, specifically to activity in February 2020. Response options were reported on a 5-point Likert-type scale. Findings from researchers’ analysis of a total of 211 surveys (65% response rate) included a daily average of 892.0 MET-minutes per day of PA and 489.4 minutes of SB. A total of 36% of parents reported their child had done much less PA in the past 7 days as compared to February of 2020; 11% of parents reported an increase in their child’s PA as compared to February 2020. A total of 41% of parents reported that their child had done much more sitting in the previous 7 days; 6% reported less sitting in the previous 7 days compared to February 2020.

While no data was available to directly compare daily METs of participants prior to the Covid-19 pandemic, using the parent perception of PA and SB pre-and-post-Covid-19 period allows for a general assumption that PA decreased and SB increased significantly due to changes in the patterns of daily living. Another notable finding of the study is the increased participation of children in PA through remote or streaming services (online classes for PA). Prior to the pandemic, children and adolescents did not regularly participate with online technologies for
sports or activity classes, possibly due to the built-in opportunities for sports and physical activity while attending school. However, the study by Denton showed that nearly 41% of children participated in online sports or activity classes during the early-Covid-19 period because of quarantine requirements and cessation of group gatherings for in-person sports classes.

Given the temporal trends of decreased PA and increased sedentary time, rising concern exists about the potential contributors of decreased health status. Thus, it is important to describe why adolescent PA levels have decreased over time and focus research on contemporary avenues of opportunity that help facilitate physical activity. A promising path for this is the use of online programming that is age appropriate for adolescents.

**Mobile Health**

Mobile health (mHealth) is defined as the use of mobile or wireless devices to support medical and public health practice (Ryu, S. 2011). For example, individuals using wireless devices can use applications (apps) that include encouragement and monitoring of health-related information. Several research studies noted that mHealth apps are successfully used to monitor glucose levels in individuals with diabetes, antiretroviral medication adherence, and asthma control (Free et al., 2013; Marcolino et al., 2018). However, research results of the effectiveness of mHealth for facilitating PA in adults were nonsignificant. One systematic review revealed no impact on PA outcomes (Stephens et al., 2013), and one meta-analysis showed a moderate effect on step counts (Fanning et al., 2012). There could be different reasons for the lack of definitive findings. For example, the lack of consistency in results could be contributed to low app quality and lack of capturing accurate PA data. Also, app creators are not compelled to meet evidence-
based criterion, including application of theoretical models of behavior change as relevant to physical activity participation. It may be inferred from other health promotion initiatives that for an app to facilitate PA in an adolescent, the app would ideally be designed with behavior change theories established in this population. Another factor could be that apps also rely heavily on self-reported data collection as the measurement for the user; therefore, inaccurate reporting may occur.

To date, one scoping review described adolescent use of mHealth to facilitate PA (Lee et al., 2019). Using the methodology proposed by Arksey and O’Malley (2005), the following 5 stage process occurred: (1) research question identified, (2) relevant studies identified, (3) studies selected, (4) data charted, and (5) results collated. Of note, the main purpose of a scoping review is to identify information that is relevant to a broad research question, whereas a systematic review seeks information for a specific research question and requires an assessment of evidence quality.

In the scoping review, Lee et al. (2019) categorized sixteen studies according to the mHealth components used by the subjects: app, wearable + app, website, website + wearable, and website + wearable + app). Interventions for increasing PA were variable, with activities such as walking and strength training. Measurement processes, along with subjective reports of minutes spent performing PA and objective reports of step count and MVPA, were captured by the wearable devices. Due to the variable methodology of each study, a direct comparison of increase in PA for each modality was not feasible. However, in 12 of the 16 studies, a general improvement in PA outcomes occurred over time, with length of studies varying from 6 weeks to 24 weeks.
As with any health intervention, for a successful outcome to potentially occur, the intervention must be accepted by the participant to engage in the intervention (Sekhon et al., 2017). Health intervention delivery and participation through traditional delivery models, such as face to face sessions between care providers and patients, has been well studied. In this scenario, the term acceptability was established as the preferred terminology for both the recipient and the provider of the intervention. However, there has been a lack of agreement on a singular definition of acceptability, with most research focusing on a few attributes, such as the attrition rate of the recipient participating in the intervention and how they felt about the intervention (Ben-Zeev et al., 2014; Holloway et al., 2014; Mullen, Berry, & Zierler, 2004). To advance the field of research in mHealth acceptability, it is necessary to reach agreed upon constructs defining the term and create a theoretical framework that guides the formation of research questions and methods (Sekhon et al., 2017).

**Theoretical Frameworks**

In an effort to create a commonly accepted definition of acceptability, a recent study by Sekhon et al. (2017) analyzed 43 systematic reviews both inductively and deductively to identify constructs relating to acceptability of health interventions. Their work resulted in identifying seven constructs applicable to acceptability, including affective attitude, burden, perceived effectiveness, ethicality, intervention coherence, opportunity costs, and self-efficacy. Definitions are as follows:

- **Affective attitude**: How an individual feels about the intervention.
- **Burden**: The perceived amount of effort that is required to participate in the intervention.
• **Ethicality**: The extent to which the intervention has good fit with an individual’s value system.

• **Intervention coherence**: The extent to which the participant understands the intervention and how it works.

• **Perceived effectiveness**: The extent to which the intervention is perceived as likely to achieve its purpose.

The constructs that emerged allowed the authors to conceptualize and operationalize the term *acceptability*. The Framework of Acceptability (TFA; Figure 1) was established from the review and is meant to be used in prospective, retrospective, and active use of health interventions for intervention recipients and providers. However, the TFA was not developed through evaluation of mHealth interventions, nor was it specific to the adolescent population.

![Figure 1. The Framework of Acceptability](image-url)
The TFA is the first known framework to address acceptability of health interventions. However, it was not developed with the consideration for age-specific factors of adolescents or with the use of mHealth apps. Therefore, to extend this line of research, Chen et al. (2019) operationalized, defined, and extended the existing constructs of the TFA and developed and validated a scale measuring the acceptability of health apps among adolescents (AHAA). The original 22 item scale was adapted for the purpose of my research. In the development of the AHAA, Chen noted that the construct of self-efficacy was the most predictive in an individual’s acceptance of using an mHealth app (Appendix A).

Similar research conducted by Zhang et al. (2017) focused on efficacy factors in individuals’ mHealth adoption decisions. The efficacy factors included response-efficacy and self-efficacy. Response-efficacy was defined as an individual’s assessment of the effectiveness of proposed behavior, and self-efficacy was defined as the perceived ability to conduct the behavior. In Zhang and colleague’s research study, the constructs and their items were adapted from research performed by Johnston and Warkentin (2010), within which self-efficacy and response -efficacy with computer use was analyzed. Similar to the research completed by Sekhon (2017), the findings of the study by Zhang et al. (2017) included self-efficacy and response-efficacy being equally predictive of an individual’s acceptance of mHealth adoption.

Summary

The limited research of adolescent PA and use of mHealth over the last decade produced inconsistent findings. Direct comparisons of research studies are difficult to achieve due to the lack of research in adolescent PA and inconsistent methodologies used in existing studies. For
example, the length of studies varied from 8 weeks to 24 weeks, the age of participants ranged from 11 to 24, and the location of the studies ranged from school-based to home-based. It is also notable that few research studies featured in this proposal used or described theoretical frameworks related to adolescent PA and technology use or theoretical frameworks relevant to behavior change or health beliefs. This is an important gap, as it is well known in health research that the most successful interventions and studies are based on established theoretical frameworks (Sekhon et al., 2017). Finally, it was evident that there is not an agreed upon operational definition for several constructs in the research studies, and that limits comparisons. Variable constructs included adolescent age span, type of PA, or inclusion criteria for mHealth apps being used.

An additional significant finding of this review of research studies is the decrease in PA of adolescents over time. When considering the importance of PA for overall health benefits, identifying when PA decreases on a temporal span may indicate opportunities for targeted interventions. Furthermore, applying and adapting theoretical frameworks relevant to PA and mHealth to the adolescent population can help progress the nascent nature of the constructs and frameworks that will be useful in adolescent PA research.

The proposed use of the TFA and AHAA for research in the adolescent population may help extend the validity of each framework. While each framework illustrates factors to evaluate for mHealth acceptability in adolescents, it is important to note that adolescent use of technology and mobile apps is different than in adults (Pew Research Center, 2018b). Therefore, what is thought to be acceptable for mHealth use in adults may vary in adolescents. Neither the TFA nor AHAA is well evaluated in the adolescent population, thus indicating a gap in the research. In
addition, examining the role of response efficacy as an additional construct to the AHAA and the relationships that exist regarding mHealth app adoption intention is novel. My line of research is grounded in the TFA, which is an established theoretical framework and uses the AHAA, which is a survey instrument designed specifically for measuring the acceptability of health apps in the adolescent population.
CHAPTER 3: METHODS

Overview

The purpose of this study was to examine relationships between response-efficacy, constructs related to mHealth app acceptability, and the likelihood of mHealth app adoption in older adolescents. The first chapter of this dissertation introduces this study’s topic, and the literature review in the second chapter includes information about the current state of adolescent PA, risks associated with low PA in this population, and the lack of use of mHealth apps for PA by adolescents. While some evidence exists regarding the use of mHealth apps in the adolescent population, there is a gap in the literature regarding the factors that influence mHealth app adoption and use. This study provided the potential for discovering information pertinent to adolescents accepting and using mHealth apps. In turn, the information gained may provide guidance for intervention recommendations for using mHealth as a resource for PA in adolescents. The following section includes the outline of the research design and research questions, the hypotheses, population and sampling procedures, instrumentation, data collection procedures, and data analyses.

Research Design

This quantitative study used cross-sectional survey design to obtain data measuring the descriptive variables of mHealth app acceptability, response-efficacy, and adoption intention for mHealth app use for physical activity in adolescents. A correlational approach was used to
examine the relationship between the variables (Creswell, 2014). Data collection occurred at a single time point and was administered through an electronic survey, which was completed by the participants on a mobile device or computer. The survey consisted of questions selected from the Adolescent Health App Acceptability instrument (Chen, 2019) and from the constructs of response-efficacy and the construct of intention to adopt from Johnston and Warkentin (2010). Due to the high rate of mobile device ownership, as well as the access to computers during class hours, electronic survey delivery was chosen for use in the study population (Schaefer, 206). Participation and survey results were confidential. A tailored design approach as described by Dillman (2009), was used in the study design and delivery to facilitate an enhanced response rate. The results of this dissertation study may inform further development of frameworks used to guide the use of mHealth apps with adolescents.

**Research Questions and Hypotheses**

The three research questions that directed this study were the following:

1. What relationship exists between mHealth app acceptability (measured by the Adolescent Health App Acceptability scale [AHAA] Questionnaire) and response-efficacy (measured by constructs validated by Johnston and Warkentin (2010) in a sample of adolescents?

2. What relationship exists between response efficacy and intention to adopt mHealth app(s) for PA?

3. Among factors associated with mHealth app acceptability (measured by the Adolescent Health App Acceptability scale [AHAA] Questionnaire) and response-efficacy (measured
by constructs validated by Johnston and Warkentin (2010), is one most significantly correlated with intention to adopt mHealth apps among a sample of adolescents?

The hypotheses were as follows:

- Acceptability of mHealth apps is positively associated with response efficacy among adolescents.
- Response-efficacy is positively associated with intention to adopt mHealth apps among adolescents.
- Response efficacy is the greatest predictor of mHealth app adoption intention.

**Population and Sampling Procedures**

Evidence suggests that four out of five adolescents do not achieve the level of recommended PA each week (Hayes et al., 2019). Research exists that identifies barriers to adolescent participation in PA. However, little evidence exists regarding the adoption and/or use of health apps as an intervention to help increase PA in adolescents. Finally, there is a gap in the literature examining the factors that influence adolescents in the adoption and/or use of mHealth apps, especially in the older adolescent population. Therefore, in an effort to gain information on factors that influence adoption of mHealth apps, the population for this study consisted of 18-19-year old adolescents who have access to smart phones or computers.

The population for this study consisted of adolescents ages 18-19 attending a midwestern university. Convenience sampling was used to select study participants. Freshman students at the selected university received an email invitation to participate in the study; the invitation was
distributed through Clearinghouse services, which coordinated with the registration and records department. The demographic range of the students chosen to participate in this study are representative of the demographic variability of freshman college students in the United States. Inclusion criteria included enrollment as a college freshman at the university, being within the ages of 18-19, accessibility to a smart phone or computer; and ability to read at a 7th grade level. Exclusion criteria included inability to access computer or mobile technology, having identified as unable to read, or affliction of a communication disorder that would prohibit answering survey questions.

A priori power analysis of multiple linear regression using G*Power 3.1 software program (Faul et al., 2009) with a medium effect size of 0.15, statistical power level of 0.80 and probability level of 0.05 with 8 predictors (6 from AHAA scale, age, and sex), recommends a minimum sample size of 109 participants. A medium effect size was based on Cohen’s (1992) research and statistical power at 0.80 and probability level at 0.05, due to its use as the minimum level in research studies (Pallant, 2016).

**Instrumentation**

Participants were invited to complete a 24-item survey (Appendix C). The survey included questions established from constructs established by the TFA and AHAA (Sekhon et al., 2017 and Chen, 2019) related to attitude, burden, ethicality, intervention coherence, and self-efficacy. Other questions used in the survey were related to the constructs of response efficacy and adoption intention established by research from Johnson and Warkentin (2010) and Venkatash (2008). The survey began with specified inclusion criteria, which was being among
the 18-19 year age group, enrollment as a student at the selected university, access to a smart phone or computer, and ability to read at a 7th grade level. Basic demographic questions were included next and then followed by 24 questions arranged by specific construct. Participants could start and stop the survey at any time using their smart phone or computer during the four weeks of the survey being open. The conclusion of the survey thanked the participants and included an optional and confidential link to sign up for a drawing for $50 gift cards to Amazon. However, due to a glitch in the Qualtrics survey platform, the email addresses of the participants were not collected for the drawing. Instead of gift cards being awarded, a monetary donation of $250 was made to the NIU food bank.

**Adolescent Health App Acceptability Scale**

The AHAA scale was developed using constructs from Sekhon et al.’s theoretical framework of acceptability (TFA) and was further developed into a survey instrument (Chen, 2019). Sekhon et al. (2017), synthesized 43 systematic reviews using inductive and deductive methods, resulting in seven domains of acceptability specific to health interventions. The domains are: 1) affective attitude, defined as how an individual feels about the intervention; 2) burden, defined as the perceived amount of effort that is required to participate in the intervention; 3) ethicality, defined as the extent to which the intervention has a good fit with an individual’s value system; 4) intervention coherence, defined as the extent to which the participant understands the intervention and how it works; 5) opportunity costs, defined as the extent to which benefits, profits, or values must be given up to engage in the intervention; 6) perceived effectiveness, defined as the extent to which the intervention is perceived as likely to
achieve its purpose; and 7) self-efficacy, defined as the participant’s confidence that they can perform the behavior(s) required to participate in the intervention. The prior domains were then operationalized and developed into the AHAA by Chen (2019). Chen’s research involved qualitative research with two interviews performed in one month with 19 adolescents in 7-9th grades. The interviews consisted of questions related to the domains established in the TFA with a grounded theory approach used for analysis of the interview results. Two further themes emerged from the analysis, and they included peer norms and intervention expectations. Further research by Chen included use of the newly added domains to the prior 7 domains of the TFA and then scale development using a process from Devellis (2016). In addition, Múthen and Múthen (2009)’s five-step research strategy for Exploratory Factor Analyses (EFA) and Confirmatory Factor Analyses (CFA) were used. Finally, cognitive interviews and field tests were used to strengthen the scale development process, as recommended by Bradburn et al. (2004) and Willis (2005).

In summary, the AHAA scale by Chen (2019), based on the constructs of acceptability established by Sekhon et al. (2017), was developed using a multi-step process which was categorized into three phases: item generation, theoretical analysis, and psychometric analysis. It is important to note that the format for measurement on a 4-point Likert scale (1=Strongly disagree, 2=Disagree, 3=Agree, 4=Strongly agree) was used due to being optimal with children and adolescents as respondents (Borgers, Hox, & Sikkel, 2004). Once the scale was developed by Chen, 182 students between the ages of 12 and 16 were surveyed (54%, n = 104 females). The majority of the participants identified as Black/African American (69%, n=126) and 17% (n=31) of participants identified as Hispanic or Latino.
Psychometric analysis included reliability, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). After these assessments were made, the original scale was trimmed from 52 to 22 items in six subscales. All factor loadings and communalities were above 0.5, where < 0.5 is considered low (DeVellis, 2016: Fabrigar & Wegener, 2012). The Cronbach’s alpha for the new scale was 0.91. The Cronbach’s alphas for the subscales ranged from 0.74 to 0.88.

Additional constructs used in research from Johnston and Warkentin (2010) were included in the survey instrument in the interest of capturing data pertinent to efficacy factors related to mHealth app use. These constructs are response efficacy and adoption intention. Research by Sekhon et al. (2017), emphasized that acceptability is a necessary but not sufficient condition for health-related interventions. Literature related to adoption intention of technology use shows a higher correlation with higher response efficacy scores (Johnson and Warkentin, 2010).

Response-efficacy constructs originally proposed by Rogers (1975, 1983) and further defined by Witte et al. (1992), were adapted and validated by Johnston and Warkentin (2010) through their research of fear appeals and protection motivation on behavioral intentions, specifically for computer users to adopt recommended individual computer security actions with respect to spyware. In their research, a fear appeal was defined as a persuasive message with the intent to motivate individuals to comply with a recommended course of action through the arousal of fear associated with a threat (Witte, 1992). Once the fear appeal message was received by the study participants, cognitive processes acted as a mediator in the participants’ responses, also known as protective motivation (Rogers and Mewborn, 1976). The cognitions formed by the
individual receiving the fear appeal were defined as *response-efficacy* and *self-efficacy*. The former is the degree to which an individual believes the response to be effective in alleviating a threat (Rogers, 1975; Witte, 1992); the latter is the degree to which an individual believes in their ability to enact the recommended response (Bandura, 1977).

In a study by Johnston and Warkentin (2010), 275 faculty, staff, and students from a large (unspecified) university participated in a voluntary survey designed to measure the impact of fear appeals on behavioral intent of use of anti-malware solutions with their computer use. A five point Likert Scale was used for scoring; Strongly Disagree = 1; Neutral = 3; and Strongly Agree = 5. Response efficacy and self-efficacy were two of the variables measured in a within-subjects MANCOVA, where a pretest-treatment-posttest approach was used. The average increase in self-efficacy from pre-test mean to post-test mean was 0.20; and response-efficacy was 0.36. Additionally, higher response efficacy and self-efficacy scores were directly correlated with a higher score of behavioral intention to adopt the use of spyware software, with $R^2 = 0.105$ (Response Efficacy), 0.040 (Self-Efficacy), and 0.271 (Behavioral Intent) ($p < 0.01$).

Several conclusions can be drawn from this study. Both response efficacy and self-efficacy increased in the participants after the fear appeal messaging was received. This study supports the theory that response efficacy and self-efficacy are mediating factors for a proposed behavior change. An additional construct measured in this study was termed *behavioral intent*, where the three associated survey statements were: “I intend to use anti-spyware software in the next 3 months,” “I predict I will use anti-spyware in the next 3 months,” and “I plan to use anti-spyware software in the next 3 months.” For the purpose of my study, the terminology
behavioral intent was changed to adoption intention, and each associated question changed the term anti-spyware to mobile health app (see Table 1 and Table 2). (Text resumes after Table 2.)

Table 1
Acceptability of Health Apps Among Adolescents Scale Items (AHAA)
(Adapted from Sekhon et al., 2017 and Chen, 2019)

<table>
<thead>
<tr>
<th>Construct</th>
<th>Code</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude</td>
<td>ATT 1</td>
<td>I like using health related apps.</td>
</tr>
<tr>
<td></td>
<td>ATT 2reverse</td>
<td>I dislike using health related apps.</td>
</tr>
<tr>
<td></td>
<td>ATT 3</td>
<td>I enjoy using health related apps.</td>
</tr>
<tr>
<td></td>
<td>ATT 4reverse</td>
<td>I hate using health related apps.</td>
</tr>
<tr>
<td>Burden</td>
<td>BUR 1</td>
<td>Health related apps are easy to use.</td>
</tr>
<tr>
<td></td>
<td>BUR 2reverse</td>
<td>Health related apps are hard to use.</td>
</tr>
<tr>
<td></td>
<td>BUR 3reverse</td>
<td>Health related apps are confusing.</td>
</tr>
<tr>
<td></td>
<td>BUR 4</td>
<td>Health related apps are simple.</td>
</tr>
<tr>
<td>Ethicality</td>
<td>ETH 5</td>
<td>I care about my physical health.</td>
</tr>
<tr>
<td></td>
<td>ETH 6</td>
<td>Physical health is important to me.</td>
</tr>
<tr>
<td></td>
<td>ETH 7reverse</td>
<td>Physical health is unimportant to me.</td>
</tr>
<tr>
<td></td>
<td>ETH 8</td>
<td>It’s good to care about physical health.</td>
</tr>
<tr>
<td>Intervention Coherence</td>
<td>COH 2</td>
<td>I can show a friend how to use a health related app.</td>
</tr>
<tr>
<td></td>
<td>COH 4</td>
<td>I understand how to use health related apps.</td>
</tr>
<tr>
<td></td>
<td>COH 5</td>
<td>I can show someone how to use all of the features of health-related apps.</td>
</tr>
<tr>
<td>Self-Efficacy</td>
<td>SELF 3</td>
<td>I’m confident I can use a health-related app even if I’m really busy.</td>
</tr>
<tr>
<td></td>
<td>SELF 5</td>
<td>I’m confident I can use a health-related app even if I’m not reminded to do it.</td>
</tr>
<tr>
<td></td>
<td>SELF 6</td>
<td>I’m confident that I can use a health-related app for physical activity even if I’m really busy.</td>
</tr>
</tbody>
</table>

Note: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree
Table 2

Response Efficacy and Adoption Intention

<table>
<thead>
<tr>
<th>Construct</th>
<th>Code</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response Efficacy</td>
<td>RESP 1</td>
<td>Mobile health services work in keeping me healthy.</td>
</tr>
<tr>
<td></td>
<td>RESP 2</td>
<td>Mobile health services are effective in keeping me healthy.</td>
</tr>
<tr>
<td></td>
<td>RESP 3</td>
<td>When using mobile health services, my health is more likely to be good.</td>
</tr>
<tr>
<td>Adoption Intention</td>
<td>AI1</td>
<td>I intend to use a mobile health app in the next 3 months.</td>
</tr>
<tr>
<td></td>
<td>AI2</td>
<td>I predict I will use mobile health apps in the next 3 months.</td>
</tr>
<tr>
<td></td>
<td>AI3</td>
<td>I plan to use mobile health services in the next 3 months.</td>
</tr>
</tbody>
</table>

(Adapted from Johnston and Warkentin, 2010)

Note: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree

Pilot Test of Survey Instrument

A pilot test was conducted using the survey instrument to gain feedback regarding survey length and readability. A convenience sample of seven adolescents ages 16-18 from a midwestern school district were recruited for the pilot test from November 15-30, 2021. Participants were informed of the purpose of the pilot test and the research study via face to face conversation. A link to the survey on the Qualtrics software platform was provided. The participants were asked to provide feedback regarding readability of the questions, ease of accessing the survey online, and time taken for survey completion. Pilot testing feedback was minimal, with no reports of readability issues or access difficulty to the survey. The average
amount of time for survey completion was eight minutes. Pilot study participants were not part of the final research survey.

**Ethical Considerations**

An application for Institutional Review of Research Involving Human Subjects was submitted to Northern Illinois University’s Institutional Review Board (IRB) to warrant ethical compliance in this study. IRB approval was received on November 22, 2021 (Appendix B). This study was designed and conducted in a manner that upheld the tenets of the Belmont Report for protection of human subjects: respect for persons, beneficence, and justice (Gliner, Morgan, & Leech, 2009). Inviting voluntary participation, including informed consent, ensuring privacy and confidentiality through the use of an anonymous survey, and providing contact information for me, my dissertation chair, and the NIU IRB director demonstrates how protection of human subjects was accomplished. Risk to participants was estimated to be negligible.

**Data Collection**

Due to the proximity in age and life stage development of college freshman to the participants of the pilot study, the research study was appropriate to use in this age group. While the pilot test was administered in a convenience sample of high school aged adolescents, it was determined that recruitment for study participants was more likely to occur in the college freshman population. An addendum to the approved IRB requesting the study sample population change to college freshman was submitted and approved on August 18, 2022. An application for performing a survey of freshman in a midwestern university was then filed with the university
Registration and Records department, and an email with a recruitment flier, QR code, and survey link to the Qualtrics software platform was sent to university freshmen through Clearinghouse. Participants were invited to read the first page of the survey detailing the purpose of the study and requesting informed consent. Participants were assured that information obtained from the survey would be anonymous and confidential. When participants gave informed consent, they were prompted to begin the survey. If participants did not give informed consent, the survey defaulted to the end message which thanked them for their time. The survey was open for four weeks, with a second invitation to participate sent via email at the two week mark. This method was based on research by Dillman et al. (2017), finding that multiple email invitations as well as the ability to take a survey on a smartphone or computer has a higher rate of survey response than a survey without these factors.

Demographic information was collected for each participant via self-report within the survey. This information included: gender (male/female/non-binary); age, ethnicity/race (American Indian/Alaska Native, Black/African American, Asian American, Hispanic/Latino, Native Pacific Islander/White-Non Hispanic); age (18,19); current rate of use of mHealth apps for PA; current rate of use of mHealth apps for chronic health condition management; and Covid-19 diagnosis (if present). The remaining survey questions were measures for the constructs associated with the Adolescent Health App Acceptability scale (Chen, 2019), response efficacy, and adoption intention of mHealth apps for PA (Johnston and Warkentin, 2010). All items were measured using a Likert scale with anchors of 1 (strongly disagree) to 4 (strongly agree). A total of 315 surveys were completed from September 24-October 22, 2022.
At the end of the survey, study participants were given the option to enter in a raffle for one of ten $50 Amazon gift cards. If they selected yes, the survey was coded to direct participants to a separate link where they could enter their email addresses, which would then allow for random selection of ten winners. However, at the midpoint in survey data collection, it became evident that no participant emails were being collected in the Qualtrics secondary survey. The dissertation chair was informed, and multiple efforts were made to contact the survey coordinator at the participating university for assistance in the matter; unfortunately, no response was received, and survey respondents were unable to provide the information necessary to complete the raffle as planned. As a solution, a monetary donation of $250 was given to the university food bank.

Data Analysis

Data from the study’s survey was analyzed using SPSS statistical software (version 26). Data was examined for outliers, missing elements, normality of distribution, and general accuracy. Frequencies and percentages were assessed for the categorical variables of gender (male/female/non-binary); age, ethnicity/race (American Indian/Alaska Native, Black/African American, Asian American, Hispanic/Latino, Native Pacific Islander/White-Non Hispanic); current use of mHealth apps for PA; current use of mHealth apps for chronic health condition management; and Covid-19 diagnosis (if present).

Multiple linear regression was performed and analyzed for significance (p < 0.05) using the data from the AHAA, response efficacy, and adoption intention to determine the strongest predictors of adolescent health app acceptability.
Summary

The acceptability of mHealth apps in the adolescent population is an area of research that may provide information to help address this population’s lack of PA. It is well established in the literature that adolescents do not attain the recommended amount of PA, and the associated health risks are significant. Using information from the survey conducted may help inform further research in interventions designed for improvement in the levels of PA in adolescents.
Chapter 4: Results

Results

The purpose of this study was to evaluate the relationships between attributes of mHealth app acceptability, response-efficacy, and intention to adopt mHealth apps in adolescents, specifically 18-19 year old college freshmen, utilizing the AHAA by Chen et al., as well as individual constructs of response-efficacy and constructs of intention to adopt the recommended intervention validated by Johnston and Warkentin (2010).

Analysis Procedures

Pallant (2016)’s guide was used as a reference during data analysis. Prior to data analysis, all variables were assessed for accuracy, missing values, and multivariate assumptions. Missing values represented 9.6% of the data and mainly appeared in random patterns. Pairwise deletion was used that excluded the case(s) missing data required for the specific analysis. The cases with missing data were included in analyses for which they had the necessary information (Pallant, 2016). Using pairwise deletion is unlikely to diminish the power of the results due to the large number of surveys completed (Donner, 1982).

Of the 316 online surveys recorded, 287 responses were deemed usable for this study. Based on the online survey distribution method, the exact number of individuals that had access to the survey is not certain; however, all college freshmen at the participating university were sent the invitation to participate in the survey via email. The participating university freshman
class was recorded as having 2,440 students as of September 2022; thus, the response rate of the survey is estimated at 12.4%. The demographic characteristics of the sample population were similar to that of the participating university student population. The survey respondents were 21.5% Black/African American, 7.3% Asian American, 23.4% Hispanic/Latino, 0.3% Native Pacific Islander, and 41.8% White/Non-Hispanic. This compared to the NIU undergraduate population, which consisted of 17.3% Black/African American, 6.1% Asian, 20.2% Hispanic/Latino; 0.06% Native Pacific Islander, and 46.5% White/Non-Hispanic.

**Characteristics of the Sample Population**

The number of participants who reported never using a health-related app (HRA) for PA was 46% \( (n = 120) \), followed in ascending order by use of less than one hour (28.7%, \( n = 75 \)), one to five hours (25.3%, \( n = 66 \)), and six or more hours (9.6%, \( n = 25 \)). Most of the participants were female (59.7%, \( n = 171 \)), White non-Hispanic (44.8%, \( n = 128 \), and age 18 (76.7%, \( n = 219 \)). The largest percentage of participants (92.3%, \( n = 264 \)) had not used an HRA for health management. Most participants (54.5%, \( n = 156 \)) believed they get the recommended amount of physical activity, with a majority (39.2%, \( n = 112 \)) reporting their physical activity levels increased after the COVID-19 pandemic (see Table 3).

Descriptive statistics were completed on the survey data. Each of the sub-scales including the means, standard deviations, and response ranges for all scale items were calculated. These results are presented in Table 4. (Text resumes after Table 4.)
### Table 3

Demographic and Other Characteristics of Adolescents Responding to Survey

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>n</th>
<th>% of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender (n = 287)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>108</td>
<td>37.6</td>
</tr>
<tr>
<td>Female</td>
<td>171</td>
<td>59.6</td>
</tr>
<tr>
<td>Non-Binary</td>
<td>8</td>
<td>2.8</td>
</tr>
<tr>
<td><strong>Age (n = 286)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>219</td>
<td>76.7</td>
</tr>
<tr>
<td>19</td>
<td>67</td>
<td>23.4</td>
</tr>
<tr>
<td><strong>Ethnicity/Race (n = 286)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>American Indian/Alaskan Native</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Black/African-American</td>
<td>65</td>
<td>22.7</td>
</tr>
<tr>
<td>Asian American</td>
<td>21</td>
<td>7.3</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>71</td>
<td>24.9</td>
</tr>
<tr>
<td>Native Pacific Islander</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>White Non-Hispanic</td>
<td>128</td>
<td>44.8</td>
</tr>
<tr>
<td><strong>Use of Apps for PA (n = 261)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None at all</td>
<td>120</td>
<td>46.0</td>
</tr>
<tr>
<td>Less than one hour</td>
<td>75</td>
<td>28.7</td>
</tr>
<tr>
<td>One to five hours</td>
<td>66</td>
<td>25.3</td>
</tr>
<tr>
<td>Six or more hours</td>
<td>25</td>
<td>9.6</td>
</tr>
<tr>
<td><strong>HRAs for Health Management (n = 286)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>22</td>
<td>7.7</td>
</tr>
<tr>
<td>No</td>
<td>264</td>
<td>92.3</td>
</tr>
<tr>
<td><strong>COVID-19 Activity amount (n = 286)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stayed the same</td>
<td>77</td>
<td>26.9</td>
</tr>
<tr>
<td>Decreased</td>
<td>97</td>
<td>33.9</td>
</tr>
<tr>
<td>Increased</td>
<td>112</td>
<td>39.2</td>
</tr>
<tr>
<td><strong>Belief in PA Amount (n = 286)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>True</td>
<td>156</td>
<td>54.5</td>
</tr>
<tr>
<td>False</td>
<td>130</td>
<td>45.5</td>
</tr>
</tbody>
</table>
Table 4
Minimum, Maximum, Mean, Standard Deviation (SD), and Variance Results for the AHAA, Response Efficacy, and Intention to Adopt

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean ± SD</th>
<th>Median (IQR – 25th, 75th)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attitude (n = 293)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like using health apps</td>
<td>2.77 ± (0.60)</td>
<td>3.00 (2.25, 3.00)</td>
</tr>
<tr>
<td>I dislike using HRAs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I enjoy using HRAs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I hate using HRAs</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Burden (n = 282)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health apps are easy to use</td>
<td>2.86 ± (0.56)</td>
<td>3.00 (2.50, 3.00)</td>
</tr>
<tr>
<td>Health related apps are hard to use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health related apps are confusing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health related apps are simple</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ethicality (n = 280)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I care about my physical health</td>
<td>2.94 ± (0.30)</td>
<td>3.00 (2.75, 3.25)</td>
</tr>
<tr>
<td>Physical health is important to me</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical health is unimportant to me</td>
<td></td>
<td></td>
</tr>
<tr>
<td>It’s good to care about physical health</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Intervention Coherence (n = 280)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can show a friend how to use a health related app</td>
<td>2.79 ± (0.62)</td>
<td>3.00 (2.50, 3.00)</td>
</tr>
<tr>
<td>I understand how to use HRAs</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Self-Efficacy (n = 276)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I’m confident I can use a HRA even if I’m busy</td>
<td>2.48 ± (0.66)</td>
<td>2.67 (2.00, 3.00)</td>
</tr>
<tr>
<td>I’m confident I can use a HRA even if I’m not reminded to do it</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I’m confident I can use a HRA for PA even if I’m really busy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Continued on following page)
Table 4 (continued)

<table>
<thead>
<tr>
<th>Response-Efficacy ( (n = 272) )</th>
<th>2.64 ±(0.63)</th>
<th>3.00 (2.33, 3.00)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRAs work in keeping me healthy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HRAs are effective in keeping me</td>
<td></td>
<td></td>
</tr>
<tr>
<td>healthy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>When using HRAs for PA, my health</td>
<td></td>
<td></td>
</tr>
<tr>
<td>is more likely to be good</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Adoption Intention ( (n = 272) )</th>
<th>2.48 ± (0.85)</th>
<th>2.67 (2.00, 3.00)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I intend to use a health app in the</td>
<td></td>
<td></td>
</tr>
<tr>
<td>next 3 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I predict I will use a HRA in the</td>
<td></td>
<td></td>
</tr>
<tr>
<td>next 3 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I plan to use a health app in the</td>
<td></td>
<td></td>
</tr>
<tr>
<td>next 3 months</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: 1 = Strongly Disagree, 2 = Disagree; 3 = Agree; 4 = Strongly Agree

Reliability Analysis

Reliability analysis tests were performed for the constructs used from the AHAA (Chen, 2019) and from Johnston and Warkentin (2010) by assessing Cronbach’s alpha coefficient measures. In this study, the Cronbach’s alpha of the entire survey tool was 0.91. Internal consistency of the instrument was analyzed using Cronbach’s alpha, and the score of each of the subscales were as follows: attitude (0.87), burden (0.89), ethicality (0.81), intervention coherence (0.84), self-efficacy (0.89) and response efficacy (0.86). According to Chen and colleagues (2019), the AHAA had good internal consistency with a Cronbach alpha coefficient of 0.90 for their study, comparable to 0.91 for my study.
Tests of normality show that the variables measured do not meet normality assumption since the p-value for the Shapiro-Wilk test is less than 0.05 (all p-value=0.00), which is normal in large sample sizes larger than 100 (Pallant, 2016). According to the Central Limit Theorem, if a sample size larger than 30 and normality assumptions are not met, the statistical inference is still valid due to the robustness of the t-test against non-normality.

Results of Hypothesis Testing

Correlations Between Acceptability, Response Efficacy, and Adoption Intention

Hypothesis 1 predicted a positive correlation between acceptability of mHealth apps and response efficacy among the sample population. It was anticipated that adolescents who reported higher scores of response efficacy would also report higher scores of acceptability as measured by the associated subscales of the AHAA.

First, the relationship between acceptability and response efficacy was investigated using Pearson’s Correlation Coefficient. The strengths of the relationships between the variables used in this correlational analysis were measured using Cohen’s guidelines cited in Pallant (2016); small: r = .10 to .29, medium: r = .30 to .49, and large: r = .50 to 1.0. Acceptability was calculated by summing means of each subscale (except response efficacy), then correlated with response efficacy results. The Pearson correlation coefficient between acceptability and response efficacy was positive, r = .768, p = .000. The findings from this analysis strongly supported Hypothesis 1.
Hypothesis 2 predicted that response efficacy is positively associated with intention to adopt mHealth apps among this sample population. The Pearson correlation coefficient was calculated between response efficacy and adoption intention. There was a positive correlation between the two variables, \( r = .568, p = .000 \). The findings from this analysis strongly supported Hypothesis 2.

Hypothesis 3 predicted that response efficacy is the greatest predictor of adoption intention in this sample of population. Multiple linear regression was used to assess the variables associated with acceptability as well as demographic variables to predict adoption intention. This approach allowed an investigation of whether specific variables in this study were predictive of adoption intention while considering other variables that may have influenced the outcome variable (Pallant, 2016).

Bivariate correlations among all variables were calculated, followed by regression analysis. The correlation matrix associated with the variables is presented in Table 5. After regression analysis was performed, variance inflation factor (VIF) and tolerance were used to assess the presence of multicollinearity. Per guidelines by Bowerman & O’Connell (1990), Meyers (1990), and Ménard (1995), if the Largest VIF is greater than 10 and the average VIF is substantially greater than 1, the regression may be biased. If tolerance is below 0.1, a serious problem exists with the data. The VIF and tolerance of this data showed all factors < 2, indicating a low correlation among variables under ideal conditions (see Table 5).
Table 5

Correlation Matrix (Pearson)

<table>
<thead>
<tr>
<th>Subscale</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Adoption Intention</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Ethicality</td>
<td>.151</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Intervention Coherence</td>
<td>.468</td>
<td>.135</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Self-Efficacy</td>
<td>.482</td>
<td>.105</td>
<td>.512</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Response Efficacy</td>
<td>.568</td>
<td>.118</td>
<td>.483</td>
<td>.470</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Attitude</td>
<td>.631</td>
<td>.151</td>
<td>.542</td>
<td>.427</td>
<td>.626</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>7. Burden</td>
<td>.265</td>
<td>.161</td>
<td>.569</td>
<td>.301</td>
<td>.339</td>
<td>.393</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Note: **p < .01 (2-tailed). *p < .05

Preliminary analysis was conducted using residual scatterplots to ensure assumptions (outliers, normality, linearity, homoscedasticity, and independence of residuals) were not violated (Pallant, 2016). The overall regression was then analyzed for significance, as was each predictor (p < .05), in order to determine significant predictors of adoption intention of apps for PA. Overall, the regression was significant: $F(6, 264) = 41.82, p < .001, R^2 = .49$. Findings indicated that 49% of the variance in the scores of the subscales measured can be explained by the effect of the predictors on the outcome variable of adoption intention. Of the predictors investigated, self-efficacy ($\beta = .184, t(264) = 3.41, p < .05$), response-efficacy ($\beta = .209, t(264) = $
3.51, \( p < .05 \), and attitude \( (\beta = .392, t(264) = 6.43, p < .05) \) were statistically significant. The strongest unique contribution to adoption intention was attitude when all other variables were controlled. Response efficacy was the second strongest contributor, and self-efficacy ranked third. Ethicality \( (\beta = .047, t(264) = 1.04, p < .05) \) was not a significant predictor of adoption intention, nor was intervention coherence \( (\beta = .099, t(264) = 1.58, p < .05) \) or burden \( (\beta = -.079, t(264) = -1.457, p < .05) \). Therefore, Hypothesis 3 was not supported by the findings (See Table 6).

Table 6

Summary of Regression Analysis for Predictors of Adoption Intention

<table>
<thead>
<tr>
<th>Predictors</th>
<th>( B )</th>
<th>( SE \ B )</th>
<th>( \beta )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethicality</td>
<td>.130</td>
<td>.125</td>
<td>.047</td>
<td>.299</td>
</tr>
<tr>
<td>Intervention Coherence</td>
<td>.135</td>
<td>.086</td>
<td>.099</td>
<td>.116</td>
</tr>
<tr>
<td>Self-Efficacy</td>
<td>.233</td>
<td>.068</td>
<td>.184</td>
<td>.001</td>
</tr>
<tr>
<td>Response Efficacy</td>
<td>.278</td>
<td>.079</td>
<td>.209</td>
<td>.001</td>
</tr>
<tr>
<td>Attitude</td>
<td>.545</td>
<td>.085</td>
<td>.392</td>
<td>.000</td>
</tr>
<tr>
<td>Burden</td>
<td>-.117</td>
<td>.080</td>
<td>-.079</td>
<td>.156</td>
</tr>
</tbody>
</table>

*Note. n = 264*
Further regression analysis was completed to determine if there was a significant difference in gender, race, time spent on apps in the past week, PA related to before/after COVID-19 pandemic, and use of apps for management of a health related condition. All results were non-significant except for the time spent using health apps in the last week: less than an hour ($\beta = .047$, $t(249) = 4.93$, $p < .05$); one to five hours ($\beta = .518$, $t(249) = 5.04$, $p < .05$); six or more hours ($\beta = .771$, $t(249) = 5.018$, $p < .05$).

**Summary**

The descriptive statistics resulting from this study revealed that apps for PA were not used in a majority of 18–19-year-old college students from this sample population (46%, $N = 261$). In addition, most participants reported they believed they achieved the recommended amount of PA daily (55%, $N = 286$). Finally, almost one third of participants reported having increased their levels of PA since the COVID-19 pandemic (32%, $N = 112$).

Correlation coefficients indicated that there were statistically significant relationships between self-efficacy, response-efficacy, attitude, and adoption intention. In other words, the adolescents who demonstrated higher reports of self-efficacy, response-efficacy, and attitude reported an increased likelihood of app adoption for PA. The most significant predictor of adoption intention was attitude, followed by response efficacy and then self-efficacy.

This chapter focused on the presentation of data analysis findings. The next chapter provides a summary of this study and a discussion of conclusions as well as implications and recommendations for future practice and research.
CHAPTER 5: DISCUSSION

Discussion

Through online distribution of a survey, this dissertation research used the Acceptability of Health Apps among Adolescents scale that measures distinct aspects of acceptability (affective attitude, burden, ethicality, intervention coherence, and self-efficacy) with the addition of a response efficacy sub-scale to predict intention to adopt health apps for PA in older adolescents. While response-efficacy was not shown to be the most predictive attribute related to adoption intention as hypothesized in the 18 and 19 year old sample population, responses on attitude and self-efficacy were predictive of adoption intention (values). Self-efficacy is a construct that has been more robustly researched in terms of its impact on the outcome being measured; thus, it was theorized that self-efficacy would be a significant predictor of adoption intention. However, the impact of attitude as a predictive variable is not as prevalent in research, and the significance of attitude impacting adoption intention was unexpected.

When discussing the results of this study, it is important to consider the original development and use of the AHAA and then compare findings from the original use to my study population. First, the AHAA was developed with younger adolescents (7th - 9th grade) and with a smaller population (N = 16), and it was used as a predictor for actual app usage (N = 182), whereas my study was with an older, larger population (ages = 18-19; N = 302) and was used to predict the adoption intention of a health app for PA. In addition, response-efficacy was added as a sub-scale to the original AHAA to explore the theorized contribution to adoption intention in
the sample population. Finally, while the original use of the AHAA was also intended to support
a hypothesis of acceptability being a higher order latent factor with six sub-constructs, that
theory was not explored within the context of this study. The developer of the AHAA (Elizabeth
Chen) found in her research that ethicality and self-efficacy were predictive of actual app usage
(β=0.018, p<0.05 for ethicality, β =5.16, p<0.05 for self-efficacy). Second, Chen theorized that if
the AHAA were used in larger sample sizes, each sub-scale would have equal predictive strength
of health app use. This study offers information to reject this conjecture, as each sub-scale in a
large sample population (N = 262) did not have equal predictive strength of health app adoption
intention. While the dependent variable is different in each study (app use vs adoption intention),
one may infer that the process of app use is preceded by adoption intention.

Strengths

The strengths associated with this dissertation study are as follows: large sample size in a
specific age range of adolescents, a study sample population reflective of the student population
from which it originated, and the use of survey questions that were validated in another
adolescent population. Another strength includes the statistical analysis; both the results
computed by the consulting statistician and primary researcher revealed the same findings. First,
the Cronbach’s alpha of the AHAA, including the response-efficacy subscale with my study, was
0.91; multi-collinearity was not considered a problem with all VIF factors < 2; and self-efficacy
and attitude were the most significant predictors of adoption intention in the sample population.
While self-efficacy has been shown in prior research to be an important contributor to health-
related behaviors in adolescents, attitude in the operationalized form of the AHAA has not been
as well studied. Thus, the finding that attitude was the most significant predictor of adoption intention was a new finding unique to this study. This indicates the opportunity to research the subconstruct of attitude and its impact on app adoption intention for PA in adolescents. Additionally, all attributes of acceptability measured by subscale scores were positive contributors to mHealth app acceptability and adoption intention even if the results were non-significant. This finding reinforces the operationalized definitions of the six attributes of acceptability, which offers further evidence of the accuracy of research completed by Sekhon and Chen.

**Limitations**

The limitations of this study include the following: a convenience population sample of a limited age range which consisted of freshman students at one midwestern public university, potentially limiting socioeconomic variability and geographic location of participants; use of a newer instrument and additional sub-scale in a population with which it was not originally validated; and lack of specificity in terms of apps for PA. To account for these limitations, future research is needed in a wider age range of adolescents and a non-convenience sample, which may also allow for more generalizability of the study results. Also, providing a variety of apps designed for PA engagement for the participant to choose from may influence adoption intention. Finally, a longitudinal study regarding the consistency of the predictive values of the AHAA and app adoption may provide further direction for refinement or changes of the attributes currently used in the AHAA. Additionally, further research of the predictive values of acceptability within
each suggested age group of adolescents may illuminate factors that are currently not included in the theoretical framework of acceptability, nor in the AHAA. Finally, randomizing the order of attribute blocks within the survey may alleviate the possibility that attitude was the most significant contributor to AI. For this research study, the questions related to attitude immediately followed the initial demographics questions; thus, the participants may have exhibited higher attention levels and positivity compared to questions answered later in the survey.

Implications and Future Research

The purpose of my study was to assess the predictive values of the attributes of acceptability and response efficacy on adoption intention of mHealth apps in a sample population of 18-19 year old college freshman. I hypothesized that response efficacy would be the strongest predictor of adoption intention and that a positive correlation existed between response efficacy and adoption intention as well as between response efficacy and acceptability.

The results of my study showed that attitude and self-efficacy were the highest predictors of adoption intention in the sample population. These findings supported existing evidence related to the predictive value of self-efficacy on adoption intention, but in an older adolescent sample of 18-19-year-old college freshman. Thus, self-efficacy has been shown to be a significant predictor of adoption intention in both younger and older adolescents. However, the high predictive value of attitude on adoption intention was a new finding in this area of research. This suggests the significance of attitude as an attribute of acceptability and predictor of adoption intention in this sample population of adolescents was unexpected and warrants further
exploration in research. One explanation for the high predictive value of attitude on adoption intention is the age of the participants. Attitude, in this case, how the participants’ felt about app adoption, is a feeling that may be influenced by the state of autonomy that college freshman have in decisions for health related activities. College freshman may be highly in tune with how they feel about a proposed activity due to their life stage of newly gained independence and necessity of decision making for their daily activities.

It is possible that certain constructs of the AHAA are more predictive of adoption intention based on age of the adolescent and that the predictive value may change throughout adolescence. An example of this applies to response efficacy which is defined as averting a health threat by participating in the recommended intervention. Younger adolescents may be likely to respond to the fear appeal of experiencing adverse health conditions if they don’t use the recommended intervention due to the consistent messaging and educational instruction experienced during health and physical education(PE) classes. Older adolescents attending college are less likely to experience the frequency of education regarding health and PE, thus, less likely to base decisions on fear appeals and response efficacy.

There are several implications from my research findings that may be applied to future research, education, and healthcare. First, further use of the AHAA in a longitudinal study design would be valuable to assess potential changes in sub-scale predictive values. Accruing data that supports the theory that attributes of acceptability change throughout adolescence can contribute to more specific research, care delivery methods, and educational focus on interventions for PA in the adolescent population. For instance, if a new population sample was selected for use of the AHAA and its predictive value of adoption intention, and the results showed response efficacy as
being the most significant predictor, further research illuminating potential reasons for this result would be valuable. Understanding the unique contribution each attribute of acceptability has in populations of adolescents in specific age ranges may also bring new information to any themes or differences in predictive values. For example, the AHAA and adoption intention could be used in a study divided into young (13-15), middle (16-18), and older (19-23) adolescents. Further implications from my study results for research and education include support of the initial purpose of the AHAA, which is to assess the acceptability of mHealth apps. There is also potential for extending the AHAA to include response efficacy and adoption intention, as both attributes are important factors in the determination of mHealth app intervention recommendations.

Another implication from my study results is that the importance of screening adolescents for interest in app use for PA holds significant potential for health care providers (HCPs), parents, educators, and adolescents. If an adolescent has no interest in app use, the focus for helping them increase PA can be directed elsewhere. Conversely, if the adolescent is interested in app use for PA and is given the AHAA as a screening measure, the results may be used to reveal the predictors that indicate which acceptability attributes may be the strongest as well as the weakest. This information can be helpful in the development of individualized intervention recommendations for PA for adolescents. In turn, HCPs, parents, and educators will benefit from knowledge that mHealth app acceptability and response efficacy are precursors for app adoption and use, which can be helpful in discernment of mHealth app intervention recommendations.
Finally, app designers may also use the information garnered in this study in their programming to create app functions for PA based on acceptability attributes of their consumer audience. mHealth app developers would benefit from the use of the survey questions used in this study in all phases of app design and pilot testing. Information gained from surveying the intended users of the mHealth app could direct developers to change or enhance features of the app for improved acceptability and adoption intention. Additionally, policies should also be enacted that app designers must create mHealth apps based on research findings that apply to the age group the app is designed for. Regulating mHealth apps and designers to use research based approaches would help in improving the quality and potentially, usability of mHealth apps.

Conclusion

This dissertation examined the relationship between the constructs of the AHAA with an additional construct of response efficacy and adoption intention of health apps for PA in an 18–19-year-old population. Using a measurement tool specifically designed for adolescent health app acceptability in a large sample population provided new information regarding what factors were most predictive of adoption intention. While there were findings consistent with prior research using the AHAA, new information was yielded in terms of the importance of attitude predicting health app adoption. Further research to understand the uniqueness of attitude regarding adoption intention of health apps in the 18-19 year old population is warranted. The same is true for all ages of the adolescent population.
REFERENCES


Chen, E., Moracco, K. E., Kainz, K., Muessig, K. E., & Tate, D. F. (2022). Developing and validating a new scale to measure the acceptability of health apps among adolescents. Digital Health, 8, 20552076211067660.


World Health Organization (n.d.) Adolescent health. https://www.who.int/health-topics/adolescent-health#tab=tab_1


APPENDIX A

DEFINITIONS AND MEASUREMENT TOOLS FOR STUDY VARIABLES
<table>
<thead>
<tr>
<th>Variable</th>
<th>Description/Definition</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>mHealth app acceptability</td>
<td>If the intended users (adolescents) will use a health app in their daily lives. (Samkange-Zeem et al., 2015)</td>
<td>Acceptability of Health App Among Adolescents Scale Items; using 5 of the original 7 subscales with scores ranging from 1 to 4. Subscales: Attitude, Burden, Ethicality, Intervention Coherence, Self-Efficacy. Total sum of Likert-scale responses (1 = strongly disagree; 2 = disagree; 3 = agree; 4 = strongly agree).</td>
</tr>
<tr>
<td>Response-efficacy</td>
<td>The degree to which an individual believes that a recommended response is effective in averting a health threat (Rogers, 1975; Johnston &amp; Warkentin, 2010).</td>
<td>User Acceptance of mHealth Scale; using response efficacy subscale; Total sum of Likert-scale responses (1 = strongly disagree; 2 = disagree; 3 = agree; 4 = strongly agree).</td>
</tr>
<tr>
<td>Adoption intention</td>
<td>The degree to which an individual believes they will adopt an mHealth app (Johnston &amp; Warkentin, 2010).</td>
<td>User Acceptance of mHealth Scale; using adoption intention subscale; Total sum of Likert-scale responses (1 = strongly disagree; 2 = disagree; 3 = agree; 4 = strongly agree).</td>
</tr>
</tbody>
</table>
APPENDIX B

IRB APPLICATION, ADDENDUM, AND APPROVAL LETTER
Submit a SIGNED COPY OUTSIDE OF THIS DOCUMENT WHEN YOU ARE READY TO SUBMIT EVERYTHING!

DO NOT USE THE PRINT BUTTON AT THE TOP OF THE FORM

Try this, select "neutral" or "command" - P - then use "More Settings" in order to select "Minimum" margins 4x4x2.5x4.5

Title:  Efficacy factors and alcohol app adoption in adolescents

Name:  Deborah, Colorado

Department: College of Health and Human Sciences

For all researchers completing the CITI course "Social and Behavioral Research - Basic Course" in the past 6 months:

"Pick it Up"

All SPP forms in a retrieved, on-screen format are already filled out, ready to fill in. Pick the correct form. If necessary, initiate submission page. (Form information will be filled in by the same record rather than entered into the application.)

With the exception of only click, fill out and submit the entire pages before initiation. Each study/senior tip checking of revisions, a practitioner or other researchers include locally when the project is NOT a thesis or dissertation.

PLEASE BE AWARE THAT ALL COMMUNICATIONS WILL BE SENT TO THE E-MAIL ACCOUNTS OF THE PERSONAL ACCOUNTS - CHECK YOUR ACCOUNT REGULARLY OR LINK IT TO A PREPARED EMAIL ACCOUNT

If the main researcher on this project is a student (either undergraduate or graduate) is a student submitting the project?

Yes

No

STUDENT/RESEARCH: Check the box to the left to find the scroll down to check the student (check the box for all grad and undergrad projects)

Help, Beverly M

Select the appropriate option below:

☐ Check this box if the project is being reviewed as a part of a graduate student's dissertation (the application should be submitted to ETSP proposal defense)

☐ Check this box if the project is for a graduate Student Education Group.

☐ Check this box if the project is for an undergraduate student (NSF Proposal)

☐ Check this box if the project is an undergraduate project ( newer than named: Nomenclature, Innovation, Innovation, Innovation, Innovation)

☐ Check this box if none of the above apply (regular department research)

☐ Is the project listed in the above? (regular department research)

☐ Is the project labeled as an internal or external funds?

Yes

No

Select any terms below that are relevant for your project [Note: this section will open additional sections to complete including one labeled on the left]:

☐ The study involves deception

☐ The study involves compensation (e.g., cash, travel, payment)
The purpose of this study is to examine the relationship between physical activity, smartphone use, and school performance. Physical activity is defined as any movement produced by the contraction of skeletal muscles that increases energy expenditure above resting levels. School performance is measured by academic performance, which includes grades and standardized test scores. This study aims to determine if there is a relationship between physical activity and school performance, and if smartphone use moderates this relationship. The study design involves a longitudinal approach, where participants are followed over a period of time to assess changes in physical activity, smartphone use, and academic performance. Participants will be recruited from local schools and will be divided into groups based on their physical activity levels. The main outcome measures will be changes in physical activity and academic performance over the study period. The study conclusions will be based on statistical analysis of the collected data.
13-Sep-2022
Celeste Hendricks
College of Health and Human Sciences Dean

RE: Protocol # HS22-0185 “Efficacy factors and mHealth app adoption in adolescents”

Dear Celeste Hendricks,

Your Protocol Amendment submission was reviewed and approved under Member Review procedures by the Institutional Review Board on 13-Sep-2022.

Proposed changes:
Change in age of participants

Please note the following information about your approved research protocol:

Protocol Approval period: 14-Jan-2022 - 13-Jan-2023

If your project will continue beyond that date, or if you intend to make modifications to the study, you will need additional approval and should contact the Office of Research Compliance, Integrity, and Safety for assistance. Annual review of the project will be necessary until you no longer retain any identifiers that could link the subjects to the data collected.

It is important for you to note that as a research investigator involved with human subjects, you are responsible for ensuring that the project has current IRB approval at all times, and for retaining any signed consent forms obtained from your subjects in a secure place for a minimum of three years after the study is concluded. The committee also recommends that the informed consent include an acknowledgement that the subject, or the subject's representative, that he or she has received a copy of the consent form. In addition, you are required to promptly report to the IRB any injuries or other unanticipated problems involving risks to subjects or others.
APPENDIX C

INSTRUMENTATION
### Acceptability of Health App Among Adolescents Scale Items (AHAA)
(Adapted from Sekhon et al., 2017 and Chen, 2019)

<table>
<thead>
<tr>
<th>Construct</th>
<th>Code</th>
<th>Item</th>
<th>Respons: 4-point Likert scale (1=Strongly disagree, 2=Disagree, 3=Agree, 4=Strongly agree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude</td>
<td>ATT_1</td>
<td>I like using health related apps.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ATT_2reverse</td>
<td>I dislike using health related apps.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ATT_3</td>
<td>I enjoy using health related apps.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ATT_4reverse</td>
<td>I hate using health related apps.</td>
<td></td>
</tr>
<tr>
<td>Burden</td>
<td>BUR_1</td>
<td>Health related apps are easy to use.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BUR_2reverse</td>
<td>Health related apps are hard to use.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BUR_3reverse</td>
<td>Health related apps are confusing.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BUR_4</td>
<td>Health related apps are simple.</td>
<td></td>
</tr>
<tr>
<td>Ethicality</td>
<td>ETH_5</td>
<td>I care about my physical health.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ETH_6</td>
<td>Physical health is important to me.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ETH_7reverse</td>
<td>Physical health is unimportant to me.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ETH_8</td>
<td>It’s good to care about physical health.</td>
<td></td>
</tr>
<tr>
<td>Intervention</td>
<td>COH_2</td>
<td>I can show a friend how to use a health related app.</td>
<td></td>
</tr>
<tr>
<td>Coherence</td>
<td>COH_4</td>
<td>I understand how to use health related apps.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>COH_5</td>
<td>I can show someone how to use all of the features of health related apps.</td>
<td></td>
</tr>
<tr>
<td>Self-Efficacy</td>
<td>SELF_3</td>
<td>I’m confident I can use a health related app even if I’m really busy.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SELF_5</td>
<td>I’m confident that I can use a health related app even if I’m not reminded to do it.</td>
<td></td>
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<tr>
<td></td>
<td>SELF_6</td>
<td>I’m confident that I can use a health related app for physical activity even if I’m really busy.</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX D

PERMISSION LETTERS
Request For Permission To Use Instrument from 2010 Empirical Study

From: Celeste Hendricks <C13306628@students.niu.edu>
Sent: Monday, September 20, 2021 3:08 PM
To: stjohnston@niu.edu; mwarkentin@acm.org
Cc: Beverly Henry <bwhenry@niu.edu>
Subject: Request For Permission To Use Instrument from 2010 Empirical Study

Good afternoon, Dr. Johnston and Dr. Warkentin,

My name is Celeste Hendricks and I am a Health and Human Sciences Ph.D. candidate from Northern Illinois University. My dissertation chairperson is Dr. Beverly Henry, whom I’ve included in this email.

I am writing to request permission to use the constructs measuring response-efficacy developed in the publication authored by both of you titled:
Fear appeals and information security behaviors: An empirical study

If permission is granted for use of the response-efficacy constructs from your publication, I will use them with other instruments which measure constructs related to adolescent health app acceptability and physical activity.

Please contact me if you have questions to this email address. I appreciate your time and consideration.

Gratefully,

Celeste Hendricks
RE: Request For Permission To Use Instrument from 2010 Empirical Study

Cc: Beverly Henry

External Email Warning

**CAUTION:** This email originated from outside of NIU. Do not click links, open attachments, or provide personal or account information, unless you recognize the sender and know the content is safe.

Celeste (and Dr. Henry):

Thank you for your interest in our work. I’ve attached the PDF, which you already have, along with a few of our other (subsequent, related) papers. Note that Dr. Johnston has moved campuses, so I have c/o’d him at his new email address.

You have our permission to use our measurement scales for the latent construct “response efficacy” and any other scales we used in that paper. We only require, of course, that you cite them properly.

If you have any other questions, please let us know. Good luck in your research.

Merrill Warkentin, PhD
James J. Rouse Endowed Professor of Information Systems
William J. Glise Distinguished Professor
Mississippi State University
ACM E-Commerce Editor, Editor of the Journal of Interactive Marketing (JIM) (2011-)
FIM, journal of the ACL, AMLASC, ACIS, ACIS Journal, Information & Management (co-editor)
Co-Founder and Senior Advisor, EDV Working Group on E-Business/Research
Chair of Virginia & Het TNM - Chairman of Business - Mississippi State University
654 Lynch Hall (716) 635-1098 Mississippi State, MS 39762-1098 USA
www.mississippi.edu / 662-325-5551 / mewarkentin@msstate.edu
APPENDIX E

RECRUITMENT INFORMATION
Mobile apps and physical activity: what are your thoughts?

No experience required with using mobile apps to participate in this study!

What is involved in participating?

This is a survey that takes about 5 minutes and can be completed on a smart phone, computer, or tablet. You will be asked questions related to your thoughts and abilities for using health apps.

This short survey is part of a study that may help improve the understanding of what college adolescents think about app use for physical activity. No experience necessary using health apps to participate in this study!

Am I eligible to participate?

Eligibility criteria for the study:

- Ages: 18-19
- Attending Northern Illinois University
- Independent with reading and reading comprehension at the 7th grade level
- Access to a smart phone, computer, or tablet

Why should I take the survey?

This information can help scientists, health care providers, and you and your peers learn more about possible methods of improving physical activity levels in your age group.

Participants will also have a chance to win one of ten $50 Amazon gift cards!

How do I participate?

Follow the link or scan the QR code on the right side of this page to access the survey. You can start and stop the survey at any time! All information gathered is confidential and anonymous. The survey will be accessible for four weeks.

If you’re unsure if you meet the requirements, call or email a member of the study team:

- Celeste Hendrickx, Ph.D. Candidate
  Northern Illinois University
  Email: Z1806628@students.niu.edu
  Dr. Beverly Henry, Dissertation Chair
  Email: bwhenry@niu.edu
- Northern Illinois University Institutional Review Board: IRB Chair Patty Wallace, Ph.D.
  Email: pwallace@niu.edu
  Phone: 815-753-8588

Have you thought about using an app to help improve your physical activity?

Access the survey here by following the link below or scanning the QR code!!

https://niu.az1.qualtrics.com/jfe/form/SV_bk209b0xAFkp0y2
Dear Participant,

You are invited to participate in a research study investigating the relationships between self-efficacy, response-efficacy, mHealth app acceptability and intended use of mHealth apps in high-school aged adolescents, by Celeste Hendricks, a Ph.D. in Health Sciences candidate at Northern Illinois University. You have been invited to participate because you are a high-school aged adolescent. This online survey will take approximately 10 minutes to complete.

I understand that if I agree to participate in this study, I will be asked to complete an online survey on my behaviors and thoughts related to adopting mHealth apps for physical activity. I do understand that I am requested to complete the survey honestly and completely.

I understand that no information collected from this survey will be used to identify me and that all information gathered during this study will be kept confidential. All data will be stored on a password-protected computer accessible only to the researcher. I am aware that my participation is voluntary and may be withdrawn at any time without penalty or prejudice.

I understand that the intended benefit of this study includes a better understanding of the relationships between efficacy behaviors and mHealth app adoption in high-aged adolescents. I have been informed that the researcher does not anticipate any potential risks for my participation in this study.

If I have any additional questions concerning this study, I may contact Celeste Hendricks at Z1806628@students.niu.edu; or her dissertation chair, Dr. Beverly Henry at bwhen@niu.edu. I understand that if I wish for further information regarding my rights as a research participant, I may contact the Office of Research Compliance at Northern Illinois University at (815) 753-8588.

I understand that for my participation in this study, I will be entered into a drawing for a $50.00 gift card to Amazon.

I have read and understand the above information. By clicking the “Yes” button to enter the survey, I am volunteering to take the survey.
Do you wish to participate in this study?

- Yes, I wish to participate in this study.
- No, I do not wish to participate in this study.

Condition: No, I do not wish to participate is selected, Skip to: End of Survey.
APPENDIX G

DRAFT QUALTRICS SURVEY SHORT FORM
<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I am confident that I can use a health related app even if I’m really busy.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>I’m confident that I can use a health related app even if I’m not reminded to do it.</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td><strong>I can show someone how to use all of the features of health related apps.</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>I understand how to use health related apps.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>I can show a friend how to use health related apps.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>It’s good to care about physical health.</strong></td>
<td></td>
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<tr>
<td><strong>Physical health is unimportant to me.</strong></td>
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<tr>
<td><strong>Physical health is important to me.</strong></td>
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<tr>
<td><strong>I care about my physical health.</strong></td>
<td></td>
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<tr>
<td><strong>Health related apps are simple.</strong></td>
<td></td>
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<td></td>
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<tr>
<td><strong>Health related apps are confusing.</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Health related apps are hard to use.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Health related apps are easy to use.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>I hate using health related apps.</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>I enjoy using health related apps.</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>I dislike using health related apps.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>I like using health related apps.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Health related apps work in keeping me healthy.</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Health related apps are effective in keeping me healthy.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>When using health related apps, my health is more likely to be good.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>I intend to use a health app in the next 3 months.</strong></td>
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<td></td>
<td></td>
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<tr>
<td><strong>I predict I will use a health app in the next 3 months.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>I plan to use a health app in the next 3 months.</strong></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Efficacy Factors and mHealth App Adoption

Consent

Dear Participant,

You are invited to participate in a research study investigating the relationships between self-efficacy, response-efficacy, mobile health (mHealth) app acceptability and intended use of mHealth apps in college freshman, by Celeste Hendricks, a Ph.D. in Health Sciences candidate at Northern Illinois University. In this survey, the definition of mHealth apps are computer or phone programs that are used for facilitation, measurement, encouragement, tracking OR teaching of any type of physical movement.

You have been invited to participate because you are a college freshman at Northern Illinois University ages 18-19. This online survey will take approximately 10 minutes to complete. I understand that if I agree to participate in this study, I will be asked to complete an online survey on my behaviors and thoughts related to adopting mHealth apps for physical activity. I do understand that I am requested to complete the survey honestly and completely. I understand that no information collected from this survey will be used to identify me and that all information gathered during this study will be kept confidential.

All data will be stored on a password-protected computer accessible only to the researcher. I am aware that my participation is voluntary and may be withdrawn at any time without penalty or prejudice. I understand that the intended benefit of this study includes a better understanding of the relationships between efficacy behaviors and mHealth app adoption in college freshman. I have been informed that the researcher does not anticipate any potential risks for my participation in this study.

If I have any additional questions concerning this study, I may contact Celeste Hendricks at Z1806628@students.niu.edu; or her dissertation chair, Dr. Beverly Henry at bwhenry@niu.edu. I understand that if I wish for further information regarding my rights as a research participant, I may contact the Office of Research Compliance at Northern Illinois University at (815) 753-8588. I understand that for completing a survey in this study, I will be entered into a drawing for one of ten $50.00 Amazon gift cards. I have read and understand the above information. By clicking the “Yes” button on the next question, am volunteering to take the survey. Do you wish to participate in this study?
Consent: Yes/No  Do you wish to participate in this survey?

- Yes, I wish to participate in this study. (2)
- No, I do not wish to participate in this study. (4)

End of Block: Block 8

Start of Block: Demographic information

Gender:  Indicate which gender you identify with.

- Non-binary (1)
- Male (2)
- Female (3)
- I prefer not to answer (4)

Age:  What is your age?

- 18 (6)
- 19 (7)
Ethnicity/Race: Please indicate the ethnicity/race you identify as.

- American Indian/Alaska Native (1)
- Black/African-American (2)
- Asian American (3)
- Hispanic/Latino (4)
- Native Pacific Islander (5)
- White/Non-Hispanic (6)
- I prefer not to answer. (7)

Use of Apps for PA: About how much time have you spent in the last week using apps for physical activity on a phone or computer?

- None at all (1)
- Less than one hour (2)
- One to five hours (3)
- Six or more hours (4)
HRAs for Health, Man: I currently use an app to help manage a health condition (examples of health conditions: diabetes, Crohn's disease, rheumatoid arthritis.)

☐ Yes (1)

☐ No (2)

☐ I prefer not to answer (3)

COVID-19 Since the COVID-19 pandemic began, the amount of physical activity I do each day has:

☐ Stayed the same (1)

☐ Decreased (2)

☐ Increased (3)

☐ I don't know (4)

Belief in PA:  Amount I believe I get the recommended amount of physical activity every day.

☐ True (1)

☐ False (2)
Attitude 1:  I like using health related apps.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly agree (4)

Attitude 2:  Reverse I dislike using health related apps.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly agree (4)

Attitude 3:  I enjoy using health related apps.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly agree (4)
Attitude 4:  Reverse  I hate using health related apps.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly agree (4)

End of Block: Acceptability

Start of Block: Burden

Burden 1
Health related apps are easy to use.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly agree (4)
Burden 2 Reverse Health related apps are hard to use.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly agree (4)

Burden 3 Reverse Health related apps are confusing.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly Agree (4)

Burden 4 Health related apps are simple.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly Agree (4)

End of Block: Burden

Start of Block: Ethicality
Ethicality 5
I care about my physical health.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly agree (4)

Ethicality 7  Physical health is important to me.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly agree (4)

Ethicality 7 Reverse
Physical health is unimportant to me.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly agree (4)
Ethicality 8
It's good to care about physical health.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly Agree (4)

End of Block: Ethicality

Start of Block: Intervention Coherence

Int Coh 2 I can show a friend how to use a health related app.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly disagree (4)
Int coh 4 I understand how to use health related apps.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly agree (4)

End of Block: Intervention Coherence

Start of Block: Self-Efficacy

SE 3 I'm confident I can use a health-related app even if I'm really busy.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly agree (4)
SE 5 I'm confident that I can use a health related app even I'm not reminded to do it.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly agree (4)

SE 6 I'm confident that I can use a health-related app for physical activity even if I'm really busy.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly agree (4)

End of Block: Self-Efficacy

Start of Block: Response Efficacy

RE 1 Health related apps work in keeping me healthy.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly agree (4)
RE 2 Health apps are effective in keeping me healthy.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly agree (4)

RE 3 When using health related apps for physical activity, my health is more likely to be good.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly agree (4)

End of Block: Response Efficacy

Start of Block: Adoption Intention

AI 1 I intend to use a health app(s) in the next 3 months.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly agree (4)
A1 2 I predict I will use a health app(s) in the next 3 months.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly Agree (4)

A1 3 I plan to use a health app(s) in the next 3 months.

- 1 = Strongly disagree (1)
- 2 = Disagree (2)
- 3 = Agree (3)
- 4 = Strongly agree (4)

Q34
If you've completed the survey, you are eligible to enter the drawing for one of ten $50 Amazon gift cards. Your response will remain anonymous and email address will remain confidential.

Would you like to enter the drawing? If you select yes, a link to enter the drawing will be sent to the email address used to access this survey. Follow the link and you will be asked to enter your NIU student email address. Once the survey is closed and all responses collected, the ten winners will be notified by receiving their $50 Amazon gift cards.

If you select no, there will be no emails sent to you.

Thank you for your participation!
Yes (1)

○ No (2)

End of Block: Adoption Intention