AR DANCEE: AN AUGMENTED REALITY-BASED MOBILE PERSUASIVE APP FOR PROMOTING PHYSICAL ACTIVITY THROUGH DANCING

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Abstract

Being physically active is one of the most important healthy lifestyles that contribute to people's overall health and well-being. Within today's fast-paced and sedentary society, the significance of physical activity (PA) cannot be overstated. Enhancing PA levels can be accomplished through various activities such as walking, cycling, swimming, or dancing. Adults are more likely to enhance their PA when participating in an enjoyable activity like dancing. Furthermore, engaging in an enjoyable activity like dancing is likely to have a positive impact on their overall mood. These factors motivated the present research to develop a persuasive mobile-driven intervention named *AR Dancee* that aimed at encouraging the public, particularly adults, to improve their PA in an enjoyable manner, potentially leading to improved positive mood. To achieve this objective, our research leveraged the persuasive capabilities of Augmented Reality (AR), Machine Learning (ML), and gamification to foster healthy behavioral changes towards PA through dancing. By combining these innovative technologies, we strive to create an effective intervention that can positively influence individuals' mood and motivations towards PA, ultimately promoting a healthier lifestyle. We conducted a user study with 104 participants for a 15-day period and interviewed 27 participants to get more insight about the intervention. The participants were asked to rate various design aspects of the intervention and share their experiences of dancing with the intervention. Through analysis of the collected data, we found that the intervention had a significant impact on increasing the participants' PA levels, motivating them to meet the minimum recommended weekly PA level of 600 MET. Furthermore, the intervention exhibited an equal level of effectiveness in promoting PA across all gender groups. However, it was found that the intervention was more effective in promoting PA among younger adults than older adults. The analysis also revealed that the intervention successfully introduced dancing as a novel approach to enhancing or maintaining PA levels. Moreover, the intervention significantly improved the positive mood of the participants during and at the end of the study. Additionally, participants reported a reduction in anxiety levels while dancing with the intervention, indicating its potential for stress management. Overall, these findings highlight the positive impact of the intervention in increasing PA levels, promoting emotional well-being, and offering stress reduction benefits. Our work contributes to the field of HCI, persuasive technology, AR, and ML by introducing a fun and enjoyable way for people to use these technologies to motivate people to engage in PA.

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Chapter 1 : Introduction

Physical activity (PA) is defined as any form of bodily movement that requires energy expenditure and engages the muscles of the body [1][2]. It encompasses a diverse range of activities, such as walking, running, swimming, dancing, cycling, playing sports, doing household chores, and participating in exercise routines or fitness classes. Numerous studies have highlighted that PA is one of the fundamental healthy behaviors essential for maintaining overall health and well-being [3][4][5]. Consequently, engaging in regular PA is crucial for sustaining optimal health and well-being, as it yields a plethora of benefits, including enhanced cardiovascular health, strengthened muscles and bones, improved flexibility and balance, weight management, reduced risk of chronic illnesses (e.g., heart disease, diabetes), better mental health and mood, heightened cognitive function, and improved sleep patterns [6].

The primary focus of this thesis revolves around evaluating the efficacy of a persuasive intervention aimed at promoting PA through dancing, while also exploring the intervention's potential impact on users' mood.

1.1 Motivation

The World Health Organization (WHO) [7] highlights the substantial benefits of regular exercise in managing and preventing noncommunicable diseases (NCDs), such as heart disease, stroke, diabetes, and certain malignancies. Additionally, consistent physical activity (PA) has been associated with reduced blood pressure, improved mental well-being and mood, enhanced cognitive function, and better sleep quality [8][9][10]. Contemporary concerns about physical health have intensified, particularly due to daily technological advancements and increased automation, which have direct implications for individuals' physical strength required to carry out tasks. Consequently, sedentary behaviors have become more prevalent as people spend more time in stationary positions. Amidst the demands of work, family, and other responsibilities, many adults find themselves grappling with limited time and motivation to engage in PA. In the fast-paced and sedentary environment of today's world, the significance of PA cannot be overstated. Notably, leading a sedentary lifestyle [11] not only affects physical health but also exerts a toll on mental well-being [12]. Hence, addressing the importance of regular physical activity is of paramount importance in promoting overall health and wellness. As a result, understanding and promoting strategies to increase PA participation in today's society hold significant implications for public health and well-being.

The prevalence of sedentarism among adults has risen, highlighting an urgent need for interventions aimed at increasing physical activity (PA) levels [11]. The World Health Organization (WHO) has established the standard recommendation for adults, advocating at least 150 minutes of moderate-intensity aerobic physical activity per week or 600 metabolic equivalent task (MET) minutes [7]. Activities such as brisk walking, cycling, swimming, and dancing can help individuals achieve these PA targets. Dancing holds promise as a pleasurable activity that prompts individuals to respond to musical rhythms with bodily movements [13]. The enjoyment associated with dancing makes it a compelling option to encourage increased PA among adults. Moreover, engaging in enjoyable activities like dancing may also have a positive impact on individuals' overall mood.

Motivated by these factors, this research seeks to develop a persuasive intervention to encourage the adult population to improve their PA levels through enjoyable means, such as dancing. Another goal is to positively influence mood and overall well-being. To achieve this objective, we propose to leverage the persuasive potential of Augmented Reality (AR) technology [5], Machine Learning (ML) techniques [14], and gamification strategies [15]. By combining these innovative technologies, we aim to promote healthy behavioral changes, fostering a more active lifestyle through dancing as an engaging and enjoyable form of physical activity.

1.2 Problem Statement

According to the Center for Disease Control and Prevention (CDC), insufficient PA can give rise to diverse forms of cardiovascular diseases, even in the absence of other risk factors [6]. Research has demonstrated that inadequate PA can amplify the incidence of depression and anxiety among individuals. Remarkably, it has been projected that eliminating physical inactivity could potentially prevent approximately 3.2 million deaths globally [2]. However, the most recent data from the World Health Organization (WHO) reveals a disconcerting trend, with 81% of adolescents and 25% of adults worldwide failing to meet the recommended levels of physical activity [16]. This phenomenon can be attributed to a myriad of factors, including evolving transportation patterns, escalated utilization of technology for work and leisure, prevailing cultural norms, and a surge in sedentary behaviors, particularly evident in developed nations.

In recent times, an escalating concern among various stakeholders, including organizations, corporate entities, and government agencies, revolves around the proliferation of unhealthy behaviors and sedentary lifestyles, notably physical inactivity. These deleterious patterns have been linked to a myriad of adverse outcomes, prompting the exploration of strategies to mitigate their impact. Technological innovations, such as mobile games, mobile health applications, and wearable devices like smartwatches that facilitate the monitoring and tracking of PA, have been introduced as potential interventions to promote PA engagement. However, despite the availability of these technological aids, a substantial proportion of adults still exhibit suboptimal commitment to incorporating physical activity into their daily lives, and various factors contribute to this phenomenon. One conceivable reason lies in the perceived time constraints faced by individuals with busy schedules, making it arduous to allocate time for PA pursuits. Additionally, some adults view PA as an uninteresting and burdensome task, offering limited enjoyment and requiring considerable dedication. Consequently, fostering PA engagement and devising effective interventions to encourage individuals to enhance their PA levels proves to be an arduous task, particularly when motivational factors are lacking, and legitimate reasons to abstain from PA exist.

1.3 Solution

Dancing serves as a distinct and captivating form of physical exercise, serving as an avenue for individuals to express their inner emotions to the external world [13]. In the work by Kim et al. [17], dancing is highlighted as an optimal exercise, not only enhancing fitness levels but also fostering enjoyable social interactions, thereby reducing tension and stress. Numerous studies (e.g., [13], [17], [18]) have consistently revealed the multifaceted benefits of dancing in promoting both physical and mental well-being. Concurrently, investigations have underscored the potential of technology in sustaining and augmenting such healthy behaviors, with mobile applications proving to be effective tools for motivating individuals towards increased physical activity [5],

[19], [20]. However, given the continuous advancement of technology, it is crucial to leverage its evolving capabilities to further augment its impact on human health and wellness.

In recent years, the incorporation of innovative technologies such as AR [5] and ML [14] has demonstrated their efficacy in designing intuitive systems aimed at enhancing human engagements and productivity [5], [21]. AR involves the overlay of digital information, such as images, videos, or 3D models, onto the real-world environment, thereby augmenting our perception of reality [22], [23]. This integration of computer-generated elements with the user's physical surroundings typically occurs through devices such as smartphones, tablets, or AR headsets. On the other hand, ML is a specialized subfield of artificial intelligence (AI) [24] focused on developing algorithms and models that enable computers to learn and make predictions or decisions without explicit programming [14]. It emphasizes the creation and implementation of systems that can automatically analyze and interpret complex data, identify patterns, and improve their performance over time by learning from examples or experiences.

In the realm of health and behavioral change interventions, AR and ML technologies have been increasingly utilized to promote PA [5][25]. Notably, Marquet et al. [26] conducted a study evaluating the impact of an AR-driven intervention utilizing location tracking and mapping technology to create engaging tasks, such as searching and capturing virtual creatures (e.g., Pokémon), to encourage PA among college students in the United States. Similarly, Escalona et al. [21] employed AR and ML to implement a rehabilitation intervention that assists patients in their home-based recovery after an injury and elderly individuals in improving their physical capabilities. While these studies have reported positive outcomes, it is essential to recognize the significance of designing interventions that are perceived as enjoyable by the target users while engaging in PA. Such a consideration ensures a higher likelihood of sustained engagement and adherence to the interventions, thereby maximizing their potential impact on health and well-being.

Moreover, to heighten the motivation levels associated with PA, the adoption of gamification, integrated through the persuasive design model (PSD) [27], was pursued. Gamification entails the integration of game-like elements, mechanics, and design principles into non-game scenarios or activities, with the purpose of amplifying engagement, motivation, and user involvement [28][29].

This approach has been recognized by Orji et al. [30] as effective in encouraging healthy behavioral changes through heightened engagement. Hence, the incorporation of gamification into interventions aimed at promoting PA is likely to yield improved effectiveness.

Therefore, the integration of these technologies in formulating a persuasive mobile intervention aimed at promoting PA through dancing presents an intriguing opportunity to explore novel approaches for incentivizing individuals to embrace a healthy lifestyle by partaking in PA in an enjoyable fashion. Our proposed approach involves synergistically harnessing the persuasive attributes of AR, AI, and gamification to heighten the motivational aspects associated with engaging in PA.

1.4 Contribution

The objective of this research was to create engaging and effective interventions for encouraging physical activity among the target users. To achieve this, we conceived the idea of implementing healthy behavioral change techniques that are not only fun and enjoyable but also highly effective. As a result, we developed a cutting-edge mobile intervention named "AR Dancee" by leveraging the power of AR and ML technologies.

Our research aimed to assess the efficacy of the AR Dancee app in promoting PA through dancing and to investigate its potential impact on users' mood. To gauge the effectiveness of the intervention, we conducted a comprehensive study involving 104 participants, utilizing both quantitative and qualitative methods. At the end of the study, all participants rated various design elements of the intervention and 27 of them shared their experiences dancing using the app in an optional interview.

Upon analyzing the collected data, both quantitative and qualitative, we observed that the intervention significantly increased the PA levels of the participants, effectively encouraging them to meet the recommended minimum weekly PA level of 600 MET [31]. Furthermore, we noted that the app had an equally positive effect on promoting PA across all gender identities. However, its effectiveness in promoting PA was particularly higher among younger adults within the age group of 18 to 25.

Our investigation also revealed that the intervention succeeded in introducing dancing as a novel means to improve or maintain PA among the participants. Moreover, we found that the app significantly elevated the participants' positive mood during and after the study. In addition to its mood-enhancing benefits, the intervention was praised by participants for reducing their anxiety levels and aiding in stress management while dancing with the app.

Our intervention proves highly effective in providing people with a new and enjoyable approach to engaging in PA through dancing. This novelty approach utilizes AR and ML algorithms to design dance interventions that solely require a smartphone, eliminating the need for external peripherals or human assistance. Participants can now improve their PA in a perceived enjoyable manner. One novelty aspect of AR Dancee is its capability to accurately calculate the number of calories burned during the dance sessions. This feature adds to its persuasive appeal as a tool to enhance physical activity. To the best of our knowledge, implementing such a mobile, AR, and ML driven dance intervention represents a novel approach to promoting physical activity. Unlike previous dance interventions [17][32][33], which involved dance instructors and wearables to track calories, AR Dancee enables a more accessible and enjoyable experience. This innovative intervention not only benefits current users but also holds promising potential for future researchers. By combining the persuasive elements of AR, AI, and gamification, AR Dancee effectively encourages individuals to maintain a healthy lifestyle through enjoyable and fun PA sessions.

In conclusion, our study's findings lead us to propose design recommendations for interventions focused on promoting PA through dancing. These recommendations encompass various aspects, including integrating diverse dance patterns, accommodating individual user dance styles, extending mechanism to accommodate users' choice of music, include mechanism to allow users' to rehearse behavior, include an audio feedback, introducing preparatory sessions, and implementing interactive AR element. By incorporating these suggestions, it is likely that people will find the interventions more engaging and effective in encouraging physical activity through dancing.

1.5 Research Overview

The remainder of this thesis is organized as follows:

- In chapter 2, we review background research in the field of sedentary behavior, behavioral change, physical activity, mobile and AR technology, dancing, and design strategies to build persuasive interventions that formed the foundations for this research.
- In chapter 3, first, we define concrete objectives that we aim to fulfill through our research. Then, we explain the development of our intervention in detail.
- In chapter 4, we provide an outline of the study design to capture the effectiveness of our intervention.
- In chapter 5, we present the results from the analysis conducted after study.
- In chapter 6, we discuss our findings in relation to existing research, reflect upon our research objectives, and share our design recommendations. Then, we identify the limitations of our work and offer directions for future research.
- In chapter 7, we summarized the main findings of the research and offer some closing remarks.

Chapter 2 : Related Works

The implementation of behavioral change interventions has been a longstanding practice. Over time, researchers and the general population have accumulated evidence demonstrating that adopting healthy behavioral lifestyles leads to improved well-being and reduced risk of premature mortality. This body of evidence has played a crucial role in shaping the development and application of innovative approaches to healthy behavioral interventions. In particular, the focus on promoting physical activity (PA) has witnessed numerous advancements and novel strategies aimed at meeting current demands. The World Health Organization (WHO) has highlighted several factors driving the need for refined PA interventions, including shifts in transportation patterns, increased reliance on technology for work and leisure, evolving cultural norms, and a rise in sedentary behaviors, particularly in developed countries [16]. Despite these efforts, recent WHO statistics indicate that 81% of adolescents and 1 in 4 adults worldwide still fail to engage in sufficient physical activity [16]. This highlights the importance of further exploring effective interventions to address this global concern.

In this chapter, we embark on a comprehensive examination of the extant corpus of research pertaining to interventions aimed at promoting PA. This exploration serves as the fundamental basis for our own research endeavor, underpinning our understanding of the current state of the field. Our discussion on related work will encompass several key aspects, including the cutting-edge interventions that have been developed, and the various methodologies that have been employed to effectuate successful interventions within the domain of PA. To ensure coherence and precision in our review, we have opted to adopt a structured approach. We commence our investigation by focusing on related works concerning sedentary behavior and its mitigation, as well as research centered on facilitating healthy behavioral changes to foster increased PA. Additionally, we delve into studies that investigate the integration of technology into PA interventions, and specifically explore the synergy between AR and PA promotion.

Furthermore, we address the role of dance as a form of physical activity, delving into studies that shed light on its effectiveness and potential impact on overall health and well-being. Finally, we examine research that explores the implementation of persuasive strategies in the context of PA interventions, aiming to understand how such strategies can be harnessed to encourage sustained engagement in physical activities. By synthesizing and critically analyzing these diverse strands of related research, we gain valuable insights into the gaps and opportunities that exist within the current literature. Drawing upon this knowledge, we have devised a research idea that not only leverages existing works but also integrates innovative technologies to enhance the efficacy and appeal of our proposed intervention.

2.1 Sedentary Behavior and its effect on Health

In contemporary discourse, a prevalent misconception exists regarding the conflation of physical inactivity, characterized by minimal exercise, with sedentary behavior [34]. However, it is essential to recognize that engaging in sedentary behavior poses a far greater concern, particularly in light of the growing number of young adults who find themselves in a stage where they possess ample energy but lead sedentary lifestyles. The term "sedentary behavior" has been the subject of numerous definitions in academic research [34]–[36], but certain common elements are inherent in these definitions. It generally refers to any activity involving prolonged sitting without engaging the body, especially the lower part, in any form of physical exertion.

For instance, Tremblay et al. [37] succinctly define sedentary behavior as any waking activity characterized by an energy expenditure ≤1.5 metabolic equivalents of task (METs) while in a seated, reclined, or lying posture. Given the modern advancements in entertainment media, such as television and video games, people find it increasingly challenging to avoid falling into the trap of sedentary behaviors [38]–[40]. Moreover, factors like prolonged office chair usage or extended periods of sitting in a car without the option to stand further contribute to this lifestyle. Consequently, sedentary behavior encompasses any activity that involves prolonged sitting, leading to a state where the human body predominantly expends little to no metabolic energy. It is imperative to note that an escalation in sedentary behavior has been closely associated with several adverse medical conditions, including cardiovascular disease, type 2 diabetes, obesity, high blood pressure, and mental health issues like depression and anxiety [41]. These correlations underline the significance of addressing sedentary behavior and promoting active lifestyles to safeguard public health.

Owen et al. [42] conducted a captivating investigation into sedentary behavior, presenting the ecologic model of sedentary behavior, which consists of four distinct domains: Occupation, Leisure time, Transport, and Household. They postulated that within each of these domains, environmental factors play a significant role in either promoting or discouraging sedentary behavior. The Occupation domain encompasses sedentary behavior within school and workplace environments, while the Leisure time domain includes facilities and aspects of the neighborhood that influence sedentary behaviors in recreational settings. In the Transport domain, the focus is on transit facilities that can impact sedentary behaviors, and lastly, the Household domain covers the home environment and its settings that influence sedentary behavior.

This model's importance is underscored by empirical evidence. For instance, Clark et al. [43] demonstrated that Australian adults with lower education levels living in rural areas tend to spend more time engaging in sedentary activities, such as watching TV, primarily in the Household domain. Similarly, research conducted in the US [44] concluded that people in suburban environments spend more time sitting in their cars during commutes due to limited availability of public transit options, which falls within the Transport domain. Considering the four domains outlined by Owen et al. [42], it is evident that environmental factors play a significant role in influencing sedentary behavior. Therefore, interventions targeted at addressing sedentary behavior must be adapted to specific environmental settings to achieve optimal effectiveness, as what may work effectively in one environment might not yield the same results in another.

Sharon and Leon [36] conducted a study utilizing an Actical accelerometer to investigate the contribution of office work to the overall sedentary behavior of office workers in Australia. The researchers recruited a sample of 50 office workers employed by a large resource company. These participants were instructed to wear the Actical accelerometer for a duration of seven days, during all waking hours, except during specific activities such as bathing and engaging in contact sports. To ensure comprehensive data collection, the participants were advised to wear the accelerometer both on working days and non-working days. This approach enabled the researchers to analyze sedentary behavior patterns in different contexts. Additionally, the researchers measured the level of light activity exhibited by the participants on both workdays and non-workdays. The results revealed that 78% of the participants exhibited a higher proportion of sedentary time on workdays compared to non-workdays. Furthermore, 84% of the participants displayed proportionally less light activity on workdays in contrast to non-workdays. Based on these findings, Sharon and Leon [36] argued that although office workers are often perceived as having lower risks in comparison to field workers (e.g., engineers and plumbers), they may, in fact, face significant health-related challenges due to their high levels of sedentary behavior. This suggests that interventions targeting the reduction of sedentary behavior among office workers are crucial to safeguard their well-being.

In a distinct research endeavor, Carl et al. [45] undertook an extensive investigation to examine the implications of sedentary behavior and physical inactivity on all-cause and cardiovascular disease (CVD) mortality. The study spanned a 12-year period and involved 17,013 Canadian participants who self-reported their behaviors. Carl et al. [45] conducted a longitudinal study in Canada, wherein they observed that 54% of the participants who reported engaging in nearly constant daily sitting had a significantly higher risk of mortality from all-causes and CVD when compared to those who reported minimal time spent in sitting positions.

To further explore the link between sedentary behavior and mortality risk, Carl et al. [45] also considered a related study conducted in Australia by Clark et al. [43]. This Australian study spanned approximately 7 years and examined the habits of Australian adults who spent different amounts of time watching television in a seated position. Among the 8,800 participants who self-reported their television viewing habits, it was observed that those who watched television for less than 4 hours per day experienced an 80% increase in the risk of all-cause and CVD mortality, while those who watched television for less than 2 hours per day experienced a 45% increase in such risk. Based on the cumulative findings of these studies, Carl et al. [45] put forth the argument that individuals who engage in prolonged periods of sitting without engaging in intermittent physical activity may experience reduced expression of key metabolic regulators, which could consequently contribute to increased mortality risks from all-causes and CVD. Furthermore, it is worth noting that previous research has suggested a close association between physical inactivity and metabolic disorders, particularly impaired glucose metabolism. This association has been identified as a significant contributing factor to the heightened risk of CVD [46].

The present study delves into a captivating dimension of sedentary behavior; its direct impact on depressive symptoms. While extensive research exists on the association between sedentary behaviors and various chronic diseases, the potential risks on mental disorders, particularly depression, have been comparatively understudied. To address this knowledge gap, Teychenne et al. [11] conducted a comprehensive examination of the evidence surrounding the influence of sedentary behavior on the risk of depression. The researchers employed rigorous methodologies, adhering to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines [47] for observational studies and the CONSORT (Consolidated Standards of Reporting Trials) guidelines [48] for intervention studies, ensuring the quality assessment of each study.

In their investigation, the team utilized the Beck Depression Inventory [49] and the Center for Epidemiologic Studies Depression Scale [50] as validated measures to assess the association between sedentary behaviors and depression in both observational and intervention studies. Among the seven observational studies analyzed, one particular study [51] revealed a significant finding. Participants exhibiting the highest levels of sedentary habits at baseline (>42 h/week) exhibited a 31% increased likelihood of being at risk for a mental disorder compared to those with lower levels of sedentary behavior at baseline (<10 h/week). In contrast, the two intervention studies examined by Teychenne et al. [11], identified as [50] and [51], displayed minimal associations between sedentary behavior and depression. Specifically, one of these intervention studies [52], which explored sedentary behavior associated with internet use, observed that participants initially displayed high depressive symptoms. However, over time, these symptoms diminished, suggesting that sedentary time spent on the internet may have a beneficial effect in reducing the risk of depressive symptoms.

In light of these findings, Teychenne et al. [11] cautiously concluded that while the relationship between sedentary behavior and mental disorders such as depression warrants further investigation, their results suggest that the nature or purpose of sedentary behavior could play a defining role in its association with depression.

Owen et al. [35] investigated the potential metabolic health consequences of sedentary behavior, particularly extended periods of sitting time, even among individuals who meet the weekly global physical activity standard of engaging in over 150 minutes per week of moderate-to-vigorous intensity PA [54]. Contrary to common assumptions, Owen et al.'s argument [35] demonstrates that meeting the recommended physical activity levels does not render the metabolic impact of sedentary behavior inconsequential. Owen et al. [35] assessed the association between a common leisure-time sedentary behavior, such as television viewing time, and biomarkers of cardio-metabolic risk in a cohort of 11,000 Australian adults without clinically diagnosed diabetes.

Their self-reported data revealed a positive correlation between prolonged television viewing time while sitting and undiagnosed abnormal glucose metabolism [55] as well as the metabolic syndrome [56]. It is important to note that these associations were observed even in individuals who met the weekly global physical activity standard, suggesting that excessive sitting time may independently contribute to metabolic health risks. In addition, Owen et al. [35] examined the relationship between television viewing time and continuous metabolic risk in both men and women who consistently met the global physical activity standard over time. Their results further reinforced the potential adverse effects of prolonged sitting on metabolic health, regardless of individuals' compliance with the physical activity guidelines. To mitigate the negative impact of sedentary behavior on metabolic health and mortality risks, Owen et al. [35] study emphasizes the importance of breaking up prolonged sitting time at regular intervals. Encouraging individuals to engage in brief bouts of activity throughout their day may prove beneficial in reducing metabolic health risks associated with excessive sedentary behavior, such as prolonged television viewing.

In accordance with Owen et al.'s [35] research, which emphasizes the advantages of mitigating metabolic health risks through interruption of sedentary time, the findings align with the investigations conducted by Saunders et al. [57]. A key aspect of Saunders et al.'s [57] study was to explore the consistency of these outcomes in children with a familial history of obesity. For this purpose, the researchers recruited a cohort of 522 Canadian children aged 8 to 11 years, all of whom had at least one parent with obesity. Throughout the study, the participants were directed to wear an accelerometer on their right hip during all waking hours for a duration of 7 days, encompassing weekends, except during activities like bathing or swimming. Additionally, the children were requested to report the duration of time spent engaging in sedentary activities such as watching television or playing computer games while in a seated position, also for the same 7-day period.

To ensure precision in their research, the investigators measured several parameters, including sedentary bouts (periods of uninterrupted sedentary time), breaks in sedentary time, and overall sedentary behavior for each participant. The results of the study consistently aligned with the researchers' hypothesis, which posited a positive association between continuous cardiometabolic risk scores and sedentary behavior, along with a negative association with breaks in sedentary time within this specific population. According to their findings, children who frequently interrupted their sedentary time demonstrated lower levels of cardiometabolic risk compared to those with fewer breaks in their sedentary behavior. Moreover, the researchers suggested that the associations between breaks in sedentary time and cardiometabolic risk may be particularly pronounced among participants with a familial history of obesity, considering previous studies that have linked parental obesity to heightened childhood cardiometabolic risk. It is essential to acknowledge that the researchers caution against generalizing their findings to all children or young adults, as the sample specifically focused on children with a familial history of obesity. Consequently, the outcomes may not be universally applicable across diverse populations.

In an effort to address the underlying cause of sedentary behavior, Prapavessis et al. [58] conducted research aiming to establish preliminary evidence for the influence of Social Cognitive theories [59], particularly the Theory of Planned Behavior (TPB), as a fundamental factor in driving individuals to adopt sedentary behaviors, which they refer to as "sedentarism." The researchers focused on exploring the role of psycho-social variables in motivating people to engage in sedentary behaviors, without necessarily evaluating the trade-off between benefits and costs associated with such behaviors. According to the TPB, an individual's intention to engage in sedentarism is a primary determinant of actual sedentary time. Therefore, comprehending both conscious and unconscious decision-making processes that lead to sedentary behavior is crucial for developing effective intervention approaches. Prapavessis et al. [58] identified three key determinants of intentions that influence individuals to engage in sedentary behavior: attitude, subjective norms (SN), and perceived behavioral control (PBC). Attitude refers to an individual's perception of the benefits and costs associated with sitting and reclining, SN represents how others perceive an individual's actions towards sedentary behavior, and PBC reflects an individual's perception of control over the time spent being sedentary.

The researchers acknowledged that intentions to engage in sedentary behaviors may vary depending on the context, such as comparing non-leisure sedentary activities (e.g., work/school computer use) to leisure sedentary activities (e.g., television viewing, video gaming, listening to music, and socializing). Consequently, there was a need to assess the predictive strength of TPB determinants on individuals' sedentary intentions in different contexts. In summary, Prapavessis et al.'s [58] study sheds light on the significance of Social Cognitive theories, particularly the TPB, in understanding the motivations behind sedentary behavior. Their findings highlight the importance of considering attitude, subjective norms, and perceived behavioral control as influential factors in shaping individuals' intentions to engage in sedentary behavior, which can aid in developing targeted and context-specific interventions to promote more active lifestyles.

Moreover, Prapavessis et al. [58] conducted a comprehensive investigation utilizing the Theory of Planned Behavior (TPB) framework to assess the impact of social-cognitive factors on sedentary behavior among individuals. The study employed a sedentary behavior questionnaire [60] that was refined to include pertinent inquiries pertaining to the three key determinants of intentions, namely attitude, subjective norms (SN), and perceived behavioral control (PBC). A sample of 372 Canadian adults was recruited for the study, and participants were required to provide information regarding the amount of time they spent engaged in various forms of sedentary activities on both weekdays and weekends over a period of seven days. The study's findings offer further support for the practicality of social-cognitive constructs grounded in TPB for comprehending the intentions and behavior associated with sedentary lifestyles. The research highlights that addressing an individual's sedentary intentions may be just as crucial as addressing their behavioral outcomes.

It is evident that numerous individuals, despite being aware of the health risks associated with prolonged sitting and sedentary behaviors, continue to adopt sedentary habits due to conscious or unconscious decisions. While the TPB constructs demonstrate considerable predictive power in explaining the intentions behind sedentary behaviors, the researchers acknowledge the necessity for more extensive investigations to establish the validity of this framework in guiding future interventions aimed at reducing sedentary behavior among the population. Further research in this area would be instrumental in formulating effective strategies to promote a more active lifestyle and combat sedentarism in individuals.

2.2 Healthy Behavioral Change

In contemporary society, the pursuit and advocacy of healthy behavior and lifestyle have gained significant prominence as intangible assets. These aspects are not only perceived as crucial for maintaining a state of well-being but also recognized as key contributors to overall health [61]. Nevertheless, the prevalence of unhealthy behaviors and lifestyles, such as physical inactivity, has raised substantial concern among various stakeholders, including organizations, corporate bodies, and government agencies, due to their adverse effects on individuals' lives [62].

Despite the overwhelming evidence linking healthy behaviors to overall health and wellness, unhealthy lifestyles persist among a significant portion of the population [63]. The reasons for this persisting trend are multifaceted. Nevertheless, the implementation of effective campaigns promoting healthy living through diverse techniques can make a substantial difference. These techniques are collectively referred to as healthy behavioral change techniques, as their primary objective is to motivate individuals to consciously adopt healthy behaviors and lifestyles. Several common healthy behavioral change techniques, such as awareness creation, knowledge improvement, intention promotion, self-efficacy, and social influence, have been identified as foundational elements in promoting healthy behavior and lifestyle [63]. However, it is crucial to recognize that the efficacy of a healthy behavior change intervention is closely tied to the specific behavioral change techniques employed. The effectiveness of techniques utilized to promote one healthy behavior may not necessarily yield the same results when applied to another healthy behavior promotion [63]. Therefore, the success of a healthy behavioral change program hinges on the careful design and implementation of appropriate techniques tailored to the targeted healthy behavior. By adopting a systematic approach and employing evidence-based strategies, a well-crafted healthy behavioral change program is more likely to achieve its intended goal of promoting the desired healthy behavior.

Javier et al. [64] conducted a research study aimed at evaluating the impact of a school-based multiple healthy behavior change (MHBC) intervention on young adults in high school. The researchers based their intervention design on three theoretical frameworks: the Social Ecological Model (SEM) [42], Self-Determination Theory (SDT) [65], and Theory of Planned Behavior (TPB) [59]. This intervention, known as "Paths of the Pyrenees," was implemented both within and outside the school setting. To assess the effectiveness of the MHBC intervention, the researchers recruited a total of 210 participants from two different schools in Spain. The participants were divided into two groups: the control group and the intervention group. The targeted healthy behaviors included physical activity, sleep quality, diet, and sedentary screen time. The study duration spanned one academic year, during which curricular and extracurricular activities were employed. Data on participants' health literacy skills and lifestyle were collected before and after the study to measure the impact of the intervention. For the intervention group, the researchers integrated the MHBC program into the participants' curricular activities, delivered by their respective teachers. To enhance the effectiveness of the extracurricular sessions, participants were required to engage in these sessions alongside their parents or guardians. Both the curricular and extracurricular sessions included health education lessons and health action recommendations, which the intervention group participants were expected to learn and apply. On the other hand, participants in the control group did not receive any health education lessons or healthy lifestyle recommendations to follow during the study period. At the conclusion of the study, the researchers observed significant improvements in health behavior knowledge and lifestyle related to the targeted healthy behaviors among the participants in the intervention group when compared to those in the control group.

Downs et al. [66] devised a health-oriented behavioral change intervention known as "The Strong Healthy Women" intervention, aimed at fostering a healthy lifestyle among women before, during, and after pregnancy, specifically pertaining to weight gain and Body Mass Index (BMI). The intervention targeted various health-promoting behaviors, encompassing the reading of food labels for nutritional information, the use of a daily multivitamin containing folic acid, adherence to recommended physical activity levels per week as established in previous studies [54], and the consumption of fruits and vegetables on a daily basis. Within the confines of a 12-week study they conducted, the researchers observed a noteworthy and statistically significant positive outcome resulting from the implementation of this intervention. The study findings indicated that the intervention showed promise in potentially influencing women's behavior, thereby mitigating adverse pregnancy outcomes, such as preterm birth and low birth weight. However, the researchers acknowledged the necessity to ascertain the effectiveness of the intervention over an extended period. They posited that examining the persistence of healthy behavior compliance within 6-12 months of follow-up might reveal if similar or even more favorable results could be obtained.

Subsequently, to address this aspect, Weisman et al. [67], in their own research endeavor, carried out a randomized control trial involving 362 women aged between 18 and 35 years. This trial involved the utilization of "The Strong Healthy Women" intervention developed by Downs et al.

[66]. Weisman et al. [67] conducted a study to assess the effectiveness of a healthy behavior change intervention, focusing on three key factors. Firstly, they sought to determine whether the adoption of a healthy behavior lifestyle by women was sustained over a 12-month period. Secondly, the researchers investigated whether compliance with the intervention had any impact on the weight and BMI status of the participants during the 12 months of follow-up. Lastly, they examined whether intervention compliance played a role in influencing the level of weight gain among women who became pregnant and gave birth within the 12-month study period.

For the subgroup of women who gave birth during the study period, the researchers observed a significant positive effect of the intervention on weight gain and BMI levels compared to the control group. Additionally, all women in the intervention group demonstrated a positive outcome in terms of weight and BMI compared to women in the control group. However, it was noted that some aspects of the participants' healthy lifestyle declined over the 12-month follow-up period for certain behaviors promoted by the intervention. The specific reasons for this decline were not explicitly mentioned in the study. Nonetheless, the researchers inferred that a lack of continuous support from the healthy behavioral change program could have influenced these outcomes. The Strong Health Women intervention provided extensive information on healthy diet and lifestyles, including regular exercise. Weisman et al. [67] argued that the plausible long-term results regarding weight, BMI, and pregnancy weight increase were attributable to the comprehensive nature of the intervention's content.

Zabaleta-del-Olmo et al. [68] conducted a research study aimed at evaluating the effectiveness of a primary health care (PHC) intervention program for promoting healthy behavior change in Spain, targeting individuals between the ages of 45 and 75 years old. The study focused on implementing a multiple health behavior change (MHBC) intervention that aimed to reduce smoking, increase PA, and encourage adherence to a healthy diet plan. The researchers enrolled a total of 3,062 participants in the study and randomly divided them into two groups: a control group and an intervention group. Over a period of 12 months, both groups were closely monitored and assessed based on their ability to maintain a healthy lifestyle with regard to the three targeted behaviors specified in the intervention. The control group received engagement in a Program of Preventive Activities and Health Promotion [69], designed to assist them in maintaining a healthy lifestyle. On the other hand, the intervention group followed a comprehensive daily health practice tailored to their individual behaviors and stages of change, utilizing approaches at the individual, group, and community levels.

To measure the level of adherence to each of the targeted behaviors, the researchers collected data before and after the 12-month study for both randomized groups. Upon analyzing the results, the researchers found that participants in the intervention group demonstrated a significantly more positive change in at least two-thirds of the targeted healthy behaviors compared to the control group. Based on their findings, the researchers concluded that the MHBC intervention was more effective and impactful in promoting healthy behavior change among adults aged 45 to 75 than the standard care provided during the same study period. This highlights the potential of PHC intervention programs, specifically tailored to address multiple health behaviors simultaneously, in influencing positive changes in healthy behaviors among the target age group.

Kelly et al. [70] conducted a study exploring the relationship between treating substance use disorder and the potential impact on engaging in other unhealthy behaviors, such as smoking, physical inactivity, and poor diet. The researchers employed a non-randomized pilot study involving 77 participants who were currently undergoing treatment for substance use disorder. The main objective of their healthy behavior intervention was to prevent patients from resorting to increased smoking or other unhealthy habits during their withdrawal from substance use. The study spanned over a 5-week intervention period, followed by a 10-week post-intervention observation phase. To assess the effectiveness of the intervention in promoting health recovery, the participants were divided into experimental and control groups. It is crucial to note that the control group received standard treatment for substance use disorder, while the experimental group received the standard treatment along with the additional healthy behavior intervention. The findings revealed that the intervention had a moderate effect on reducing or ceasing smoking habits. However, its impact on mitigating physical inactivity and improving dietary habits was relatively limited. Importantly, the researchers emphasized that the lack of significant effect on the latter behaviors did not imply that the participants exhibited a decline in those aspects. Rather, both the experimental and control groups demonstrated a slight positive change and willingness to improve the targeted healthy behaviors, with no substantial difference between the two groups.

Clare et al. [71] conducted a research study to examine the effectiveness and acceptability of a healthy behavior intervention with a particular emphasis on goal setting. Their investigation was centered around healthy behaviors involving cognitive and physical activities known to potentially reduce the risk of dementia during the aging process. To carry out the study, the researchers recruited 57 participants, employing a randomized controlled approach, and subsequently divided them into three distinct groups. The first group was designated as the control group, while the second group constituted the intervention group with a focus solely on goal setting. The third group shared similarities with the second group but also participated in a mentorship program as an additional component of the intervention. The design of the intervention was based on behavior change models [72], which aimed to foster the adoption of healthy behaviors that could be sustained over an extended period.

During the study, each participant engaged in a 90-minute one-on-one interview, during which health-related information was discussed. It is important to note that both the goal setting group and the goal setting and mentorship group were exposed to the intervention. The primary distinction between these two groups was that the latter participated in a mentorship program throughout the 12-month follow-up period. Based on their findings, Clare et al. [71] observed that the intervention significantly contributed to improving participants' adoption of healthy behaviors, particularly when facilitated by goal setting. Notably, the researchers noticed a comparable level of effectiveness between the two groups that received goal setting interventions. Consequently, the study suggested that goal setting plays a pivotal role in motivating participants to adhere to intended healthy behaviors and lifestyle changes. Thus, the incorporation of a goal setting approach holds substantial promise when designing future healthy behavior interventions intended to mitigate the risk of dementia during aging.

The exploration of personal traits in relation to the effectiveness of interventions promoting healthy behavior changes remains an area of limited investigation. Stieger et al. [73] worked on this domain by conducting a comprehensive 5-week study aimed at assessing the impact of a healthy behavior intervention concerning the participants' individual traits. The researchers focused on personal traits such as high conscientiousness and healthy neuroticism [74], hypothesizing that these factors could influence the level of adherence to healthy behavior practices, particularly regarding physical activity. To conduct their investigation, the researchers recruited 52 participants and utilized randomization to divide them into two groups: a control group and an implementation intention group. Before the intervention, each participant's baseline levels of conscientiousness and neuroticism were assessed. Both groups were exposed to the same intervention, which involved the utilization of Fitbit [75] technology. However, the implementation intention group received additional instructions on how to effectively plan and manage their PA routines. The results of the study indicated that participants possessing high conscientiousness traits exhibited greater effectiveness in improving their physical activity levels through the health behavior intervention. Moreover, individuals with higher levels of neuroticism and conscientiousness demonstrated a higher willingness to adhere to the intervention requirements compared to those with lower levels of either or both of these personality characteristics. These findings shed light on the potential significance of personal traits in influencing the success of interventions geared towards promoting healthy behaviors. Further research in this area may offer valuable insights for designing more tailored and effective behavior change programs in the future.

In the context of healthy behavioral change interventions, a recurrent trend among the discussed methods is the incorporation of at least one healthy behavioral change technique, such as awareness creation, knowledge improvement, and intention promotion. Notably, the majority of these interventions have been reported by researchers as effective. However, it is imperative to explore avenues that ensure the maintenance of sustained healthy behavior among the target audience. The motivation for engaging in healthy behaviors can often stem from a reminder-based approach, wherein individuals are reminded of the benefits associated with adopting a healthy lifestyle or the consequences of an unhealthy one. Traditional methods of employing reminder approaches have become less prevalent since the advent of technology, which has proven to be more efficacious in this regard [5]. Of particular significance are the behavioral change strategies proposed by various theories. These strategies offer a promising framework for facilitating the acquisition of self-regulatory skills necessary for individuals to effectively engage in and maintain healthy behavior over the long term. Among these skills, goal setting and self-monitoring play pivotal roles [76]. Further exploration and implementation of these theories could contribute significantly to fostering enduring positive behavioral changes in individuals.

2.3 Technology and Physical Activity

The progression of the Internet of Things (IoT) [77] has become increasingly prominent, alongside the widespread integration of technology, facilitating the implementation of effective interventions aimed at mitigating sedentary behavior and physical inactivity [5]. Physical activity is defined as voluntary bodily movements involving muscular engagement and energy expenditure [78]. Maintaining a physically active lifestyle is widely recognized as a pivotal element in promoting overall well-being [5]. Various means exist to engage in PA; however, the significance of technology cannot be underestimated in fostering a sustainable culture of healthy living across diverse age groups. Researchers acknowledge the pivotal role of technology in shaping our daily lives and its potential to facilitate the accomplishment of numerous tasks. As a result, contemporary interventions frequently incorporate various forms of technology to enhance their efficacy.

Lyon et al. [79] conducted a research study aimed at exploring the effectiveness and acceptability of a PA wearable technology intervention, coupled with periodic phone counseling, on older adults aged 55 to 79 years. The researchers posited that while designing physical activity interventions with wearable technology has proven effective in younger adults, its acceptance and impact among older adults, who are more prone to engage in sedentary activities, remains largely unexplored. To address this gap, they carried out a 12-week study involving 40 participants, who were randomly assigned to either the control (waitlist) or intervention group. During the study, all participants were required to set daily and weekly step count goals. Additionally, they were provided with an idle monitor that alerted them when they remained physically inactive for more than an hour. In the intervention group, participants were exposed to the PA wearable technology intervention, which enabled them to monitor their progress toward meeting their step count goals. Moreover, the intervention group received weekly telephone counseling sessions to discuss their progress and reinforce their commitment to the set goals.

The findings of the study indicated that the use of the PA wearable technology intervention, in conjunction with phone counseling, was well-received and deemed feasible by the participants. This integrated approach was found to be acceptable to the older adult population, reflecting their willingness to engage with the technology and counseling sessions. As a result, the researchers concluded that more extensive application of the intervention might lead to modest yet potentially clinically significant improvements in both the duration of PA and step count among older adults. The study's results encourage the implementation of such interventions to promote PA and health in this particular age group. Further research and larger-scale studies are recommended to validate and expand upon these findings.

In their research, Berg et al. [80] employed internet technology as a means to implement a home-based PA intervention for patients with Rheumatoid Arthritis (RA). The primary objective of their study was to compare the effectiveness of two distinct technology interventions they developed to promote PA among RA patients. The first intervention took the form of a web-based system providing general information about various forms of PA along with practice recommendations. The researchers regularly updated this information on a monthly basis. In contrast, the second intervention was also web-based, but it featured personalized user accounts through which participants received detailed individualized PA programs every week. These personalized programs encompassed muscle strengthening exercises, range-of-motion (ROM) exercises, and cycling on a bicycle ergometer.

To carry out their study, Berg et al. [80] recruited 160 RA patients from three hospitals in the Netherlands, whom they then randomly assigned to either an individualized training (IT) group or a general training (GT) group. Participants in the IT group were additionally provided with exercise equipment and received tailored feedback on their performance each week after submitting their progress through a secure email system. The researchers collected data on participants' performance and other relevant measures during four phases of the study: at the 3rd, 6th, 9th, and 12th months. The results of the study revealed that a home-based PA intervention supported by tailored feedback demonstrated higher effectiveness compared to the other intervention without personalized support. These findings are consistent with previous research demonstrating that technology-driven interventions tailored to promote healthy behavioral changes, such as increased PA, can have a significant impact on their overall effectiveness [81][5][82].

Shin et al. [83] conducted a feasibility study involving 43 participants to evaluate the efficacy and acceptability of a technology-enhanced PA intervention aimed at mid-age adults (aged 35 to 64) of Korean American descent. The primary objective of the intervention was to enhance participants' cognitive skills (knowledge and information) and behavioral approach (goal setting and self-monitoring) toward engaging in regular PA. The intervention focused on promoting walking as the preferred form of PA. To monitor participants' PA levels, each individual was instructed to wear a Fitbit device throughout their waking hours, excluding aquatic activities. The study was designed to span 12 weeks, divided into two distinct phases: an initial 4-week phase followed by an 8-week phase.

During the first 4 weeks, participants attended bi-weekly individual or small group PA education sessions. Subsequently, in the remaining 8 weeks, participants were organized into two- or three-member groups for the purpose of engaging in group walks. Additionally, all participants received weekly text message reminders regarding their walking activities throughout the entire 12-week duration of the study. Upon completion of the feasibility study, Shin et al. [83] compared the PA levels of participants before and after the intervention. The findings revealed a significant reduction in physical inactivity and failure to meet PA guidelines among the participants. Based on the results obtained, the researchers concluded that the intervention proved effective and acceptable among mid-aged adults of Korean American descent. They also suggested that the intervention's success could potentially be replicated when applied to other ethnic populations and across various age groups.

Gell et al. [84] conducted an investigation to assess the acceptability, efficacy, and effectiveness of a technology-driven intervention aimed at cancer survivors who had previously undergone a 12-week exercise-based oncology rehabilitation program. The research team recruited 24 cancer survivors and designed a 4-week study with two primary objectives. Firstly, they sought to determine if the PA levels of the cancer survivors could be maintained after completing the oncology rehabilitation through the implementation of their technology-driven intervention. Secondly, the researchers aimed to investigate whether there would be a significant increase in self-regulation, particularly in terms of goal setting and relapse prevention, among the participants. To evaluate these intended outcomes, the researchers collected data on the PA levels and self-regulation scores of the participants at the beginning and end of the study. To accurately measure physical activity, participants were equipped with a waist-worn accelerometer (Actigraph GT3X+; Actigraph, Pensacola, FL) and a portable GPS unit (QStarz BT-Q1000XT) to carry with them for

7 days. Additionally, participants wore a Fitbit One [79] PA monitor to track their step count and moderate-to-vigorous physical activity (MVPA) minutes, with the exception of aquatic activities. This self-monitoring approach allowed the researchers to provide tailored messages to the participants based on real-time PA data from the Fitbit device. Furthermore, health coaching sessions were organized for participants as part of the intervention study.

The results of the study indicated that the initial PA levels of the participants were maintained, demonstrating the effectiveness of the technology-driven intervention in promoting physical activity among cancer survivors. Additionally, the researchers observed a significant increase in the self-regulation scores of the participants. However, it should be noted that the participants also experienced a significant increase in fatigue severity by the end of the study. The researchers attributed the enhanced self-regulation primarily to the inclusion of health coaching sessions during the intervention study. In conclusion, the technology-driven intervention employed in this study was well-received by the participants, with a high level of acceptance reported. The intervention proved effective in sustaining physical activity levels among cancer survivors, while also facilitating notable improvements in self-regulation, though caution should be exercised regarding potential fatigue issues.

Blakes et al. [85] implemented a technology-based health communication intervention using email and short message service (SMS) with the primary objective of promoting a healthy lifestyle, particularly focusing on PA, among hospital employees. The study spanned a duration of 12 weeks and involved the recruitment of 266 participants from various locations across the United Kingdom. The intervention incorporated personalized and targeted text messages or emails, designed in accordance with the theory of planned behavior (TPB) [58]. To assess the effectiveness of both email and SMS in the intervention, the researchers employed a randomized control trial, dividing the participants into two groups. Both groups received the same content at the same time, with the only distinction being the delivery method: one group received the messages via email, while the other received them via SMS.

The research objectives extended beyond enhancing PA within the hospital setting; they also targeted recreational activities that could contribute to improved PA levels outside of the participants' work environment. To gauge the impact of the intervention, Blakes et al. [85]

measured the participants' PA levels at baseline, the 3rd week, the 6th week, the 12th week, and the 16th week, utilizing self-reported data obtained through global PA questionnaires. Additionally, the researchers conducted a follow-up assessment four weeks after the intervention to determine whether any positive effects on healthy lifestyle compliance persisted after the study. The findings of the study indicate that the technology-based health communication intervention employing both email and SMS successfully promoted PA among hospital employees both within and outside the hospital environment. Although both email and SMS were effective in stimulating PA, the researchers observed that emails, in particular, offered distinct benefits for hospital employees. This research sheds light on the potential of technology-based health communication interventions in positively influencing physical activity behaviors among hospital employees, providing valuable insights for future initiatives aimed at improving overall employee health and well-being in healthcare settings.

Lynch et al. [86] utilized wearable technology to investigate the effectiveness of a moderate-to-vigorous physical activity (MVPA) intervention aimed at promoting MVPA and reducing sedentary behavior among breast cancer survivors in Australia. The intervention involved two main components: the adoption of the Garmin Vivofit 2 activity monitor for behavioral feedback and goal-setting, and a series of five health coaching sessions delivered through telephone calls. The researchers recruited a total of 83 physically inactive breast cancer survivors and randomly assigned them to either the intervention group or the control group for a 12-week study period. Baseline MVPA scores were measured and recorded for all participants in both groups. Throughout the study, the control group did not receive any intervention, while the intervention group was exposed to the aforementioned components. For participants in the intervention group, the study began with a behavioral feedback and goal-setting session. Subsequently, they were provided with the Garmin Vivofit 2 activity monitor to wear on their wrist, which displayed steps, distance, calories, and sleep/rest time during the entire study duration. Moreover, the intervention group participants received five health coaching sessions through telephone calls, during which their goals were reviewed and reinforced. The results of the study indicated a significant increase in MVPA levels among participants in the intervention group, along with a notable reduction in sedentary behavior compared to those in the control group. These findings supported existing research suggesting that wearable technology, including activity monitors (commonly known as "wearables"), can facilitate changes in sedentary behavior and physical activity levels. Notably, wearable devices are considered highly favorable tools for scalable health promotion initiatives due to their cost-effectiveness and wide appeal [86].

The efficacy of technology-driven interventions is beyond question. The examination of the research papers in this section underscores the necessity for contemporary interventions, particularly in promoting physical activity, to embrace diverse technological advancements. Most of the relevant studies reviewed incorporated multiple technological devices or approaches to create effective interventions. However, it is worth noting that the development of such interventions could be resource-intensive and time-consuming for both researchers and potential users. Furthermore, interventions reliant on numerous technological tools may suffer from limited reach due to geographical constraints, as potential users might be required to access these interventions in a laboratory setting.

As technology continues to advance, its demands and capabilities grow in tandem. The ubiquity of innovative technology has addressed the challenge of reaching a broader population to a considerable extent, leveraging the power of miniaturization [87]. Technological innovations have proven effective in delivering interventions without requiring direct physical proximity to the target audience. Consequently, there is an imperative to further explore the potential of technology to develop interventions that are cost-efficient, highly effective, and require less development time. Additionally, researchers must investigate methods to target a more extensive and geographically diverse audience when designing physical activity interventions, given that physical activity is considered a fundamental aspect of healthy behavior [5]. In light of the ubiquitous nature of technology, we propose a cost-efficient physical activity intervention that can reach a wider audience and address the challenges identified in previous research. By leveraging technology effectively, we aim to develop interventions that will be accessible to a larger population and contribute to promoting healthier lifestyles.

2.4 Mobile Technology and Physical Activity

The advent of mobile technology has ushered in new possibilities for the development of effective and viable behavioral interventions aimed at promoting healthier lifestyles. Specifically, the widespread availability and accessibility of mobile health (mHealth) apps have enabled researchers to reach a broader audience, encompassing a larger number of individuals who can actively participate in monitoring their progress towards healthy behavioral changes [5]. Among the various interventions delivered through mobile apps, PA interventions have emerged as a prominent focus in recent times [88]. Extensive research has demonstrated the impact of smartphone-driven interventions in promoting PA [89], [90]. By leveraging such interventions, users are empowered to uphold self-regulatory practices, including goal setting and self-monitoring, thereby enhancing the likelihood of successful behavioral modification. A prevailing concern pertains to designing mHealth interventions that facilitate user engagement, irrespective of their location. This strategic approach holds immense potential in shaping the healthy behavioral lifestyle of target users and fostering adherence to positive behavioral changes. Furthermore, the ubiquity of smartphone usage across all age groups makes it feasible to tailor PA interventions for both the general population and specific age groups, catering to their unique needs and preferences with relative ease.

Dzielska et al. [91] conducted a research study to investigate the effectiveness of the Health Me program, which is a mobile technology-driven intervention aimed at promoting healthy behavioral changes among Polish teenage girls aged 15 years. The researchers identified a pressing concern for the future health of young girls, especially around the age of 15, due to unhealthy practices that are prevalent among them from a younger age. To assess the impact of the intervention, the researchers employed the Social Cognitive Theory [58] as the theoretical foundation and structured the intervention into four thematic phases: physical activity, eating behavior, risk behavior, and personal and social competencies. In total, 1111 girls were recruited for the study and randomly assigned to one of three groups. The first group, referred to as the Full group, received the complete set of intervention components. The second group, known as the Partial group, was exposed to only some of the intervention components, while the third group, named the Null group, received little to no components of the intervention. Each participant was provided with a dedicated mobile app and a fitness band tailored to their group, which facilitated the collection of data related to step count, heart rate, distance covered, and sleep quality.

One notable distinction between the intervention groups was that both the Full and Partial groups received health lifestyle tips through short messages within their mobile apps, whereas the Null group received none. Furthermore, the Full group exclusively had access to healthy lifestyle articles and gamification elements, such as PA competitions and leaderboards for comparison, in their mobile app version. Despite these differences, all groups participated in health promotion campaigns focusing on physical activity, healthy eating, and personal and social competence within their schools and on social media. To evaluate the effectiveness of the intervention, the researchers analyzed participants' healthy behavior change using a health behavior index (HBI). The HBI scores were compared at baseline, immediately after the intervention, and at a 3-month follow-up. The results indicated that the intervention was effective overall. Additionally, it was observed that girls with excess body weight (overweight or obese) scored higher on the HBI after the three-month intervention period compared to non-overweight girls. As suggested by Dzielska et al. [91], this difference could be attributed to the higher motivation exhibited by overweight girls towards using the mobile-driven intervention, despite the intervention being targeted to 15-year-old Polish girls in general.

Haque et al. [92] conducted a research study that aimed to investigate the effectiveness of a persuasive mHealth app called iGo in promoting PA among office workers within their workplace environment. To design the intervention, the researchers incorporated elements of persuasive technology [27], drawing upon the principles of the self-determination theory (SDT) of motivation [93] and gamification [28]. Both SDT and gamification have previously demonstrated efficacy in developing motivational apps across various health domains, including PA. The hypothesis posited by the researchers was that office employees tend to display low levels of physical activity during their work hours. Consequently, they proposed that an intervention incorporating the SDT and gamification model could serve as a means to motivate target users to engage in physical activity even while at work. To evaluate their hypothesis, the researchers conducted a 4-week study involving 84 office-based employees recruited from four different countries (Finland, Ireland, United Kingdom, Bangladesh). The participants were randomly assigned to either the experimental group, which utilized the iGo app, or the control group, which used a traditional paper diary. During the study, the experimental group interacted with the iGo app, logging their breakfast and lunch times, and customizing the app to suit their preferences. The app, leveraging persuasive elements, including the leaderboard, reward points, and reminders, encouraged participants to take a 10-minute walk shortly after breakfast or lunch. Furthermore, the iGo app utilized the built-in accelerometer to measure walking time and distance. To sustain motivation, users could set personal goals and choose to walk alone or with another user at specified times.

On the other hand, the control group's paper diary app lacked intervention features, except for an alarm system and a form for logging walking activity. The researchers aimed to determine whether the persuasive elements of the iGo app would significantly impact participants' physical activity compared to the control group. Upon concluding the study, the researchers observed that the persuasive mHealth app, iGo, effectively promoted physical activity among office employees. Additionally, the results indicated that among the three components of the SDT of motivation (autonomy, competence, and relatedness), autonomy and competence emerged as the primary sources of motivation for employees to engage in physical activity through the app.

Tong et al. [4] conducted a quasi-experimental pilot study with the objective of evaluating the efficacy of a mobile-driven intervention aimed at promoting PA. The intervention comprised three main components: a mobile app called "fit.healthy.me," a Fitbit wearable tracker, and short message service (SMS) texts and emails. The researchers sought to assess the overall effectiveness of the intervention while also considering user engagement, as previous studies suggested that incorporating social elements in the app could enhance engagement levels. To achieve this, the researchers integrated self-regulatory and social features, enabling users to set personalized PA goals, compare their performance with peers, and provide support to each other through a private messaging feature. For the pilot study, 55 participants were recruited and followed for a duration of 6 months. Although the participants were not randomly assigned, the researchers conducted an initial baseline assessment during the first 7 days of the study to determine their individual PA levels at the outset, which served as a reference for comparison with their PA levels at the study's conclusion. The researchers further classified the participants into two subgroups based on their baseline step counts. The first group consisted of participants whose step count exceeded a predetermined threshold of 10,000 steps, while the second group comprised individuals with step counts below this threshold. All participants received the full suite of intervention components and were instructed to wear the Fitbit device for at least 10 hours daily.

The results of the study were in line with the researchers' initial hypotheses, as they found that the intervention effectively promoted PA among the participants. Moreover, a noteworthy observation emerged when comparing the baseline and post-study step counts within the subgroups. Specifically, the subgroup with baseline step counts below the threshold of 10,000 steps experienced a significant increase in step count after participating in the intervention. This led the researchers to propose that the intervention might be particularly advantageous for individuals who are physically inactive, offering greater potential for improvement compared to those who already engage in regular physical activity. Overall, the quasi-experimental pilot study by Tong et al. [4] sheds light on the effectiveness of the mobile-driven intervention in promoting PA and highlights the potential differential impacts on individuals with varying levels of physical activity. Further research and larger-scale studies may be warranted to corroborate and generalize these findings.

The study conducted by Tong et al. [4] closely aligns with the findings of Ellis et al. [94], who also investigated the impact of an mHealth intervention on promoting PA among individuals with Parkinson's disease (PD). Previous research by Lynch et al. [86] highlighted that cancer survivors tend to exhibit high levels of physical inactivity and sedentary behavior, which can be detrimental to their health. Similar challenges are faced by people living with PD [95]. Consequently, Ellis et al. [94] sought to explore the potential of mHealth intervention in facilitating PA among individuals with PD. The research involved the recruitment of 51 participants diagnosed with mild-to-moderately severe idiopathic PD, capable of walking independently for 6 minutes without assistance or assistive devices, and already on medication. A randomized trial was conducted over a 12-month period, comparing the effectiveness of a mobile-driven intervention with a similar intervention delivered without the mHealth app. All participants were equipped with a waist-worn pedometer during the initial 7 days of the study, along with an ankle-worn StepWatch Activity Monitor (SAM) [96] for continuous monitoring throughout the study. The pedometer was utilized to assess the baseline PA levels of each participant, while the SAM was employed to measure their PA levels at the 3rd, 6th, and 12th month.

The intervention group had access to the mHealth app, which provided them with tailored exercise guidelines that were periodically reviewed by their therapist. In contrast, the control group participants received similar tailored exercise guidelines but in paper format. Both groups engaged in strengthening and stretching exercises, tailored to their individual challenges and progress. The results of the study demonstrated a significant increase in PA levels for all participants, with no notable difference between the two randomized groups. However, participants in the intervention group who exhibited PA levels below the threshold at baseline (<7,500 step count) experienced a noteworthy improvement in their PA levels at the 12th month. Overall, the findings suggest that the mHealth intervention holds promise in promoting PA among individuals living with PD, offering a potential avenue for improving their overall well-being. Further research may be warranted to explore the long-term effects and sustainability of such interventions on this particular population.

The effectiveness of employing persuasive mobile technology to administer interventions for healthy behavioral changes has been well-documented [12], [27]. Therefore, the development of persuasive mobile health (mHealth) applications aimed at promoting healthy lifestyles, particularly PA, is of paramount importance due to its potential to enhance user engagement. Notably, mobile-driven interventions hold several advantages over non-mobile interventions. The ecological validity of research conducted within controlled or laboratory settings may not always translate to real-world scenarios of the target audience [97]. Conversely, mobile-driven interventions offer the flexibility of assessing efficacy within the natural environments of the target users, thus yielding ecologically valid results.

Furthermore, existing research has provided evidence supporting the effectiveness of designing and implementing mobile applications to encourage increased physical activity among individuals [4], [86], [94]. In line with this body of knowledge, our research endeavors to design a mobile-based intervention that facilitates users' participation in physical activity within their natural settings. By adopting this approach, we aim to harness the advantages of mHealth technology to foster positive behavior change and promote healthier lifestyles.

2.5 Augmented Reality and Physical Activity

Augmented Reality (AR) has emerged as a cutting-edge technology with promising potential for the development of effective interventions to promote healthy behavioral change, particularly in the context of PA interventions [5], [98]. Augmented reality refers to a sophisticated technology that seamlessly integrates real-world and virtual images, creating graphically interactive experiences that respond to human inputs in real-time [99]. By incorporating interactive elements that foster user engagement, AR has the capability to enhance users' interactions with mobile applications. One of the key benefits of utilizing AR technology in apps is its ability to provide users with an enriched and immersive view of their immediate environment, thereby making the exploration of such surroundings more captivating. Additionally, this exploration process may demand both cognitive and physical exertion, potentially enhancing the overall experience and benefits of PA interventions. Consequently, incorporating AR technology into the design of PA interventions is likely to result in improved cognitive and physical capabilities among the targeted users through enhanced engagement and participation.

Bangkerd and Sangsawang [100] conducted a research study focusing on the development of an Augmented Reality (AR)-driven intervention aimed at promoting PA among elderly citizens in Thailand. Recognizing existing evidence that suggests the positive impact of yoga exercises on overall health and wellness among the elderly [101], the researchers designed the AR intervention activities to center around yoga exercises. This choice was justified by the belief that the common fitness problem among elders lies in the challenge of stretching their arm and leg muscles. As a result, all yoga scenarios incorporated into the intervention were tailored to encompass diverse stretching exercises. The study encompassed the evaluation of three key measures: first, the effectiveness of the AR app in promoting PA; second, the assessment of the participants' flexibility levels, specifically their ability to stretch their arm and leg muscles, following the intervention; and third, an investigation into user satisfaction with the intervention.

The researchers recruited a total of 30 participants from the Elderly Club in Thailand to take part in the study. Prior to introducing the AR mHealth app, each participant underwent a physical fitness test. The AR element within the app was then utilized to generate virtual yoga poses based on the participant's environment, guiding them to follow each posture displayed on the app screen. Following the intervention period, the participants' fitness levels were reassessed to determine the impact of the intervention. The results of the study indicated a notable increase in the participants' overall fitness levels compared to the baseline measurements. Furthermore, there was a modest improvement observed in the flexibility levels of the participants, particularly in their ability to stretch their arm and leg muscles. Overall, the participants expressed a high level of satisfaction with the AR-driven intervention. In conclusion, Bangkerd and Sangsawang's [100] research provides valuable insights into the efficacy of using an AR-based approach to promote physical activity among elderly citizens in Thailand, with positive outcomes demonstrated in terms of fitness improvement and increased flexibility. The study contributes to the growing body of literature on utilizing innovative technologies for health interventions in the elderly population. However, further research with larger and more diverse samples may be warranted to corroborate and extend these findings.

Sachan et al. [102] undertook an exploratory investigation aimed at assessing the efficacy of an Augmented Reality (AR)-driven intervention designed to promote PA among students attending virtual classes. The study was prompted by the increased reliance on online/virtual environments during the COVID-19 restrictions [103]. Existing research has highlighted the tendency for such settings to foster physical inactivity and sedentary behavior among individuals [20]. Notably, students who typically attended lectures in physical classrooms found themselves sitting for extended periods while participating in virtual classes, resulting in reduced PA levels. To address this issue, the researchers sought to encourage students to engage with their physical environment even within the virtual space. The adoption of AR technology facilitated the design of two interactive PA interventions, intended to promote PA during break periods between classes. The first intervention involved an AR exergame [88], which entailed users stretching and moving their bodies while attempting to catch virtual apples that appeared within their virtual environment. The second intervention was an AR micro-movement exercise, wherein users mimicked the movements required to transition from one physical classroom to another by scanning AR markers located on different virtual walls within a short distance. These interventions were implemented using AR.js [104], a JavaScript library crucial for AR marker detection.

In order to evaluate the effectiveness of the AR-driven interventions, the researchers conducted a preliminary and user-centered design [105] study involving a total of 10 participants, all of whom were university students. Participants engaged with both AR interventions and provided feedback, which was evaluated using the Zoom Exhaustion and Fatigue Scale (ZEF). The results of the study demonstrated that the AR-driven interventions effectively alleviated zooming fatigue and contributed to an improvement in PA levels, achieved through the performance of micro activities. These findings suggest that AR technology can be harnessed as a valuable tool to enhance student well-being and counteract the physical inactivity associated with virtual learning environments. Further research in larger and more diverse cohorts is warranted to validate and expand upon these encouraging results.

Intawong and Puritat [106] conducted a research study that leveraged game elements to develop an augmented reality (AR)-driven intervention called the Camt comic run, aimed at promoting physical activity (PA). The researchers posited that incorporating game elements into behavioral change interventions or applications could enhance user engagement. To examine their hypothesis, they implemented an AR-driven mobile app with various game elements using the Unity Engine [107]. The choice of the Unity Engine was driven by the researchers' goal to create an intervention compatible with both Android and iOS platforms. The Camt comic run intervention included several game elements, such as a leaderboard, score points, map progress bar, inventory system/collection, and time pressure. These elements were strategically integrated into the intervention, which required users to traverse different locations indicated on an in-built map. Users were tasked with collecting treasures or discoveries at designated locations referred to as Towers. The map guided participants to the next possible tower with treasures to be collected, motivating them to engage in physical activities and interact with the intervention actively.

An essential component of the intervention was the AR element, represented by avatars corresponding to each user within the app. Users were given the freedom to choose their preferred avatars for the interactive experience. The study involved recruiting 40 participants aged between 18 to 40 years, all of whom possessed smartphones and engaged in physical activity at least once a week. The research study lasted for four weeks, with the initial two weeks dedicated to collecting baseline data on the participants' PA levels without the app's intervention. Subsequently, during the remaining two weeks, the participants were divided randomly into two groups: the gamified group, which utilized the intervention app, and the control group, which utilized the Google Fit app [108] for tracking PA levels. Upon conclusion of the study, the results revealed that the gamified group exhibited a significant increase in their PA levels compared to the control group. Notably, participants who demonstrated lower levels of physical activity at baseline recorded more substantial increases in PA when exposed to the gamified intervention. This observation underscored the effectiveness of designing interventions with game elements to promote user engagement and encourage positive behavior change. In light of these findings, the researchers concluded that developing gamified applications, particularly those targeting specific healthy behavior changes like physical activity, can prove highly beneficial. By integrating game elements effectively, developers and health professionals can enhance user engagement, leading to improved outcomes in promoting positive behaviors related to physical activity and potentially other health-related domains.

Odenigbo et al. [20] employed the concept of Augmented Reality (AR) technology to develop a persuasive gamified application prototype called "The Journey," with the primary objective of encouraging PA among young adults. This research initiative was sparked by the urgent need to devise PA interventions suitable for both indoor and outdoor settings in the backdrop of the COVID-19 pandemic [109]. The researchers sought to explore innovative technologies, such as AR, and incorporate engaging elements like game features to design an effective PA intervention. The proposed intervention enables users to engage in physical activity while interacting with a virtual environment within the app, simulating numerous tourist destinations, and providing a means to explore these locations while navigating their actual surroundings indoors or outdoors. This approach aimed to address the prevalent issue of boredom often associated with indoor physical activity, particularly when performed in solitary environments such as one's home. The uniqueness of "The Journey" lies in its capacity to enhance physical activity participation while simultaneously allowing users to virtually experience and learn about various cultures, tourist attractions, cuisines, and other distinctive aspects of different locations and their inhabitants. Through this virtual experience, users gain valuable insights without the need for physical travel to these places.

Furthermore, Odenigbo et al. [20] implemented an intriguing feature that assigns virtual value to users' physical activity efforts. By integrating a property allocation scenario, participants were given the opportunity to purchase household properties and building materials to develop the allocated virtual land they received upon signing up for the app. To ensure the effectiveness of their intervention, the researchers adopted a User-Centered Design (UCD) approach [105] during the prototype development phase. Subsequently, the intervention was subjected to evaluation by 29 participants to determine its impact on promoting PA. The study's results indicated that "The Journey" was perceived as a beneficial tool for encouraging PA, especially among young adults.

Escalona et al. [21] introduced an augmented reality (AR)-driven intervention aimed at facilitating and evaluating rehabilitation exercises conducted at home. This research initiative emerged from the recognition of the imperative for the elderly and individuals recovering from injuries to partake in diverse rehabilitation programs. To address this need, the researchers devised a novel approach that enables therapists and their patients to achieve desired outcomes efficiently and cost-effectively. The intervention, named "Eva," capitalizes on AR technology to design rehabilitation exercises that can be readily executed at home while therapists remotely monitor the progress of their patients. Notably, the intervention includes a tailoring feature that empowers therapists to customize the rehabilitation exercises, thus accommodating the unique needs of each user. Furthermore, the app diligently records exercises performed, facilitating thorough performance reviews for both therapists and app users.

A noteworthy highlight of the application is the incorporation of a virtual exercise trainer, simulating an experience akin to exercising at a gym. This virtual trainer takes the form of a 3D human figure projected onto the user's screen, visually demonstrating each exercise that the user is required to perform. Consequently, users are guided to replicate the virtual trainer's poses during their exercise sessions with the app. Additionally, the intervention integrates a virtual mat, visually representing the user's positioning within their immediate environment. Following each exercise session, the app provides users with a comprehensive performance score and valuable feedback. This real-time evaluation feature fosters a dynamic and interactive rehabilitation experience for the users. To evaluate the intervention's efficacy, a qualitative test was conducted with the participation of ten individuals. The results from this study indicated that the intervention holds promise in actively engaging patients in their rehabilitation program. It effectively addresses the common issue of adherence to long-term rehabilitation programs, thus potentially enhancing patient outcomes and overall treatment success.

The prospect of incorporating AR technology for fostering healthy behavioral changes has garnered substantial interest across diverse user age groups and target audiences. A pivotal factor influencing this interest is the perceived engagement derived from users' interaction with their physical environment through AR-driven applications or interventions. This heightened engagement, in turn, contributes to the perceived effectiveness of such applications or interventions in facilitating positive behavioral outcomes. Existing research has demonstrated the potential of AR elements in promoting interaction within PA interventions. Nevertheless, there exists a pressing need to develop interventions that not only leverage AR technology but also prioritize enjoyment and amusement, ensuring sustained user engagement in PA activities in a more pleasurable manner. To address this gap, we have devised a persuasive mobile intervention that seamlessly integrates AR and ML technologies to encourage physical activity among adults. Central to our approach are the incorporation of fun and engaging activities, particularly dancing, which aims to instill a sense of enjoyment while promoting regular PA participation. By combining the persuasive capabilities of AR and the adaptive nature of ML, we aspire to enhance the effectiveness of our intervention in fostering healthy behavioral changes and promoting a more active lifestyle among the adult population.

2.6 Dancing of a Form of Physical Activity

Dancing, a recreational activity involving rhythmic body movements in response to music or song, is recognized for its capacity to foster enjoyment and self-expression. Dance sport, a form of aerobic exercise [110], offers the advantage of versatility, as it can be practiced indoors or outdoors, regardless of weather conditions, without requiring specialized equipment [17]. As a form of PA, dancing enables individuals to express their cultural identity [111] and holds various intriguing facets. One notable aspect of dancing lies in its aesthetic appeal and rhythmic nature, making it a captivating form of movement [13]. Moreover, dancing serves as a means of enhancing physical fitness and can be utilized for stress and tension alleviation [17]. Research reveals that dancing engages participants in multidimensional activities, contributing to the promotion of both physical and cognitive well-being across all age groups [13], [17]. Therefore, engaging in dancing not only fosters enjoyment but also provides mental and physical fitness benefits.

The integration of innovative technologies to encourage dancing as a form of PA represents a promising area of research within the domain of healthy behavioral change [112][113]. Recent advancements in technology have facilitated the delivery of effective interventions aimed at promoting PA, and there is mounting evidence of the potential impact of such interventions, especially when fun activities like dancing are adopted. This suggests that leveraging technology to encourage dancing as a form of PA holds promise for promoting overall well-being and health.

Kim et al. [17] undertook a research study to explore the potential benefits of dance as a tailored intervention for promoting cognitive function and PA among elderly individuals aged 60 and above, who had been diagnosed with metabolic syndrome (MS). The researchers justified the need for such an intervention by highlighting the decline in cognitive function experienced by MS patients, emphasizing the importance of preventing degenerative neurological diseases and brain damage through appropriate interventions. To design the intervention, the researchers selected Latin dance, as it systematically engages both upper and lower joints in the body, and its effects are comparable to those of jogging in terms of physical exertion. A 6-month pilot study was conducted, involving 38 elderly participants with MS, who were recruited for the research. At the beginning of the study, baseline measurements of all participants' cognitive functions, such as verbal fluency, word list recall, and word list recognition, as well as their physical fitness, were recorded. Subsequently, the participants were randomly assigned to either the control group or the exercise group. The control group was instructed to continue with their regular daily routines and exercises, while the exercise group participated in the dance intervention. The exercise group attended supervised dance/exercise sessions at the researchers' lab twice a week, with each session lasting for 60 minutes, under the guidance of a dance instructor. After the 6-month intervention period, the researchers compared the outcomes between the control and exercise groups.

The results indicated that participants in the exercise group exhibited significant improvements in cognitive functions, specifically in verbal fluency and delayed recall, compared to those in the control group. These findings aligned with previous reports suggesting that dance, as a form of PA, may reduce the risk of cognitive disorders in elderly individuals with MS. In conclusion, the dance intervention implemented by Kim et al. proved to be effective in enhancing both cognitive and physical health among elderly individuals diagnosed with MS. The study's outcomes contribute to the growing body of evidence supporting the potential of dance as a means to promote overall well-being in this particular population group.

Rubio et al. [33] conducted a research study aimed at investigating the acceptability and preliminary effectiveness of a theory-driven, group-based dance intervention designed for breast cancer survivor (BCS) women in low-income countries. The researchers recognized the potential efficacy of group-based PA programs in culturally organized community settings. Given the likelihood of BCS women engaging in sedentary lifestyles, adopting a community-based approach to deliver effective PA interventions appeared to be a suitable strategy. To execute the study, the researchers collaborated with healthcare institutions to develop a dance intervention targeting the enhancement of PA levels among the BCS participants. A total of 64 individuals were recruited and divided into two groups: a control group and an intervention group. The study duration spanned 8 weeks, during which the participants' PA levels were assessed at baseline, during the study, and at the study's conclusion, utilizing accelerometers for data collection. During the study period, the control group participants were informed that they would receive the intervention after 8 weeks, whereas the intervention group was exposed to the dance intervention three times per week. Throughout the study, the researchers also measured the participants' PA motivation and quality of life. The findings revealed that the intervention group participants experienced a significant improvement in both their PA levels and quality of life. Furthermore, all participants reported being motivated to enhance their PA, which may be attributed to the perception of dancing as an enjoyable activity associated with emotional, mental, and physical benefits.

Must et al. [32] conducted a research study aimed at promoting PA among adolescent girls with intellectual disorder (ID) through the implementation of a dance intervention. Inspired by the group-based dance program introduced by Rubio et al. [33], the researchers devised a similar approach; however, they innovatively created dance videos to encourage the participants to engage in individual dance sessions within the comfort of their homes. The intervention spanned a period of 12 weeks and took place simultaneously in three distinct locations, involving a total of 18 participants diagnosed with ID. Throughout the study, all participants were equipped with chest straps and output watches during the group dance sessions, while they were instructed to wear Fitbit devices when performing dance routines at home. During the group dance sessions, the participants devoted 75 minutes per week to the program, and they were encouraged to independently engage in 45 to 60 minutes of dance at home every week. At the conclusion of the study, the researchers observed variations in the moderate-to-vigorous physical activity (MVPA) levels among the participants across the different locations. Nevertheless, there was an overall increase in PA, indicating the effectiveness of the dance intervention in promoting PA among the adolescent girls with ID. Furthermore, Must et al. [32] findings revealed that the participants displayed a high level of engagement with the intervention, actively participating in the dance sessions, both within the group setting and at home. Additionally, the participants expressed overall satisfaction with the intervention, highlighting its potential for promoting PA and well-being among adolescent girls with intellectual disorders.

Bastug [13] conducted a comprehensive examination on the aspects of flexibility, balance, concentration, and body composition among individuals actively engaged in dance exercise. The study entailed the recruitment of 268 university students who actively participated in the research over a duration of 12 weeks. Baseline and concluding assessments were conducted to gauge the body composition, concentration, balance, and flexibility of all participants. To assess the impact of the dance intervention, the participants were divided into two groups: the experimental group and the control group. The experimental group engaged in dance sessions lasting between 30 to 70 minutes each week, while the control group was advised to adhere to their normal daily routine without any prescribed intervention. The findings of the study revealed a statistically significant variance in the pre and post scores concerning the body composition (body weight and BMI), concentration, balance, and flexibility among the participants in the experimental group. These outcomes strongly indicate that dance exercise can have a considerable influence on both the physical and psychological well-being of individuals.

The undeniable body of evidence supporting dancing as a pleasurable and effective exercise for enhancing PA and overall well-being highlights its significance in promoting health. The perception of dancing as an enjoyable activity often leads individuals to partake in it primarily for leisure and amusement, with the associated health benefits being secondary considerations. Consequently, it becomes crucial to develop physical activity interventions that incorporate enjoyable and entertaining elements, as these aspects can substantially enhance user engagement and motivation to adhere to the intervention. In line with this rationale, we embarked on designing a persuasive AR-driven mobile application with a dance-based approach to promote PA. By integrating dance as a core component of our intervention, we aim to explore novel avenues for people to derive enjoyment while simultaneously maintaining their fitness levels. This approach leverages the inherent appeal of dance to captivate users and create a sense of excitement, thereby increasing the likelihood of sustained engagement with the intervention.

In summary, our research endeavor seeks to underscore the undeniable merits of dancing as an enjoyable exercise, emphasizing its potential in fostering user interest and commitment to PA interventions. By introducing an AR-driven mobile application centered around dance, we strive to unlock new opportunities for individuals to experience pleasure in staying physically active and leading a healthy lifestyle.

2.7 Persuasive Strategies

Persuasive strategies refer to the various techniques and methods employed in the design of systems with the specific intent of making them persuasive. The objective of a persuasive system lies in its capacity to influence attitude or behavioral modifications within the target audience. Consequently, a persuasive system can be defined as a technological tool devised to encourage behavioral change or mold thoughts and attitudes without resorting to coercion or deception [27]. The incorporation and maintenance of attitude or behavioral change reinforcement in a persuasive system are encompassed by what is commonly referred to as persuasive strategies. Furthermore, the adoption of appropriate behavioral change strategies (persuasive strategies) plays a pivotal role in determining the success of behavioral change interventions, thus yielding the desired outcomes [5].

Based on the findings of Oinas-Kukkonen et al. [27], the Persuasive System Design (PSD) model comprises 28 distinct persuasive strategies, which are further classified into four main categories, namely: (1) primary task support, (2) dialogue support, (3) system credibility support, and (4) social support. Each of these categories serves a specific role in influencing target users towards the desired behavioral outcomes in persuasive systems. In the context of existing research, various persuasive strategies have been explored, and their relevance to our own research will be discussed within the framework of the aforementioned four categories of persuasive strategies.

The utilization of Primary Task support strategies represents a key approach in persuasive systems aimed at facilitating users in accomplishing their core objectives. These strategies encompass a range of techniques, including *rehearsal, simulation, self-monitoring and feedback, reduction, tunneling, tailoring,* and *personalization*. Distinguished researchers such as Escalona et al. [21], Odenigbo et al. [20], and Intawong and Puritat [106] have integrated the concept of *self-monitoring* and *feedback* into their interventions due to its pivotal role in enabling the target audience to track their progress while utilizing the application. Tailored interventions, as implemented by Ellis et al. [94] and Must et al. [32], have proven effective in streamlining the tasks required by the target audience, ensuring alignment with their specific needs and limitations. Similarly, the *personalization* strategy has exhibited effectiveness in various studies conducted by Haque et al. [92], Tong et al. [4], Berg et al. [80] and Lynch et al. [86]. These researchers' interventions have provided users with the opportunity to customize certain features of the persuasive system to suit their individual needs and abilities, thereby enhancing its overall impact.

In Dialogue Support strategies, a range of techniques have been identified, namely *similarity, suggestion, reminders, liking, rewards, praise,* and *social role*. The employment of these strategies serves the crucial purpose of fostering effective communication and interaction between the persuasive system and its user base. Notably, the *reminder* and *reward* strategies have garnered considerable attention due to their perceived effectiveness in various interventions conducted by researchers such as Blake et al. [85], Odenigbo et al. [20], and Haque et al. [92]. Through the use of reminders, the target audience is able to maintain focus on their tasks or objectives, while the incorporation of reward mechanisms, such as the reward/point feature, serves to amplify user motivation and satisfaction by offering tangible benefits or incentives for their accomplishments. Furthermore, in certain interventions facilitated by Dzielska et al. [91] and Tong et al. [4], users were encouraged to assume *social roles*, wherein they provided support to one another within the system. Remarkably, this cooperative engagement among users demonstrated a positive impact on the overall productivity and outcomes of the interventions. The combination of these dialogue support strategies in various research endeavors contributes to a more comprehensive understanding of their significance in fostering successful interactions between users and persuasive systems. As researchers continue to explore and investigate these strategies, they hold promising potential for enhancing user engagement, compliance, and overall experience in persuasive technology interventions.

The utilization of System Credibility Support strategies, plays a crucial role in instilling assurance among the target users regarding the authenticity and credibility of tasks or interventions, ultimately leading to the achievement of expected results. Within this category, a comprehensive set of strategies is employed, comprising elements such as *trustworthiness, expertise, authority, surface credibility, real-world feel, third-party endorsement,* and *verifiability*. In the pursuit of establishing credibility, esteemed researchers such as Javier et al. [64], Blake et al. [85] and Dzielska et al. [91] have diligently implemented their respective interventions by drawing upon proven models, theories, and directives sourced from reputable and credible institutions. By doing so, they effectively cultivate and sustain trust in the intervention, fostering confidence in the potential positive impact it will bestow upon the target users.

Social Support strategies has a means to foster behavioral changes among users [27]. These strategies capitalize on social interactions and the potency of social influence to facilitate users' journey towards behavioral modification. The list of social support strategies encompasses *social learning, social facilitation, competition, social comparison, cooperation*, and *normative influence*. In the context of promoting PA interventions, the efficacy of such endeavors heavily relies on the integration of effective social support mechanisms that can effectively influence target users to adhere to prescribed intervention tasks, thereby yielding favorable outcomes. Previous research in this domain has incorporated several common social support strategies, namely *competition* [91], *competition* through the use of leaderboards [20], [91], [106], and *cooperation* facilitated through group collaboration [17], [32], [33]. These strategies have been subject to examination and implementation in the relevant literature, bearing potential implications for refining and optimizing future PA intervention design.

In the domain of PA interventions, compelling methodologies such as persuasive strategies and gamification have exhibited notable efficacy. Previous studies [114], [115] have extensively documented the successful application of persuasive strategies to facilitate behavior change interventions. Conversely, gamification entails the incorporation of various strategies, including rewards, competition, and social comparison, into interventions. It is presumed that a persuasive system designed as a behavioral change intervention should incorporate, at minimum, one persuasive strategy [10]. Intervention Research has indicated that the combination of multiple persuasive strategies within an intervention yields even more favorable outcomes concerning behavioral change [116]. Nevertheless, it is crucial to acknowledge that the integration of numerous persuasive strategies may potentially undermine the effectiveness of an intervention, as certain strategies demonstrate superior results when utilized in conjunction with specific others [30].

For our research intervention, we strategically adopted a select set of persuasive strategy combinations, which were derived from a comprehensive review of related research. This intervention was delivered through an AR-driven mobile application, thereby harnessing the insights from the aforementioned reviewed literature. Subsequent sections will furnish detailed information about the PSD model employed in our intervention.

2.8 Summary

The present study aims to evaluate the efficacy of PA interventions in reducing physical inactivity and promoting PA, with a particular focus on incorporating enjoyable activities to enhance intervention effectiveness [13], [17], [32], [33]. Technological advancements have demonstrated their effectiveness in delivering interventions to target audiences without requiring direct physical presence. Notably, mobile-driven intervention research frequently employs persuasive strategies or techniques [27] as a key component of the intervention, which has been observed to positively influence participant engagement, motivation, adherence, and healthy behavioral sustainability, as evident from related works reviewed in this chapter.

To the best of our knowledge, while dance has been recognized as a pleasurable activity and a potential contributor to increased PA, the implementation of dance interventions using innovative technologies such as AR [117] and ML [118] has not yet been explored. The closest study related to our proposed research intervention was conducted by Escalona et al. [21], where AR was utilized to design a virtual assistant showcasing various gym exercises for home-based rehabilitation. However, the activities in that intervention were not specifically designed for enjoyment. Therefore, there remains an unexplored opportunity to create a dance intervention that incorporates current technological innovations like AR and AI (employing Machine Learning algorithms) to promote PA effectively. Most of the interventions reviewed in the literature have targeted specific audience groups. Nevertheless, considering the importance of PA in maintaining a healthy lifestyle for the broader populace, it is imperative to develop a PA intervention that can be accessible to a wider audience. Thus, our research addresses this need by designing an AR mobile-based application that promotes PA through dancing. Additionally, we hypothesize that our dance intervention will positively influence the mood of the participants, contributing to a more holistic approach to overall well-being.

In conclusion, this research endeavors to evaluate the impact of incorporating enjoyable activities within PA interventions, leveraging cutting-edge technologies like AR and ML, to develop a dance-based mobile application that encourages physical activity among a wider audience. The potential positive effects on mood arising from our intervention are also a significant area of investigation.

Chapter 3 : Methodology

Through an examination of the extant body of literature outlined in Chapter 2 of this thesis, the current research endeavors to advance PA by leveraging AR [5] and ML [14] technologies in the implementation of an AR-driven intervention, which facilitates users in maintaining PA levels through the medium of dance. In this chapter, we describe the intervention design in detail and state our research questions.

3.1 Frameworks and Technology Used

Based on our extensive literature review encompassing sedentary lifestyle, healthy behavioral change, physical activity, dancing, and prevalent technologies such as mobile applications and augmented reality (AR) that have demonstrated efficacy in promoting PA, we have embarked on the development of a system aimed at encouraging PA through dance. Our primary objective is to create a self-contained system that empowers individuals to engage in dancing using their mobile devices, without relying on external devices or involving third-party resources. To achieve this goal, we have recognized the significance of incorporating machine learning (ML) models that can efficiently facilitate the targeted task without unnecessary complexities. Initially, our intention was to create the proposed system from scratch, leveraging the Unity platform [119], widely utilized for developing AR-driven applications. However, during our research, we encountered an alternative framework known as Google ML Kit [120], which aligns closely with our system's requirements. This discovery presented an opportunity to expedite certain aspects of our intended implementations, such as the development of a 2D representation of a human being, without the need to reinvent existing solutions.

The Google ML Kit is an extensive framework developed by Google, specifically designed to enable image capture and processing through device cameras. It encompasses various implementations, including but not limited to pose detection, face detection, barcode scanning, image labeling, and text recognition. The primary objective of this framework is to facilitate developers in seamlessly integrating machine learning modeling into their applications. By offering a collection of readily available APIs and pre-trained models, Google ML Kit empowers developers to effortlessly perform tasks related to the aforementioned implementations. The framework abstracts away the intricacies of model training and deployment, streamlining the process of incorporating machine learning features into mobile applications. Furthermore, it caters to the diverse needs of developers by providing both on-device and cloud-based APIs [121], enabling them to choose the most suitable approach based on their specific requirements. In the context of our proposed system, which entails the development of an intervention as a mobile application for real-time capture and processing of users' dancing activities, Google ML Kit emerges as an ideal solution. Given that our target platform is mobile, the pose detection implementation offered by Google ML Kit appears particularly well-suited to accomplishing our intended objectives. Its compatibility with mobile platforms, along with its robust pose detection capabilities, aligns seamlessly with our project's goals.

In our intervention, we sought to incorporate AR technology [5], which entails the integration of real and virtual images to create a graphically interactive environment that responds to users' actions in real time within the physical world [99]. A primary objective of our design implementation was to utilize AR technology to project a real-time 2D image of the user while engaged in dancing, thereby enhancing user engagement. To achieve this goal, we integrated the AR element in tandem with the pose detection model from the Google ML Kit. This allowed our system to capture the user's dance movements, process them, and subsequently render each dance pose in real time. The Google ML Kit framework, featuring an AR extension that complements the pose detection implementation, emerged as a pivotal tool in the realization of our intervention's objectives. By incorporating this framework, we leveraged the capabilities of both AR and pose detection to augment user engagement and interaction throughout the dance experience.

In order to effectively disseminate our intervention to our target users, we made the strategic decision to develop it for two prominent mobile platforms, namely Android and iOS. By focusing on mobile platforms, we aimed to provide our users with a convenient means of accessing the application from virtually anywhere without the need for external tools or additional space. To realize this objective, we opted to employ the Flutter mobile app development framework. Developed by Google, Flutter is an open-source UI (User Interface) toolkit designed to construct natively compiled applications for various platforms, including mobile, web, and desktop, all from a single codebase [122]. Its versatile nature empowers developers to create visually appealing and high-performance apps, ensuring seamless performance across different platforms with native-like efficiency. At the core of Flutter lies Dart, a modern and object-oriented programming language

[123] that endows developers with a rich set of features to facilitate application development. Embracing a reactive programming style, Flutter's UI is constructed using widgets that dynamically update when underlying data changes. This is of paramount importance for our intervention, as it involves capturing dance poses and integrating AR elements, both of which necessitate continuous updates while users engage in dancing. Given the computationally intensive nature of our intervention, it became imperative to streamline certain processes. As a result, we designed the intervention's backend as Rest APIs [124] using Java, abstracting some of the resource-intensive tasks and ensuring optimal performance.

In light of recognizing the significance of fostering persuasive interventions [27], our research incorporated a combination of sophisticated technologies to enhance the efficacy of our intervention. Specifically, we employed a dancing avatar using DeepMotion [125], audio-feedback through Text-To-Speech (TTS) [126], and Firebase Notifications [127], respectively. These technologies were selected for their unique capabilities and contributions.

DeepMotion, a powerful tool rooted in advanced Artificial Intelligence (AI) techniques [24], was harnessed to facilitate the creation and animation of highly realistic and dynamic characters. By combining deep-learning algorithms with physics-based simulations, DeepMotion enabled the generation of lifelike movements and behaviors, rendering it suitable for diverse applications. Furthermore, the integration of Text-To-Speech (TTS) technology played a pivotal role in our intervention. TTS serves as an invaluable resource, enabling the conversion of written text into spoken words. By harnessing natural language processing, linguistic analysis, and speech synthesis techniques, TTS empowered computers and electronic devices to generate human-like speech, granting users the ability to audibly consume text-based content. Lastly, Firebase Notifications were utilized as a flexible and potent means of engaging with app users. By sending crucial notifications or personalized content at specified times, Firebase Notifications proved instrumental in sustaining user engagement and adherence to the physical activity intervention.

Our intervention artfully leveraged these three technologies in concert. The dancing avatar simulation provided users with visual cues, facilitating the adoption of correct dance poses. Simultaneously, audio-feedback from TTS offered constructive guidance based on the user's dance performance, further reinforcing their engagement and improvement. Moreover, Firebase

Notifications were strategically employed to serve as daily reminders, motivating users to maintain their physical activity levels through dance.

The following sections below describe each component of our intervention in detail and how these technologies were used to develop the intervention.

3.2 Dance Pattern Formulation

Dance pattern formulation presents an alluring subject, delving into the art of crafting and organizing movement sequences in dance. Although there might not exist a dedicated body of academic research solely centered on this topic, various related fields contribute significantly to our comprehension. Scholars have explored dance pattern formulation through the lenses of choreography [128], movement analysis [129], and dance composition [130]. Extensive investigations have been conducted, exploring diverse methodologies and approaches to effectively create, structure, and arrange dance patterns [128][130][131].

In this study, we undertook the development of 15 low and medium intensity aerobic dance [132] patterns by drawing insights from existing literature and online resources related to dance workouts. These dance patterns were captured as videos and can be accessed in Appendix J. The formulation of these dance patterns was based on the principles of general aerobic dance workouts, with each pattern strategically designed to target specific major muscle groups within the human body. Some patterns were predominantly focused on exercising the arms and feet, while others emphasized the waist, neck, and shoulder regions (refer to Appendix J for details). To ensure inclusivity and relevance to a diverse audience, we deliberately selected 15 danceable music pieces from four different continents, namely America, Europe, Asia, and Africa. The musical selection played a pivotal role in shaping the choreography and overall ambience of each dance pattern.

To create the dance videos, we initially crafted each dance pattern and carefully paired them with background music from the chosen musical pieces. Subsequently, we executed and recorded each dance routine for approximately 60 seconds, capturing both the dance activity and the accompanying background music as video files. In order to evaluate the practicality and user experience of these dance patterns, we shared the videos with eight individuals, each having different body shapes and heights. These participants were requested to dance to the patterns from the videos and record their dance activity, which ranged from 20 to 40 seconds. Their recorded performances were then collected after completion.

3.3 Dance Model ML Training

The process of training an ML model involves the collection and categorization of an extensive volume of relevant datasets. For our intervention dance model, we followed a similar approach, utilizing the open-source Google ML Kit pose detection model training tool, which was specifically developed using the Python programming language [133]. Python has emerged as a highly favored language for training machine learning models, owing to its user-friendly nature, adaptability, and the existence of robust libraries and frameworks tailored for machine learning tasks [14]. In our ML training model, we incorporated essential Python libraries, including NumPy, MatplotLib, and OpenCV, as they were instrumental in enabling us to train a neural network model for intricate machine learning assignments, such as capturing and processing dance poses. The link to the open-source Python training model code that we employed can be accessed in Appendix I.

The Google ML Kit's pre-trained pose detection model served as a foundational framework. However, it was necessary to undertake a retraining process tailored to our intervention's specific requirements, centered around the formulation of dance poses. The subsequent sections detail the methodology employed for the preparation of the dance pattern dataset and the model training process. To begin, dance videos from a cohort of nine individuals were gathered and subsequently converted to the standardized mp4 format. Subsequently, the dance poses were extracted from the mp4 files in the form of image files. For this task, an online tool named "mconverter" was utilized, as documented in Appendix I.

Following the extraction of image poses, a critical step was performed to ensure manageability and efficiency in dataset handling. To achieve this, the image files were compressed using the "iloveimg" online tool, as referenced in Appendix I. The compression process aimed to reduce the overall file size of the dataset, thereby ensuring that it did not exceed the maximum file size permissible. The next stage encompassed the classification of the compressed image poses into twenty-seven distinct categories. This categorization was essential to establish a well-organized and structured dataset for training purposes. The training process leveraged the Google ML Kit training tool, with approximately 35,000 pose datasets encompassing the twenty-seven pose categories being employed as the input data. This extensive dataset served as a robust foundation for the model to learn and generalize dance poses effectively. Upon the completion of the model training, the resultant dance model was extracted in the form of a CSV (Comma-Separated Values) file. This CSV file encapsulated the learned knowledge of the trained dance pose detection model. To integrate the trained dance pose detection model into our desired application, we implemented the CSV file within the flutter development environment. This environment provided a suitable framework to incorporate the model seamlessly and leverage its capabilities effectively.

3.4 Avatar Design and Training

The incorporation of an avatar into our intervention proved to be a pivotal decision, as it enabled the application to effectively simulate each dance pattern for users, facilitating easy recognition and replication of the dance movements. To achieve this, we sought a suitable tool capable of designing avatars and training them using our set of 15 dance patterns. Numerous tools were evaluated, each offering different methodologies for the task. However, after careful consideration, the approach presented by DeepMotion [125] was deemed superior due to its superior effectiveness, accuracy, and reduced complexity.

DeepMotion is a comprehensive online toolset renowned for its proficiency in generating realistic and interactive character animations across diverse applications such as games, simulations [27], and virtual reality [88] experiences. Leveraging advanced techniques in deep learning and physics simulation, DeepMotion excels in generating lifelike motions and behaviors for virtual characters. Notably, the tool supports the creation of avatars with diverse characteristics, encompassing variations in gender, color, and dress code. As a result, we designed four distinct avatars, each possessing unique attributes in terms of gender, color, and attire (refer to Figure 3.1). The purpose behind this endeavor was to empower intervention users with the freedom to select the avatar that best resonated with their preferences, subsequently enhancing their engagement and overall experience with the application.

The avatars were trained on dance patterns using a specific methodology. Firstly, a dataset consisting of 15 dance videos was employed as motion data within the DeepMotion training window. Subsequently, training parameters, including learning rates, batch sizes, and regularization techniques, were carefully configured to facilitate the deep learning algorithm's training process for the avatar. The performance of the trained model was rigorously evaluated by utilizing validation datasets or metrics, allowing for an accurate assessment of its accuracy and generalization capabilities. To further integrate the trained model with the avatar, the DeepMotion toolset was employed, enabling the generation of animations for the avatar based on the trained model's capabilities. Once the training and integration processes were completed, the trained avatar was made accessible online and implemented in our intervention as an Application Programming Interface (API) [121].

3.5 AR Dancee App Design Overview

The primary objective of this research is to investigate the potential of promoting physical activity through dancing via the implementation of an AR-driven intervention, utilizing cutting-edge Artificial Intelligence (AI) and ML algorithms to capture and analyze users' dance poses. The core purpose of this intervention is to actively engage users by offering music and dance patterns, thereby encouraging them to participate in physical activities that contribute to enhanced metabolism [38], calorie burning, and improved mood. To achieve these goals, the AR Dancee app was specifically developed to provide users with an enjoyable and interactive means of exercising through dance while still attaining their PA objectives. As this app is primarily intended for research purposes, stringent measures were implemented to ensure the integrity and privacy of user data. Upon sign-up, all users were required to provide their email address during the initial launch of the app. This step was essential in enabling comprehensive user data analysis and monitoring throughout the research study.

In the app's implementation, Figure 3.2 showcases the first screen, known as the launcher, while Figure 3.3 illustrates the straightforward sign-in screen. These user interfaces were thoughtfully designed to facilitate easy access and engagement for participants in the research intervention. The subsequent sections will delve into the key design elements integrated into the AR-driven intervention. These elements are crucial in understanding the functionality and impact of the app on promoting physical activity through dance and advancing the research objectives.

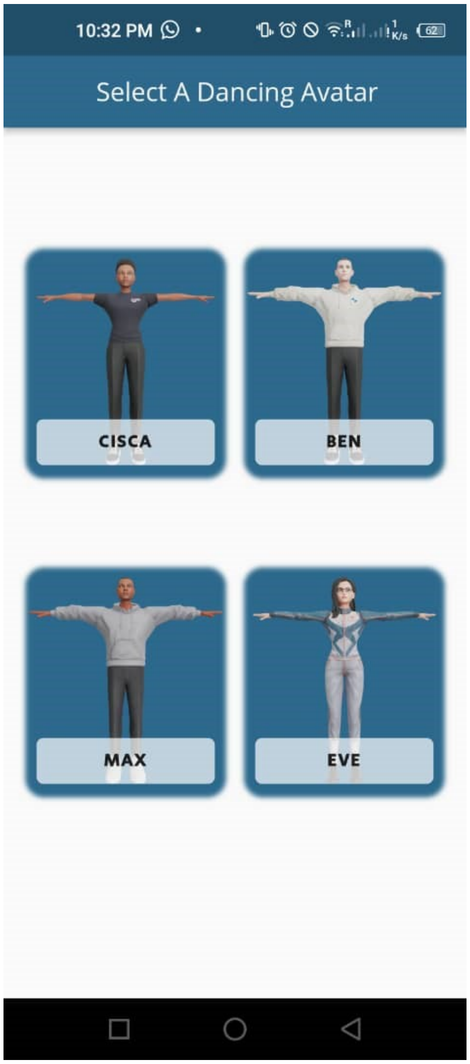

Figure 3.1 Avatar Selection screen

Figure 3.2 App launcher screen

3.5.1 Avatar Selection

The focus was on engaging a diverse public, encompassing individuals from various backgrounds, belief systems, and geographical locations worldwide. To facilitate this, we developed the AR Dancee app, which incorporates four distinct avatars (as discussed in Section 3.4), each characterized by unique attributes. Upon successful user sign-in, the app prompts individuals with an avatar selection screen, presenting them with a list of available characters. The purpose of this initial step is to allow users to select an avatar that aligns closely with their preferences. This selection process is vital, as it determines the dancing avatar that will be assigned to them during their interactive experience.

Users have the flexibility to change their avatar at a later stage if they wish to explore different character options. Figure 3.1 illustrates the avatar selection screen, providing a visual representation of this interface. Following the avatar selection process, the app proceeds to display an instruction screen (refer to Appendix K), which comprehensively outlines how to effectively utilize the app. The instructions cover various features that have been implemented, along with detailed explanations on how to navigate and use each of these functionalities. After familiarizing themselves with the instructions, users are then directed to the app's home screen, where they can commence their dance exploration.

The application offers several key functionalities that enable users to customize their experience according to their specific requirements. One such feature allows users to set their desired daily calorie burn target. By default, the app's target for each user is to burn a minimum of 200 calories per day. Nevertheless, individuals have the flexibility to adjust their calorie burn goal to align with their present PA level or their desired PA level. It is important to note that altering the calorie burn goal does not directly impact the user's overall performance within the application. Instead, it serves as a motivational tool, encouraging users to be more purposeful and committed to achieving their exercise objectives. Furthermore, users are prompted to input their current body weight as this information is essential for accurately calculating the number of calories expended during their dance sessions with the app. For reference, Figure 3.4 illustrates the screen where users can access and modify their daily calorie burn settings.

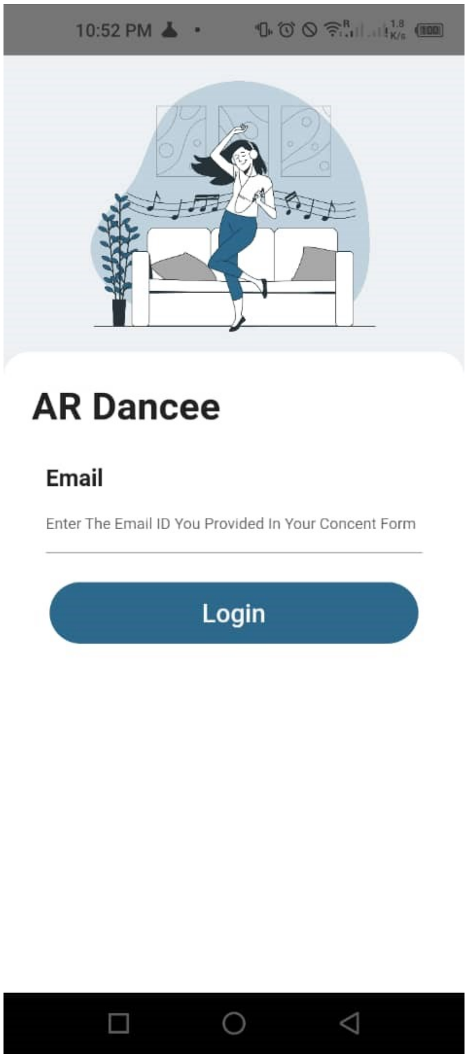

Figure 3.3 Sign-in screen

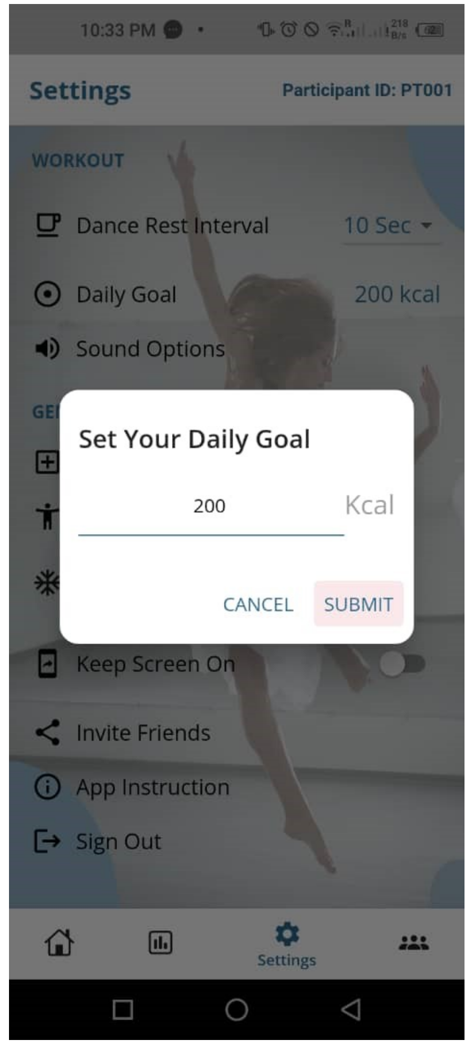

Figure 3.4 Goal Setting screen

3.5.2 Augmented Reality Elements

In this research study, we have developed and integrated augmented reality (AR) elements into an existing dance model using Google ML Kit for pose detection. The AR elements are presented as a 2D representation of the human body, which is superimposed onto the user's image in real-time while they engage with the dance app. To achieve this, the app utilizes the camera to capture, process, and render the AR elements onto the user's body. Upon opening the app for the first time, users will be prompted to grant permission for the app to access their camera. This access is necessary to enable the real-time overlay of AR elements during the dance experience. A visual representation of this process can be found in Figure 3.5. The primary objective of the app is to engage the user in dance movements by emulating a dancing avatar. Users are encouraged to focus their attention on the dancing avatar and attempt to replicate its dance steps. As the user follows these dance steps, the AR elements dynamically redraw their body positions in real-time based on the captured poses. This dynamic and interactive feature aims to enhance the user's dancing experience, as the AR elements animate and adapt to all their movements during the dance session.

3.5.3 Dance Challenge Levels

The home screen of the dance application features three distinct levels of dance challenges: Beginner, Intermediate, and Advanced. Each level consists of five unique dance patterns accompanied by corresponding music. The concept of gamification [134], which involves applying typical gaming elements to non-gaming activities, influenced our approach in calibrating the dance patterns. To provide a progressive experience, we categorized low-intensity dance patterns under the Beginner challenge, some easy-medium intensity dance [132] patterns under the Intermediate challenge, and the remaining medium-intensity patterns under the Advanced challenge. Users are required to earn points on each level to advance to the next one, fostering a sense of accomplishment and building their dancing confidence as they conquer each challenge. To add an element of motivation, all three dance challenges feature a virtual padlock, signifying that users must exert effort to unlock them. The Beginner challenge is initially accessible, allowing users to start their journey from there. However, to unlock the subsequent challenges, users need to complete a minimum of five dances and accumulate sufficient points within the 15-day study duration. The time frame for unlocking challenges was established to ensure that users could potentially unlock all challenge levels within the 15-day period. Moreover, once a user unlocks a challenge, they retain access to previously unlocked challenges, offering flexibility and opportunities for practice and improvement. Figure 3.6 showcases the home screen, displaying the three levels of dance challenges, visually illustrating the clear progression and encouraging users to engage in the dance experience progressively.

3.5.4 AR Daily Dance

Upon user selection of an unlocked dance challenge, the application proceeds to exhibit a dedicated screen featuring the World Health Organization's (WHO) authoritative stance regarding the significance and advantages of promoting physical activity (PA) through dance. The inclusion of this WHO statement serves a dual purpose: firstly, to motivate the user in commencing the chosen dance challenge, and secondly, to act as a point of reference for the broader public, encouraging widespread engagement in physical activity. The incorporation of the WHO statement aligns with our intention to bolster the credibility of our dance intervention, leveraging the well-established authority of the WHO in the realm of health promotion and behavior change initiatives. As a result, users are not only prompted to partake in the dance challenges but are also reassured by the endorsement from a globally recognized health organization. For visual reference, Figure 3.7 illustrates the appearance of the WHO Statement screen within the application.

Prior to initializing the dance sequence for the user, a pre-dance reminder screen will be presented, encompassing a concise summary of the dance instructions, along with essential guidelines to bear in mind before, during, and after the dance session. Notably, the two crucial reminder points entail the assurance that no aspect of the dance performance will be recorded, thereby ensuring user privacy, and the necessity for the user to input their current body weight on the settings screen, as the accurate calculation of calories expended relies on this weight value. Upon confirming readiness to commence the dance, the user will be seamlessly transitioned to the AR dance screen. This screen incorporates a prominently displayed 10-second countdown timer, designed to enhance anticipation and synchronization with the dance routine. The AR dance screen comprises seven fundamental elements, namely the dance countdown timer itself, a dynamic dance score bar, a convenient pause/play button for user control, a visually engaging dancing avatar, background music to amplify the experience, the AR element integrated into the display, and lastly, audio feedback for real-time interaction and motivation. This collaborative assembly of these seven elements collectively serves to engender an immersive and captivating experience for the user throughout the course of their dance performance [135]. During the dance session, users retain the flexibility to temporarily halt or resume the dance sequence as required, facilitating a smooth and personalized engagement with the application.

The AR elements employed in this research project are responsible for generating a real-time, 2D representation of the user's dance pose. Simultaneously, a virtual assistant leverages the audio feedback feature to establish communication with the user during the entire dancing session. Each dance session comprises five distinct dance patterns accompanied by corresponding music, resulting in an expected duration of approximately 10 minutes per session. Following the completion of each dance within a session, the application recommends a resting period of approximately 10 seconds, during which a rest screen is displayed temporarily but the user can extend their resting period by tapping Add More Seconds button. Should the user desire to proceed immediately to another dance within the session, they have the option to bypass the rest period by utilizing the Skip button. The temporary display of the Rest screen, which appears after each dance in a dance session, can be observed in Figure 3.8.

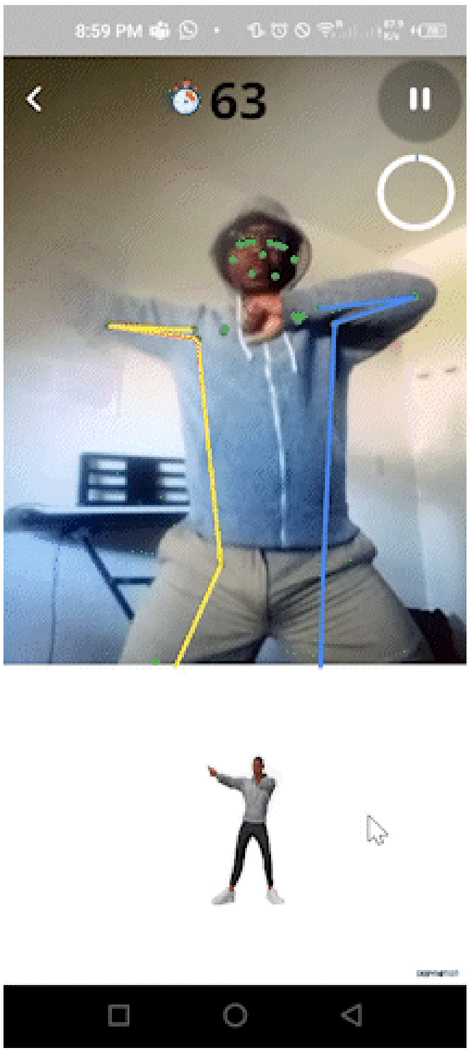

Figure 3.5 AR Dance screen

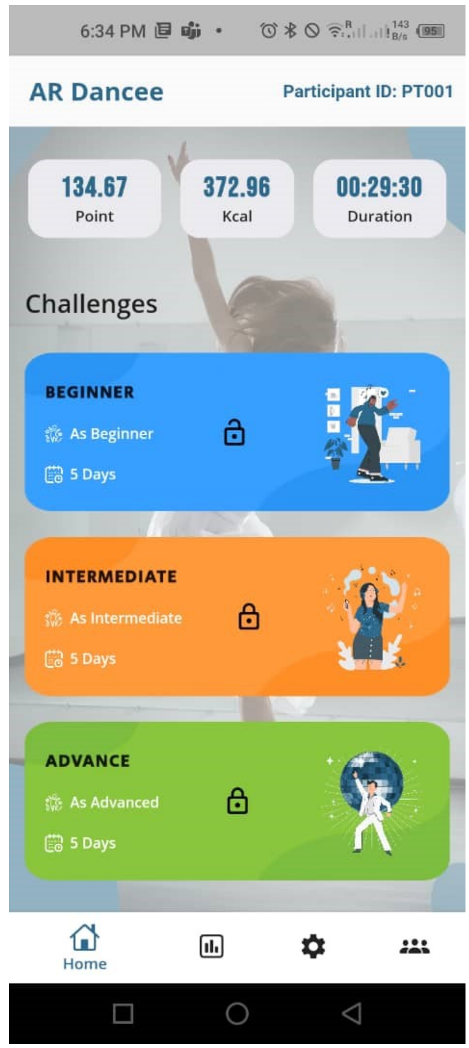

Figure 3.6 Home screen

3.5.5 Music and Avatar Dance Synchronization

In Section 3.5.4 of the research, the significance of the music and the dancing avatar as two out of seven key elements on the dance screen is underscored, highlighting their crucial role in facilitating effective user interaction with the dance app. Upon the user's initiation of a dance session, the app seamlessly activates both the dancing avatar and the accompanying music in synchrony. This synchronization was deliberately implemented to ensure that the avatar dances in harmony with the background music, fostering a cohesive and comprehensible dance pattern for the user to follow. To streamline management processes, particular attention was given to integrating the handling of the dancing avatar and music into a singular sequence of operations. This design choice proves especially advantageous when users choose to pause or resume their dance sessions, thereby enhancing overall user experience and ease of interaction.

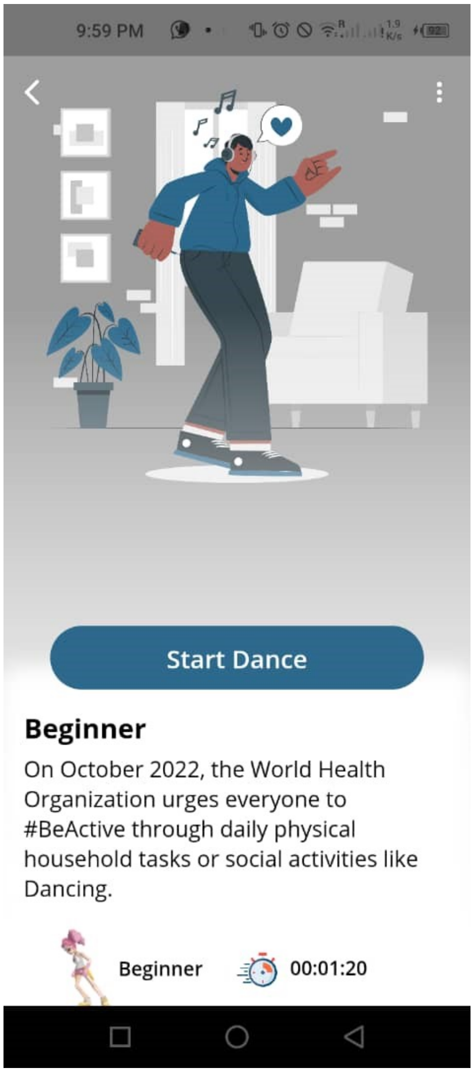

Figure 3.7 WHO Statement screen

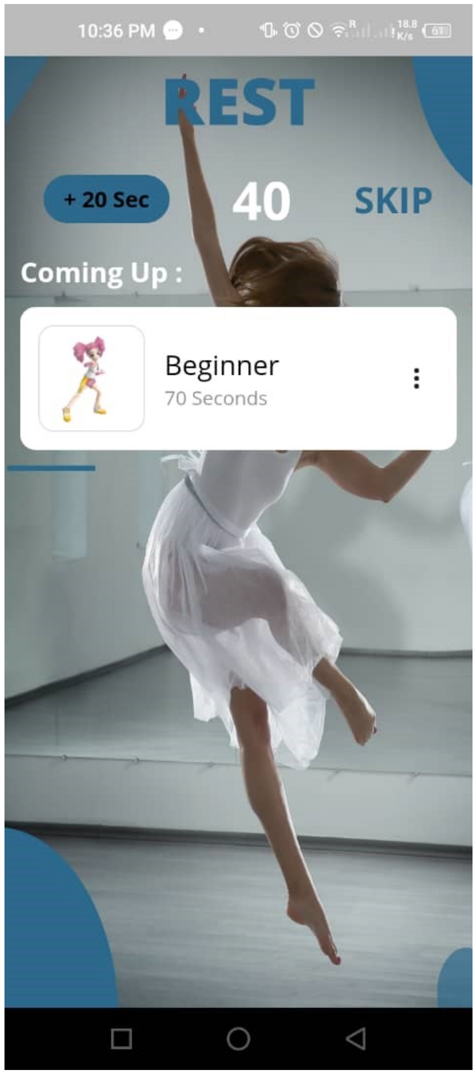

Figure 3.8 Dance Rest screen

3.5.6 Gameplay Reward and Recognition

The implementation of recognition in the leaderboard screen involved the establishment of three distinct levels of recognition. The initial level pertained to the commendation of the first 10 users who demonstrated an impressive performance on a daily basis. Subsequently, the second level of recognition was attributed to the first 10 users who exhibited remarkable weekly performance. Lastly, the third level of recognition was accorded to the first 10 users who showcased an overall impressive performance encompassing their cumulative dance sessions. The rationale behind segregating recognition into these three categories was to ensure a broader scope of acknowledgment within the application, independent of the amount of time users spent engaging with it. By recognizing users across these different timeframes, the aim was to foster motivation and encourage sustained participation in dancing activities, as individuals aspired to be among those celebrated for their exceptional one-day, weekly, or overall performances. Figure 3.9 illustrates the leaderboard screen, which prominently displays the three categories of recognition.

In addition to the leaderboard recognition, the application further celebrated users' achievements upon successful completion of each dance session by bestowing them with a virtual trophy. This feature was conceived with the intention of celebrating and appreciating every user, irrespective of their presence on the leaderboard. Following each dance session, users encountered a reward screen, which not only lauded their efforts but also provided a comprehensive summary of their performance during that specific dance session. Figure 3.10 showcases the Dance Summary screen, featuring the virtual trophy alongside the user's performance statistics. The combination of these recognition strategies, coupled with the periodic acknowledgment through virtual trophies, aimed to create a positive and engaging user experience that motivated users to remain actively involved in the dancing app.

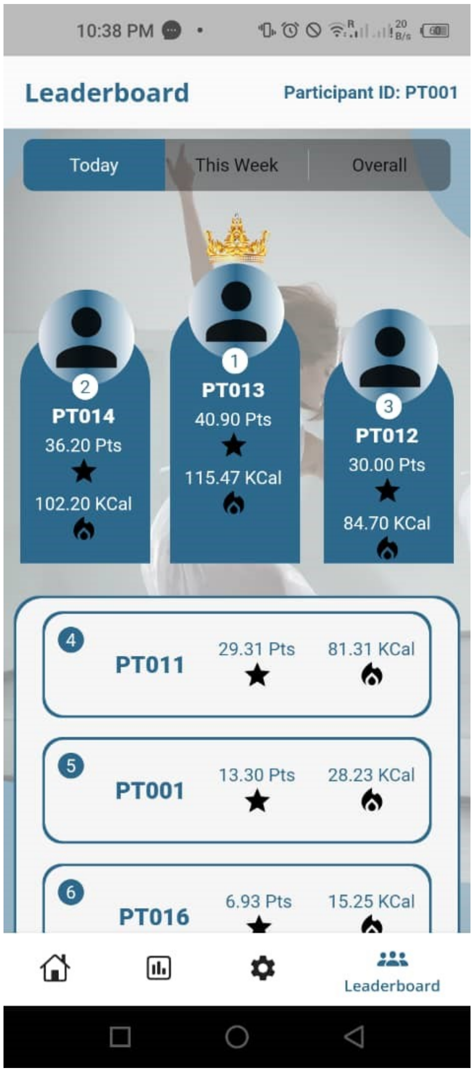

Figure 3.9 Leaderboard screen

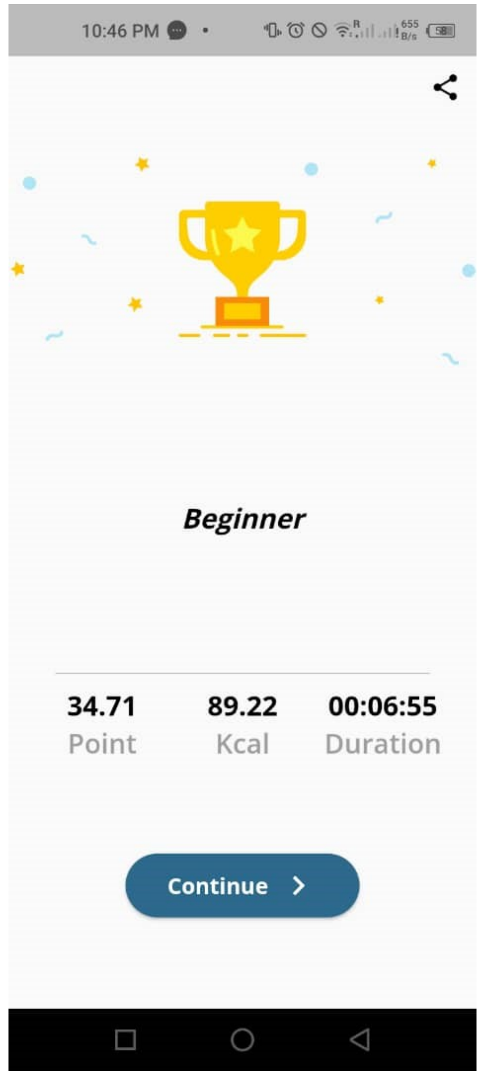

Figure 3.10 Dance Summary screen

3.5.7 App Data Log

The study focuses on the data acquisition process of the application following each dance session, where four primary data types are collected and recorded. These data types encompass the dance duration, calories burned, dance points achieved, and the immediate emotional state of the user, which is assessed through the implementation of the Immediate Mood Scale [136]. To optimize payload processing time, a strategy involves temporarily capturing and storing this data in the user's local memory throughout the duration of the dance session. Upon completion of the session, the temporarily stored data is transmitted to the database in the form of logs, facilitated by an API endpoint [124]. Notably, individual user data is distinguished and organized within the database using a unique user ID as the primary identifier.

The methodology employed for determining the number of calories burned during physical activity (PA) involved utilizing a prescribed formula: (Body Weight x MET)/200. The parameter "Body Weight" represents the specific weight of the user, while "MET" denotes the Metabolic Equivalent of Task utilized to quantify the intensity of the PA. In the case of dancing activity, a constant MET value of 4 was adopted in the calorie calculation formula. This constant value was derived from the average assigned to dance activities when estimating the calories burned through dancing. Consequently, the formula for calculating calories burned during dancing is standardized as (Body Weight x 4)/200. To assess the user's dance performance, a dance point system was implemented. Each second that the user correctly executed the designated dance pattern within the current dance session contributed a value of 1 to their dance point tally. The duration of the dance session was ascertained by capturing the total time the user engaged in dancing and subsequently converting it into seconds. On the home screen, the total calories burned, total dance points accumulated, and the overall dance duration were prominently displayed to provide the user with immediate access to their performance metrics. The presentation of this essential data can be observed in Figure 3.6, which showcases the three calculated parameters on the user interface.

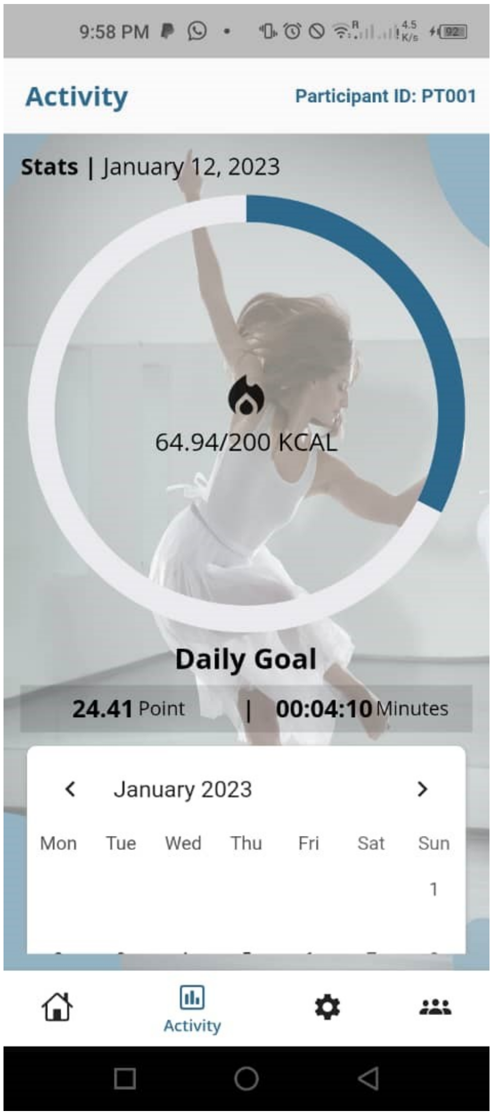

Figure 3.11 Dance Activity screen

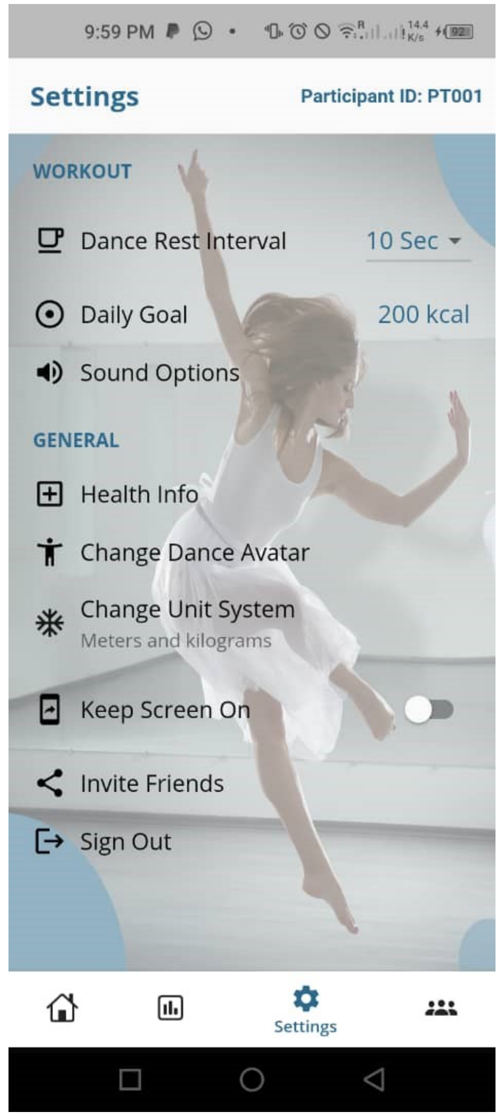

Figure 3.12 Settings screen

3.6 Implementation of Persuasive Strategies

In the pursuit of fostering positive behavior change to enhance positive mood and PA, our intervention incorporates a comprehensive selection of twelve persuasive strategies. These strategies were deliberately chosen based on their proven efficacy in constructing persuasive systems, as elucidated in section 2.7 of our research. The ensuing sections outline the precise delineation of these strategies and their respective implementations.

1. **Tunnelling:** The approach described in the PSD model [27] was adopted to provide guidance to users in their progressive development of PA from one stage to the subsequent stage. Within our intervention, we organized the 15 dance patterns into a hierarchical structure consisting of three levels of increasing challenges. The progression started with low-intensity dance patterns and advanced to medium-intensity dance patterns. As a result, most participants were able to commence their dancing activities at their current PA level and gradually work towards achieving their desired PA level.
2. **Self-monitoring:** The present study incorporates the PSD model's strategy [27], aimed at furnishing users with personalized performance history to facilitate the adjustment and maintenance of their target daily calorie burn goals. As illustrated in Figure 3.11, the Dance Activity screen portrays users' daily calorie burn objectives juxtaposed with the actual calories expended on the current day. Moreover, it enables users to retrospectively review their accumulated daily calorie burn since the inception of app usage. This particular strategy finds its basis in its widespread application in interventions designed to promote physical activity [25][26], and its demonstrated efficacy in positively influencing users' health-related behaviors.
3. **Recognition:** The strategy proposed in the PSD model [27] was incorporated into the leaderboard with the aim of motivating users to enhance their physical activity (PA) level by expending more calories while dancing. By recognizing individuals who exerted extra effort in this regard, the intervention sought to incentivize and encourage users to engage in more active dancing sessions. To implement this strategy, we devised three distinct categories for recognition on the leaderboard: daily, weekly, and overall leaders. This classification system was intended to offer users multiple opportunities for acknowledgment based on their respective levels of engagement and performance. However, it is worth noting that users who joined the intervention after a few days or weeks into the study might not be eligible for recognition as part of the overall leaders. Nevertheless, they would still have the chance to be acknowledged under the categories of daily or weekly leaders, depending on their recent performance. In summary, the intervention sought to create a fair and inclusive recognition system, ensuring that all users using the dancing app had the opportunity to be acknowledged for their efforts and accomplishments in improving their PA level through dancing.

4. **Reward:** The strategy derived from the PSD model [27] has been incorporated to express gratitude to individual users upon the successful completion of each dance session. This particular approach involves granting users a virtual trophy as a form of reward for their commitment towards attaining their daily goal of enhancing their physical activity (PA) level through dance. The utilization of rewards as a persuasive mechanism has demonstrated significant efficacy in previous interventions [27][28], further reinforcing the likelihood that our intervention will be perceived as persuasive by users when they receive rewards for accomplishing their objective of burning calories through daily dancing.
5. **Personalization:** The implementation of the PSD model's strategy [27] aimed to enhance user engagement with our intervention through a user-centric approach. To achieve this objective, we employed several key techniques. Firstly, we provided users with the option to select an avatar that best aligned with their personal identity, fostering a stronger sense of relatability. Additionally, we recognized the importance of accommodating users' diverse preferences regarding the unit of measurement for body weight. Consequently, we integrated a feature that allows users to enter their weight in either kilograms (kg) or pounds (lbs.), according to their accustomed unit. By tailoring these aspects of the intervention to individual user preferences, we sought to create a sense of inclusivity and belonging for all users. This approach is particularly significant, given that our intervention targets a broad public audience. By incorporating these user-oriented features, we aimed to enhance the overall appeal and usability of our intervention. Figure 3.12 provides a visual representation of the Settings screen, where users can easily configure these personalized features based on their preferences, further reinforcing the user-centric nature of our intervention.
6. **Goal-setting:** In the realm of persuasive strategies utilized beyond the PSD model [27], a particularly notable approach centers on goal-setting. Previous studies have demonstrated the efficacy of goal-setting in driving behavioral change [5]. Indeed, within the landscape of related research, goal-setting emerges as one of the most prevalent persuasive strategies employed to enhance the persuasiveness of interventions [25][26]. By integrating the goal-setting strategy into our own intervention, we afford each user the ability to establish personalized daily calorie burn objectives, which serve as guiding beacons throughout their engagement with the intervention. Additionally, users are provided with the opportunity to

set or modify their daily calorie burn goals, tailored to their individual capacities and determination. This approach fosters heightened motivation among users to diligently pursue their daily calorie burn targets, thus leading to an overall improvement in their physical activity levels.

7. **Rehearsal:** The methodology employed in this study draws upon the PSD model's approach [27], aiming to provide comprehensive support to all users engaging with our dance intervention. Given the unique nature of each dance pattern, which has been exclusively formulated by our team, it becomes imperative to present a visual demonstration of each pattern to users prior to the commencement of their dancing session. This strategic decision serves multiple crucial purposes, including sustaining user engagement and interest throughout the intervention and facilitating seamless guidance during their dance routines. By alleviating the cognitive burden [137] on the users to recall or remember each dance pattern while in motion, this approach ensures a smoother and more immersive dance experience.
8. **Social Role:** The implementation of the social role strategy, inspired by the PSD model [27], aims to enhance user support during the dance intervention. This intervention offers users opportunities to elevate their PA levels through independent dancing. By employing the social role strategy, our system functions as a virtual support assistant, providing audio feedback to encourage users throughout their dance sessions. Introducing users to a novel activity, such as dancing, can lead to feelings of uncertainty and disorientation, particularly when no direct guidance or cues are provided. However, by incorporating the social role strategy into our intervention, we address this issue by offering users a sense of support and guidance during their dancing experience. Consequently, users are more likely to perceive the intervention as persuasive due to the perceived assistance and encouragement provided.
9. **Reminders:** The present study incorporates the strategy proposed in the PSD model [27] to facilitate users in accomplishing their daily objectives by enhancing or sustaining their PA levels through dancing. The reminder strategy was implemented through the integration of daily in-app notifications, serving as prompts for users to engage in daily dance sessions. It is worth noting that interventions employing reminder strategies are expected to significantly contribute to the facilitation of daily goal attainment and the adoption of target

behaviors. Hence, the current intervention was devised with the specific aim of assisting users in achieving their daily caloric burning and PA objectives by consistently reminding them to engage in dance sessions on a daily basis.

10. **Praise:** The approach derived from the PSD model [27] was effectively employed to incentivize user engagement by providing commendations for their endeavors in enhancing or maintaining their PA levels. Throughout the intervention, the virtual support assistant delivered feedback to users, interspersed with praise, as they adhered to the dance patterns and accumulated dance points. The utilization of praise as a motivational tool has been well-established in prior research [5], as it fosters a sense of motivation and encourages users to persist in their adoption of healthy behaviors. Hence, in our intervention, the praise strategy was implemented through verbal reinforcement, considering that the user is expected to be actively dancing and may find verbal expressions of praise to be more impactful than visual stimuli, such as images or symbols..
11. **Authority:** The approach derived from the PSD model [27] was utilized to augment the persuasiveness of our intervention by incorporating a statement concerning dancing as a means of PA from a globally recognized authority such as the WHO. Each instance the user initiates a dance session, our intervention prominently displays the WHO statement, as illustrated in Figure 3.7. The adoption of this particular strategy serves to instill confidence in the users regarding the efficacy of engaging in dance activity for their overall health and well-being. As a consequence, the perception of our intervention being more persuasive is heightened, given the presence of authoritative endorsements like that of the WHO, affirming the merit of the activity they intend to undertake.
12. **Suggestion:** The present study incorporates the strategy proposed by the PSD model [27] to offer users the flexibility of incorporating rest periods within a dance session. This approach aims to empower users to engage in the dance activity at their preferred pace, granting them the autonomy to either take breaks or continue dancing. As a result, our intervention capitalizes on the suggestion strategy, effectively enhancing its persuasive potential.

Through the integration of twelve distinct persuasive strategies into the development of AR Dancee, our intervention endeavors to effectively promote PA through dance. Each of these persuasive strategies has been purposefully selected and aligned with the eleven key features of the application. The correlation between each feature and its corresponding persuasive strategy is detailed in Table 3.1. To gauge the persuasiveness of our intervention, we employed the eleven key features outlined in Table 3.1 as assessment criteria. This comprehensive evaluation enabled us to thoroughly examine the efficacy of our intervention by analyzing these main features. Additionally, an essential aspect of our assessment involves the examination of whether our intervention has been successful in fulfilling its overarching objectives, namely, the improvement of PA levels and fostering positive mood states. To effectively assess the achievement of these objectives, we designed a study, the details of which are provided in the next chapter.

Table 3.1 Persuasive Strategies implemented in the intervention features.

SN	Features	Persuasive Strategies
1	Home Screen	Tunnelling
2	Daily Dance Activity	Self-monitoring
3	Leaderboard	Recognition
4	Dance Performance Summary	Reward
5	Dance Avatar Selection	Personalization
6	Goal Setting	Goal setting
7	AR Dance Screen	Rehearsal
8	Audio Feedback	Social Role, Reminders, Praise
9	Settings Screen	Personalization
10	WHO Statement Screen	Authority
11	Dance Rest Screen	Suggestion

3.7 Research Questions

In this study, we developed an AR-driven intervention that can promote PA through dancing and improve users' positive mood and our research goal is to answer the following three research questions:

RQ1: How effective is the AR Dancee app in motivating physical activity in adults through dancing?

RQ2: What is the impact of AR Dancee app in influencing positive mood?

RQ3: What is the perceived persuasiveness of AR Dancee app features in influencing healthy behavioral change toward physical activity?

Chapter 4 : System Evaluation

In order to assess the efficacy of our developed intervention, we undertook a comprehensive mixed methods user study employing both quantitative and qualitative approaches. The collection of quantitative data was accomplished through the administration of pre- and post-intervention questionnaires, as well as the analysis of log data generated by the intervention. Complementary to this, the acquisition of qualitative data was carried out through semi-structured optional interviews, which provided valuable insights into participants' perspectives. Through the execution of this study, we successfully addressed the three research questions outlined in section 3.7. This chapter offers a detailed explanation of the study's methodology, elucidating the underlying design principles and processes employed throughout the study.

4.1 Materials and Procedures

The primary objective of this research is to assess the efficacy of the AR Dancee application in encouraging physical activity through dance and its potential positive impact on users' mood. To achieve this, a diverse group of participants from various geographical locations were recruited to engage with our intervention. The effectiveness of the intervention was evaluated through the use of questionnaires, which were designed to gauge its impact. Before commencing the study, ethical clearance was obtained from the university ethics committee (REB: 2022-6379). To gather participants, a recruitment notice was generated and disseminated through social media and email campaigns. Interested individuals were invited to participate in the study by accessing a link from Dal Opinio, which facilitated the provision of their email addresses, signaling their willingness to take part. Upon receiving potential participants' email addresses, we delivered the consent form and pre-study survey link to them. Completion of the consent form was a prerequisite for their participation in the study. The pre-study survey encompassed inquiries related to participants' demographic characteristics, current level of physical activity, and mood assessment. These data points were crucial in analyzing the intervention's effectiveness and its potential influence on mood improvement.

Upon the completion of the pre-study survey, participants were provided with a unique link to download the designated mobile app, along with their individual participant ID. Upon successful installation, participants commenced engaging with the app to perform a minimum of 5 dance patterns, constituting a daily dance session, over a 15-day period. Throughout the study's duration, the intervention recorded both the participants' mood and dancing data on a remote server hosted on Amazon Web Services (AWS) [138]. Upon reaching the conclusion of the 15th day, participants were sent an email inviting them to participate in a post-study questionnaire, utilizing Dal Opinio, to gather insights on their experience with the intervention. The post-study survey comprised inquiries concerning the participants' present physical activity (PA) levels, mood status, as well as their perceptions regarding the intervention's persuasiveness, simplicity, and usability.

Following the completion of the post-study survey, participants were presented with the option to partake in an additional interview at the conclusion of the study. This interview aimed to gather supplementary feedback on the intervention's effectiveness and user experience. Interested participants expressing their willingness to partake in the interview were contacted subsequently to schedule a suitable interview session. Before the commencement of the interview, participants were provided with an electronic interview consent form through a provided link. By acknowledging their consent to be interviewed, participants formally affirmed their agreement to participate in the interview process. For reference, the recruitment notice (Appendix B), study consent form (Appendix C), interview consent form (Appendix D), pre-study survey (Appendix F), post-study survey (Appendix G), and interview questions (Appendix H) are all included in the appendices section of this research. A graphical representation of the step-by-step procedures involved in completing the study can be found in Figure 4.1.

4.2 Measures and Variables

The pre- and post-surveys in this study were carefully crafted to obtain valuable feedback from participants regarding the intervention and to address the research questions outlined in section 3.7. Six specific scales were utilized for this purpose, each serving a distinct role in assessing various aspects of the intervention. The scales used in the study are as follows: the Global Physical Activity Questionnaire (GPAQ) [31] scale was employed to gauge participants' physical activity levels both before and after the intervention. The Positive and Negative Affect Schedule (PANAS) [139] scale was utilized to assess participants' mood in both the pre- and post-study surveys. The Perceived Persuasiveness [140] scale was employed to analyze participants' perceptions of the intervention's persuasiveness. The Simplicity [141] scale was used to measure participants' perceptions of the intervention's simplicity and ease of use. The Usability [142] scale was utilized to evaluate participants' perceptions of the intervention's overall usability. The Immediate Mood Scaler (IMS) [136] was used in conjunction with PANAS to further assess participants' immediate mood during the study.

The effectiveness of the intervention in promoting physical activity and positive mood, as well as the answers to RQ1 and RQ2, were determined by analyzing the variables PANAS, GPAQ, and IMS. Additionally, the other scales (Perceived Persuasiveness, Simplicity, and Usability) played a crucial role in addressing RQ3, as they allowed for an examination of participants' perceptions of the intervention's persuasiveness, usability, and simplicity. As part of the survey, participants also provided information about their demographic characteristics, including age group, gender identity, employment status, last education obtained, and computer skill level. These demographic details are essential for understanding the diverse participant pool and its potential impact on the intervention's outcomes. In terms of measurement, participants responded to all scales, except the demographic questions and GPAQ, using a 5-point or 7-point Likert scale, where 1 represented "Strongly Disagree" and 7 denoted "Strongly Agree." The specific details and descriptions of all the measures employed in this study will be provided below:

1. **Global Physical Activity Questionnaire:** To assess the current level of PA among the participants, we employed the GPAQ [31], a validated instrument comprising five pertinent questions. One of the questions, for instance, was "*In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational (leisure) activities (e.g., dancing)?*". This comprehensive scale not only gauges the extent of participants' involvement in PA during a regular week but also captures the duration of sedentary activities [34]–[36]. Both pre- and post-study surveys incorporated this instrument to ascertain the participants' initial behavioral tendencies and attitudes towards PA prior to the intervention. Furthermore, the same scale was utilized to discern any behavioral changes indicative of increased physical activity following the intervention. This data would be instrumental in addressing Research Question 1 (RQ1), which revolves around examining the impact of the intervention on participants' PA levels.
2. **Positive and Negative Affect Schedule:** We employed the PANAS [139] to assess the current disposition and negative affective state of the participants. The PANAS utilizes a 5-point scale to measure emotions such as interest, excitement, distress, and upset. This

scale has demonstrated efficacy in gauging both negative and positive emotional states, as evidenced in prior research [143][144][145]. To ascertain the potential impact of the intervention on participants' mood, our study sought to compare their overall emotional state before the intervention was introduced and examine whether the intervention led to positive mood improvements by the study's conclusion. Consequently, the PANAS scale, consisting of twenty distinct words describing various feelings and emotions, was included in the pre- and post-study surveys. By analyzing participants' responses on this scale before and after the intervention, helped us to address RQ2 concerning the influence of the intervention on mood enhancement.

3. **Immediate Mood Scaler:** The present study necessitates the assessment of participants' immediate mood on each occasion of utilizing the dance intervention. To accomplish this objective, we employed the IMS [136], a 7-point scale designed to track participants' mood states throughout the study, such as apathetic versus motivated, pessimistic versus optimistic. The integration of the IMS into the intervention prompted participants to promptly provide their mood response upon completing the first dance session each day during the study. The acquisition of participants' immediate mood data aimed to ascertain whether the intervention had a positive or negative impact on their emotional states. Additionally, we sought to compare the results obtained from the Immediate Mood Scaler with those from the PANAS scale. Thus, a comprehensive analysis of the Immediate Mood Scaler responses helped us to address RQ 2 effectively.
4. **Perceived Persuasiveness:** The Perceived Persuasiveness Scale [140] is utilized to gauge the efficacy of persuasive strategies in influencing participants toward positive behavior change. This 7-point scale incorporates four questions, such as "*This feature would influence me to improve my physical activity*", to assess the overall persuasiveness of the intervention. Through the analysis of this scale, we addressed RQ1 and RQ3. It is important to note that this scale was individually applied to each of the persuasive strategies implemented within the intervention, as outlined in section 3.6, and subsequently evaluated within the context of the eleven key features of the intervention.
5. **System Usability:** The utilization of the system usability scale (SUS) [142] was employed as a means to assess the various usability dimensions of the intervention, including ease of use, complexity, learnability, integrity, and consistency. The scale, comprising 10

questions adapted from Brooke [142], employs a 5-point rating system. Participants responded to statements such as "*I think that I would like to use this system frequently*", enabling the derivation of a comprehensive usability score for the intervention. The adoption of this scale facilitated the measurement of key usability aspects inherent in our intervention design, thereby providing essential insights for addressing RQ1 and RQ3.

6. **Simplicity:** To assess the perceived simplicity of our intervention among participants, we employed the smartphone interface simplicity scale [141], which employs a 5-point rating system. The utilization of this scale was imperative to gain insights into the ease of use and coherence of our intervention's design, given its mobile app nature. We adhered to the facets outlined by Choi and Lee [141], encompassing visual aesthetics, information design, and system complexity, which collectively contribute to the assessment of overall simplicity in the context of human-computer interaction [146][15]. The analysis of the data collected through the simplicity scale was instrumental in addressing the RQ1 and RQ3.

In addition to the validated scales presented in the preceding section, this study encompassed the collection of participants' demographic information, which was subjected to analysis in order to bolster the responses to all research inquiries. Furthermore, pertinent data pertaining to participants' daily caloric expenditure, dance duration, and dance performance scores were logged throughout the intervention. The analysis of this log data is expected to play a crucial role in addressing RQ1. As a supplementary approach, optional interviews were conducted to gather further feedback on the intervention, with the intent of addressing all three research questions comprehensively. These interviews were designed to elicit candid and unrestricted comments from participants, covering various facets of the intervention and providing valuable insights into its overall effectiveness. For ease of reference, the interview questions, demographic inquiries, and all other scales discussed in this section are included in the appendices section of this research report.

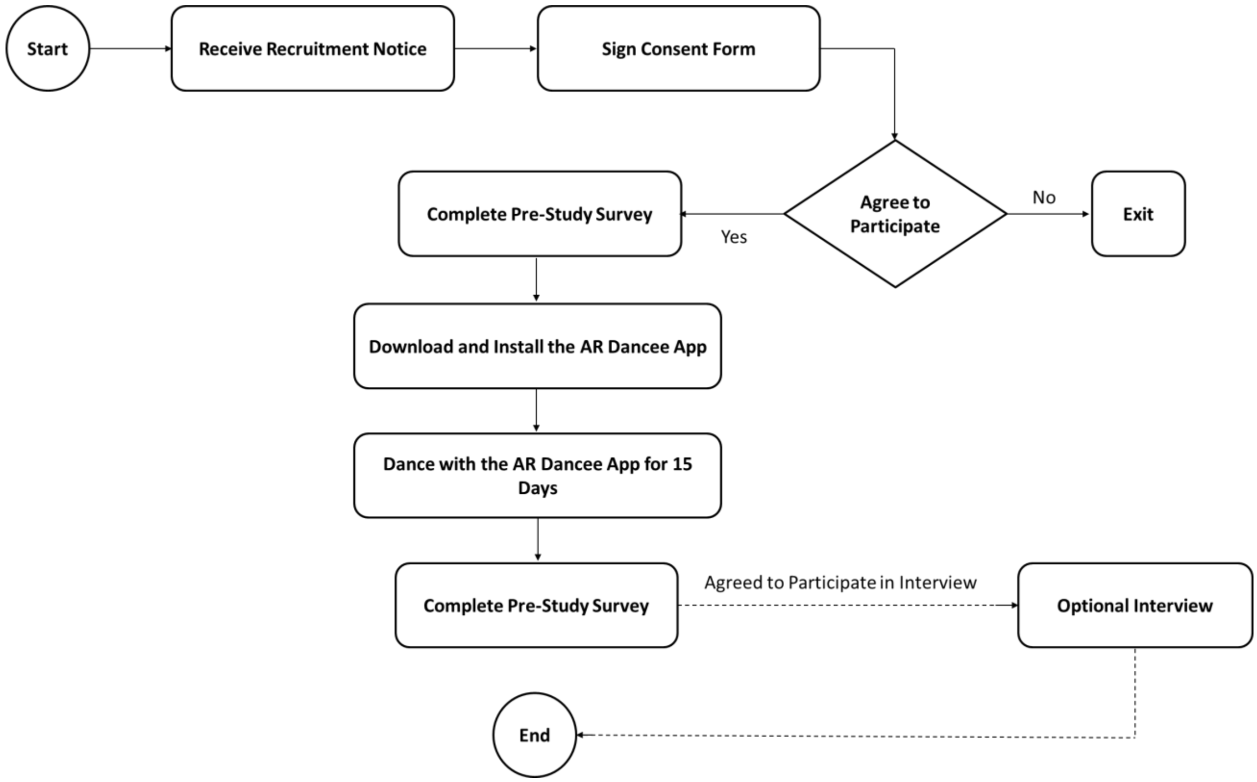

Figure 4.1 Study procedure

4.3 Recruitment of Participants

The research employed a recruitment strategy that commenced with the dissemination of a recruitment notice containing a hyperlink to Dal Opinio, where prospective participants could express their initial interest in joining the study by providing their email addresses. This notice was disseminated across university email lists and various social media platforms. In addition to these methods, snowball sampling techniques were employed to enable enrolled participants to refer other potential participants to the study. Ultimately, a cohort of 104 participants successfully completed the study, and from this group, 27 individuals volunteered to partake in further interviews. For the interview phase, interested participants received an email solicitation to schedule their respective interviews. Those who responded to the interview invitation and confirmed a convenient time were subsequently interviewed via online meetings. Each interview session lasted approximately 15 to 30 minutes and was conducted using the Microsoft Teams platform [147]. During these interviews, all records were maintained to capture the participants' responses for subsequent analysis and interpretation.

4.4 Data Analysis

The study encompassed a comprehensive data collection approach, incorporating both quantitative and qualitative data sources, which were subsequently subjected to distinct analytical methodologies. The quantitative data, procured through questionnaires and application logs, underwent statistical analysis to derive meaningful conclusions. This analysis involved the generation of graphs, charts, and tables to facilitate a more lucid comprehension of underlying patterns and trends. The statistical analysis for the quantitative data was conducted utilizing the Statistical Package for the Social Sciences (SPSS) software [148] and Microsoft Excel [149]. SPSS, renowned for its proficiency in data analysis and interpretation, offered valuable insights into patterns, relationships, and trends within the datasets. Meanwhile, Microsoft Excel, a widely used spreadsheet software developed by Microsoft, proved instrumental not only for performing calculations and organizing numerical data but also for its effectiveness in data analysis. Excel's capability to generate diverse visualizations based on different dataset types complemented the statistical findings, enhancing the overall clarity and comprehensibility of the results. The quantitative analysis entailed employing various statistical tests, including t-tests, ANOVA tests, Shapiro Wilk tests, Mann Whitney U test, and post-hoc pairwise comparison tests. Additionally, frequency histograms were constructed as necessary to visualize the distributional shape of the data. These rigorous analytical methodologies collectively enabled a robust evaluation and interpretation of the quantitative data, yielding pertinent findings to address the research objectives.

The qualitative data analysis encompassed a rigorous application of thematic analysis [150] to scrutinize the interview responses and open-ended questions, employing NVIVO [151] software for data management and coding. The process entailed a review of all transcribed data gathered during the interviews, followed by systematic coding of the responses within NVIVO [151]. These coded responses were then organized into distinct thematic categories. During the initial phase, themes were generated in a non-generalized manner to capture the richness and diversity of the data. Subsequently, a thorough examination of these initial themes took place, leading to the amalgamation of common themes to prevent redundancy and overlap. This iterative process was carried out until no further overlaps between themes were observed, ensuring comprehensive theme refinement. In the next chapter, we will present the results derived from the comprehensive analysis of both quantitative and qualitative data, shedding light on the significant findings of our study.

Chapter 5 : Results

In this section, we present the outcomes of our analysis, which was based on the data we gathered during our research study. The study had a total of 108 participants who successfully completed the entire process. However, we had to exclude the data of 4 participants due to incomplete responses on PA in both the pre- and post-study questionnaires. Analyzing the changes in their PA would have been challenging without complete information. Consequently, our final dataset comprises responses collected from pre- and post-study questionnaires, optional interview responses of 27 participants, along with data logs automatically recorded by the app, from a total of 104 participants.

5.1 Participants and Recruitment

The participant demographics summary is provided in Table 5.1. Prior to commencing the research, ethical approval was obtained from our university's ethics board. To recruit participants, we employed a multi-faceted approach, utilizing social media campaigns, word of mouth, and email broadcasts, which enabled us to gather participants from diverse geographical locations like Africa, Europe, Asia, and America. The age distribution of our participants revealed that the majority (53%) fell within the 18-25 years age group, while the 36-45 years age group had the lowest representation with only 9% of participants. It is important to note that there were no participants over the age of 45. Gender-wise, the study witnessed a greater proportion of female participants, accounting for 63% of the total, while male participants constituted 36%. A negligible 1% of participants opted not to disclose their gender. Regarding marital status, a significant portion of the participants (86%) identified as single. In terms of education levels, 38% of participants held a bachelor's degree, making it the most common educational attainment, followed closely by 31% who completed high school or an equivalent qualification.

Although the research intervention necessitated only a basic understanding of computer and smartphone usage, we evaluated participants' computer skills and smartphone usage to assess potential impacts on the research outcomes, as the intervention was considered innovative. Smartphone usage was categorized as <1 to >10 years, with the highest percentage of participants (41%) reporting usage for 5-10 years. Computer skills were assessed using a 10-point Likert scale, ranging from 1 to 10, and participants predominantly identified themselves as having intermediate computer skills (64%). Given the nature of the study, which involved the adoption of PA as a lifestyle component, we also offered participants the option to disclose their employment status. Among the participants, 54% were students, while 23% were engaged in full-time employment.

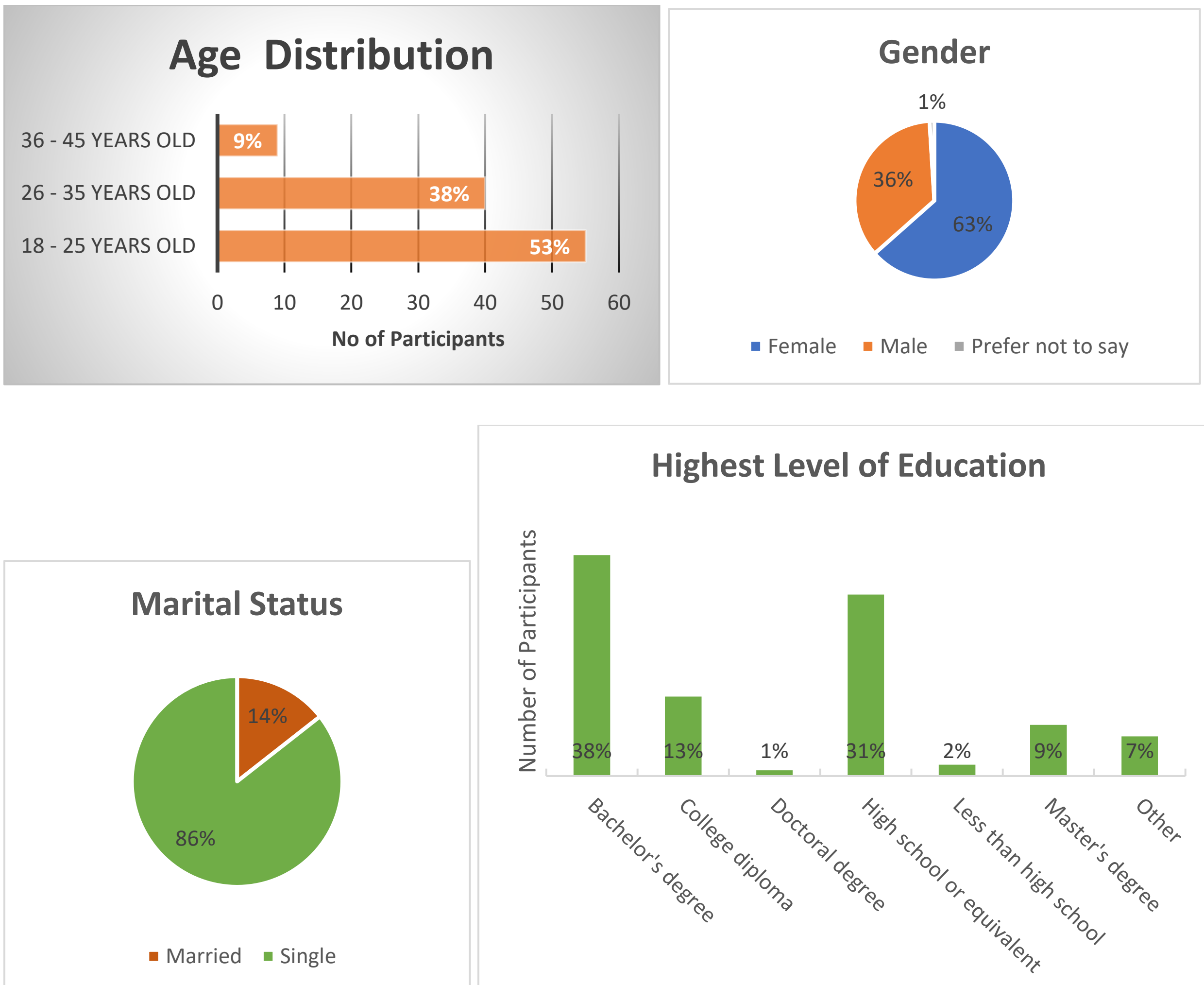

Figure 5.1 Overview of the demographics of study population

Table 5.1 Demographic characteristics of the study population

Demographic Characteristics		N (%)
Gender	Male	37 (36%)
	Female	66 (63%)
	Prefer not to say	1 (1%)
	Other	0 (0%)

Age Groups	18-25	55 (53%)
	26-35	40 (38%)
	36-45	9 (9%)
	45 and above	0 (0%)
Highest Level of Education	Bachelor’s degree	39 (38%)
	College diploma	14 (13%)
	Doctoral Degree	1 (1%)
	High School or equivalent	32 (31%)
	Less than high school	2 (2%)
	Master’s degree	9 (9%)
	Other	7 (7%)
Marital Status	Single	89 (89%)
	Married	15 (14%)
	Divorced	0 (0%)
	Widowed	0 (0%)
	Prefer not to say	0 (0%)
	Other	0 (0%)
Employment Status	Employed (full-time)	24 (23%)
	Employed (part-time)	11 (11%)
	Student	56 (54%)
	Unemployed	9 (9%)
	Other	4 (4%)
Computer Skill	Expert	26 (25%)
	Intermediate	67 (64%)
	Novice	11 (11%)
Own Smartphone	< 1 year	1 (1%)
	1-3 years	12 (12%)
	3-5 years	17 (16%)
	5-10 years	43 (41%)
	>10 years	31 (30%)

5.2 Quantitative Analysis

To address the research questions outlined in Section 3.7, an array of statistical analyses was performed on the quantitative data gathered during the study. A significance level of $\alpha = 0.05$ was utilized for most of the statistical tests, with the exception of specific instances where the Bonferroni correction was implemented to mitigate the risk of type 1 errors. Detailed findings stemming from our quantitative data analysis are expounded upon in the subsequent sections.

5.2.1 Analysis of the Perceived Change in Physical Activity

The study utilized the GPAQ scale [31] to assess changes in participants' PA levels. The questionnaire was administered at baseline and after the intervention period to capture pre- and post-intervention responses. As the study spanned over 2 weeks, the GPAQ included weekly questions on physical activity, allowing the collection of data on participants' weekly activity levels before and after the intervention. To evaluate the effectiveness of the intervention and address RQ1, the participants' responses were analyzed at baseline and after the intervention. Following the GPAQ guidelines [31], participants' responses were converted to actual metabolic equivalent (MET) values per week. The WHO recommends a minimum of 150 minutes of moderate to vigorous activity or approximately 600 MET of PA per week for individuals. Initially, descriptive statistics for the pre- and post-intervention data were computed and are presented in Table 5.1. Subsequently, a one-sample t-test was conducted to determine the mean difference between participants' physical activity at baseline and after the intervention, using the optimistic score of 600 MET (WHO weekly recommendation). This analysis aimed to identify if the difference was statistically significant. The results, shown in Table 5.2, indicate that both the baseline physical activity score ($M = 652.69$, $SD = 310.25$) and the post-intervention physical activity score ($M = 783.46$, $SD = 313.41$), exceeded the optimistic score of 600 MET as recommended by the WHO. The one-sample t-test revealed no significant difference in the baseline physical activity score $t(103) = 1.732$, $p = 0.086$. However, there was a highly significant difference in the post-intervention physical activity score $t(103) = 5.970$, $p < .001$. Furthermore, a paired samples t-test was performed to investigate whether there was a statistically significant difference between the pre- and post-intervention data. The results revealed a statistically significant increase $t(103) = 5.356$, $p < .001$, in PA levels from pre- to post-intervention.

Table 5.2 Descriptive statistics of the PA data at pre- and post-study.

Scale	Condition	*M*	*SD*
GPAQ	Pre	652.69	310.25
	Post	783.46	313.41

Table 5.3 One Sample t-test of the PA data at pre- and post-study

Scale	Condition	*t*	*df*	*p*
GPAQ	Pre	1.732	103	0.086
	Post	5.970	103	<.001

Examining Table 5.2, it is evident that the mean scores for both pre- and post-weekly PA data surpass the recommended score of 600 MET per week as prescribed by the WHO. This observation is further supported by the data depicted in Figure 5.2, which presents the results of the two mean scores. A previous analysis of descriptive statistics has indicated that the post-intervention PA score exhibits a statistically significant increase of 9% compared to the baseline score ($p < 0.001$), as illustrated in Figure 5.2. Notably, both pre- and post-PA mean scores exceeded the WHO's weekly recommendation, highlighting the efficacy of our intervention in fostering higher levels of PA among participants.

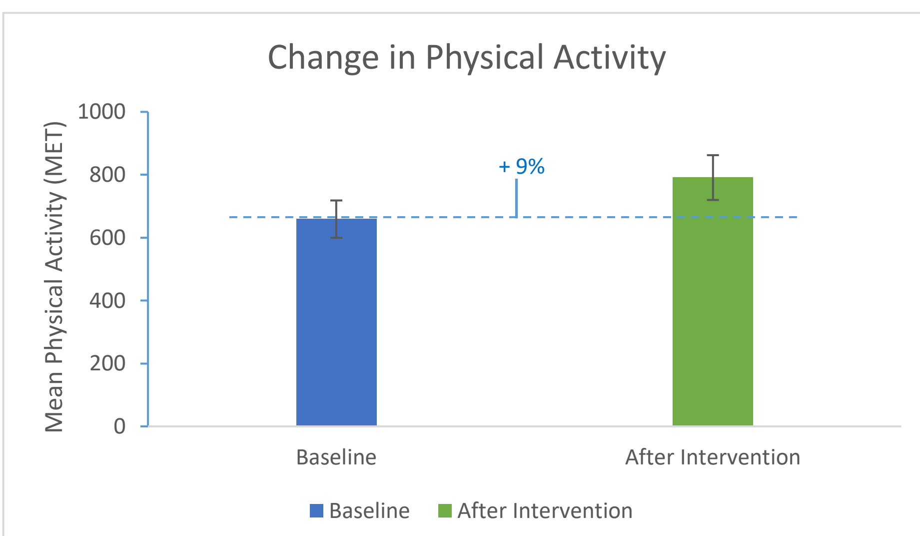

Figure 5.2 Bar chart showing the percentage difference in mean of PA at baseline and after the study.

The descriptive statistics presented in Table 5.2 offer limited information, primarily reflecting the general mean score at two stages when PA data was collected. To gain deeper insights, we conducted further analysis to identify potential patterns in the changes observed in PA between the pre- and post-data collection periods. This involved calculating the medians of the pre- and post-MET scores separately, resulting in values of 640 and 760, respectively. The rationale behind utilizing the median as a measure of central tendency was twofold. Firstly, it provided a stable representation of the data, facilitating the categorization of participants into low and high PA levels. Secondly, employing the median helped mitigate the influence of potential skewness and kurtosis, as participants' self-reported PA levels tend to vary.

Figure 5.3 visually presents the observed pattern of PA level increase as measured in MET. The data reveals that participants falling into the low PA category exhibited MET scores below 500 at baseline, whereas their MET scores rose above 500 after the intervention. A similar trend is observed in the high PA category, where participants initially reporting frequent PA engagement had MET scores below 1000 at baseline but surpassed 1000 MET following the study. Figure 5.4 also indicates a consistent increase in PA levels for both the low and high categories of participants at the conclusion of the study. These findings strongly suggest that the intervention was perceived to be effective in enhancing participants' PA engagement.

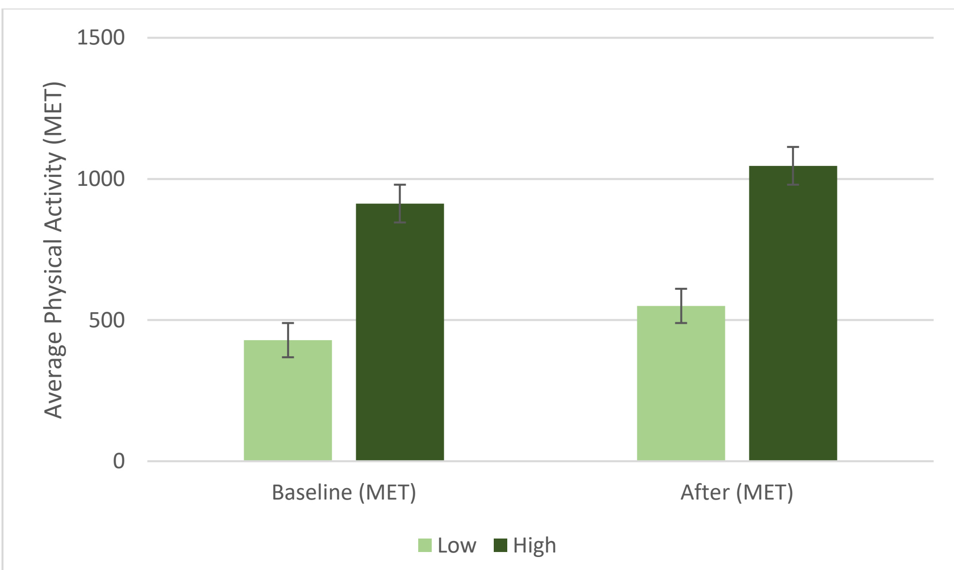

Figure 5.3 Bar chart illustrating pattern of increase in PA level at baseline and after the study

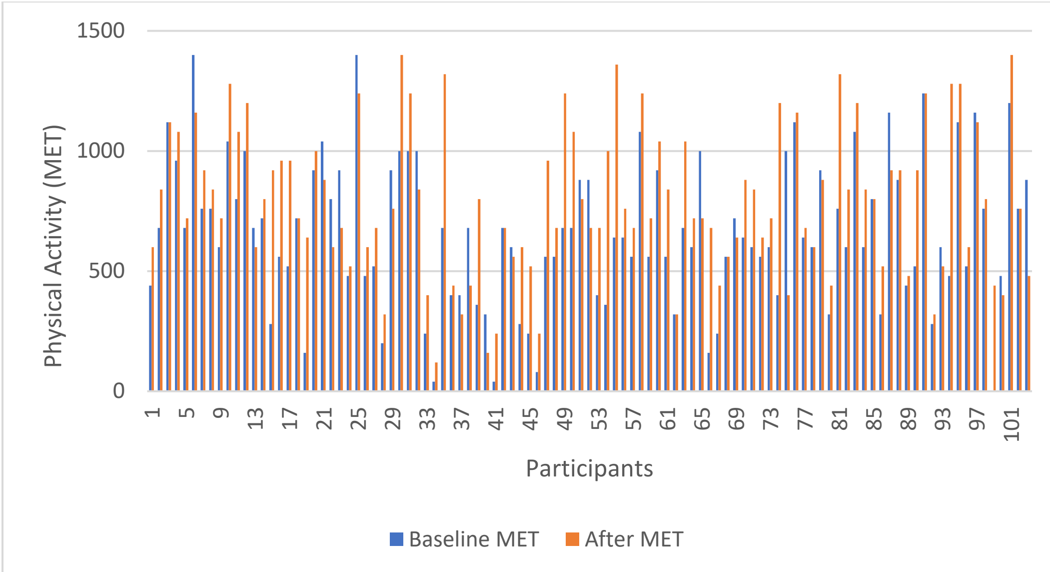

Figure 5.4 Clustered chart illustrating Participant increase in PA at baseline and after the study.

5.2.2 Analysis of Physical Activity Data with Respect to Age Groups and Genders

We developed our intervention in the form of a user-friendly mobile application aimed at promoting PA among the general public, irrespective of their age group or gender identity. Therefore, we assessed the effectiveness of this intervention across different age groups and genders. Regarding age grouping, we categorized the participants into three distinct categories: (1) 18-25 years, (2) 26-35 years, and (3) 36 years and above. However, it is worth noting that we did not have any participants who identified as being above 45 years of age, which led to the absence of a fourth age group in our analysis. Similarly, participants provided their gender information within two categories: female and male. Hence, we organized the data analysis based on these recorded gender categories. The outcomes of our data analysis pertaining to PA data concerning age groups and gender categories are presented in Table 5.4 and Table 5.5, respectively. These tables contain the descriptive statistics that allow for a comprehensive understanding of the intervention's impact across different age groups and genders.

Table 5.4 Descriptive statistics of the PA data with respect to age groups.

Condition	Age Group	*M*	*SD*	*N*
Pre	18-25	714.91	296.65	55
	26-35	613	292.17	40
	36 and above	448.89	384.59	9

Condition	Age Group	*M*	*SD*	*N*
Post	18-25	854.55	285.70	55
	26-35	725	317.06	40
	36 and above	608.89	370.83	9

Table 5.5 Descriptive statistics of the PA data with respect to genders

Condition	Gender	*M*	*SD*	*N*
Pre	Female	670.91	289.36	66
	Male	624.87	349.27	37
Post	Female	812.73	290.16	66
	Male	717.84	340.84	37

Upon confirming the assumptions of ANOVA for the PA data and the normality of the data distribution using Shapiro Wilk test, a Repeated Measures-Analysis Of Variance (RM-ANOVA) was performed, employing age groups as the between-subject factors, time (pre and post-study) as a within-subject factor, and PA as the dependent variable. The obtained results revealed a significant main effect of time across age groups, $F(1, 104) = 17.444$, $p < .001$, $\eta 2 = 0.147$. However, there was no significant interaction between time and age groups, $F(2, 104) = 0.207$, $p = 0.813$, $\eta 2 = 0.004$. Figure 5.5 presents a visual representation of the main effect of PA across different age groups. The result from the statistical analysis and the figure illustration suggests that younger participants (age 18-25) exhibited a more pronounced improvement in PA levels when exposed to our intervention.

We conducted an RM-ANOVA to examine the effects of gender as the between-subject factor, time (pre, post-study) as the within-subject factor, and PA as the dependent variable. The analysis yielded notable findings. Specifically, a significant main effect of time was observed, $F(1,104) = 17.661$, $p < .001$, $\eta 2 = 0.149$, indicating that PA levels varied significantly between the pre- and post-study measurements. Furthermore, an interaction effect between time and gender was also found to be statistically significant $F(2,104) = 4.373$, $p = .015$, $\eta 2 = 0.80$. To explore this interaction further, a post hoc pairwise comparison was conducted to assess the changes in PA for different genders before and after the study. The results revealed that female participants experienced a higher increase in PA compared to other genders. However, this increase was not found to be statistically significant when comparing females to males (p = 0.233). To further confirm that there is no significant difference between female and male PA level after study, we conducted a Mann Whitney U test categorizing male and female as the two groups, and PA after study as the dependent variable. The result show that the difference in PA level of female participants was not statistically significant compared to the male participants (U = 1009.5, p = 0.146), although the mean rank of the female gender (55.20) is higher than the male gender (46.28). The graphical representation of these results can be seen in Figure 5.6.

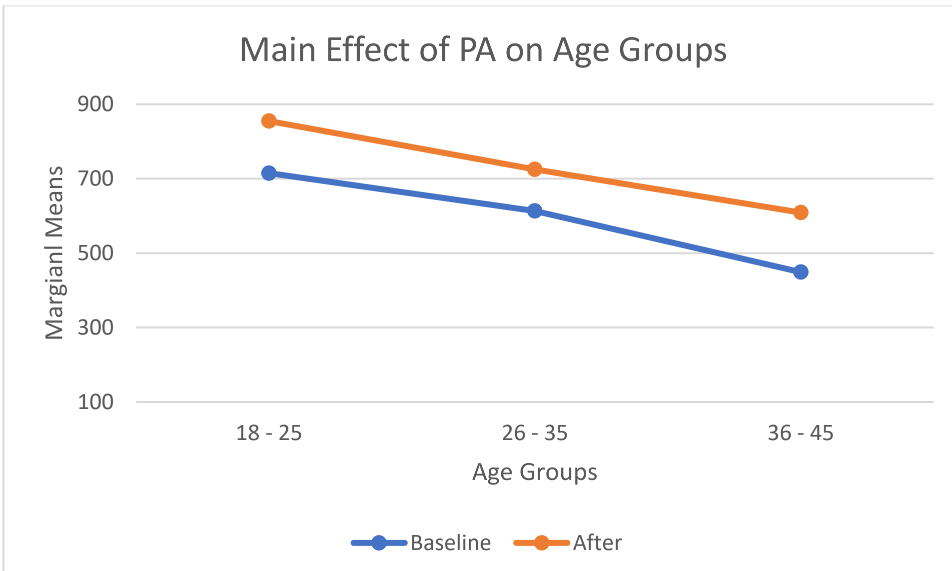

Figure 5.5 Dotted line chart showing the main effect of PA across age groups.

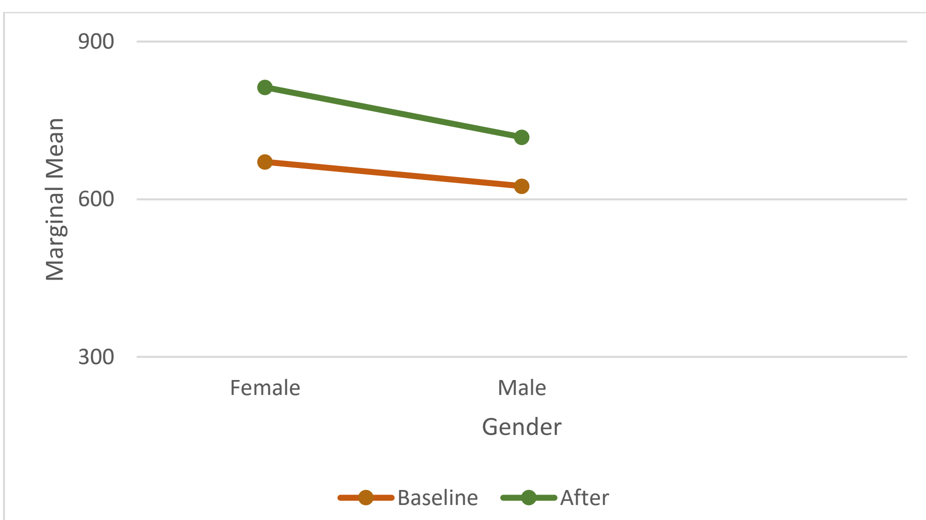

Figure 5.6 Dotted line chart showing the main effect of PA across genders.

5.2.3 Analysis of the Recorded Physical Activity (Dance Duration and Calories) During Study

As outlined in Section 3.5.7 of the study, we monitored participants' daily dance activity using app logs throughout the entire duration of the investigation. Each participant was required to engage in dance sessions with the app for about 10 minutes per day. The app automatically recorded the duration of each dance session whenever the user interacted with it. Subsequently, the aggregated dance duration data was extracted from the app logs at the conclusion of the study. Due to the natural variability in participants' dance durations, we classified them into two distinct groups: the "low" and "high" groups. To accomplish this categorization in a straightforward manner, the median value of the total dance minutes recorded for each participant was calculated, and it was determined to be 90 minutes. Participants whose dance duration fell below 90 minutes were categorized into the "low" group, while those whose dance duration surpassed this threshold were placed into the "high" group. Figure 5.7 visually represents the outcome of this group categorization process. Specifically, 49 participants exhibited an average dance duration of 121 minutes throughout the study and were thus classified under the "high" group. On the other hand, 55 participants had an average dance duration of 48 minutes and were categorized into the "low" group.

Additionally, we conducted a one-sample t-test with the total logged calorie burned by each participant during the study, using a widely recognized average dance calorie of 300 per hour [152][153]. The result of the one-sample t-test on the calorie burned by participants while dancing was found to be statistically significant $t(103) = 4.303$, $p < 0.001$. Moreover, a supplementary one-sample t-test was administered to compare the minimum obligatory calorie expenditure by the participants with the surplus calories burned, utilizing the established dataset-derived minimum calorie requirement as a threshold. This assessment yielded statistically significant results $t(103) = 2.130$, $p = 0.036$, further showing additional evidence of the motivating effect of our intervention on the participants. Furthermore, we examined if our intervention influenced the participants to engage in dance activities within the study period. To achieve this, we extracted each participant's weekly dance activity before the study and compared it with their weekly dance activity post-intervention using a paired sample t-test. The result shows that there was a significant increase in dance activity, $t(103) = 6.133$, $p < .001$, from pre- to post-intervention. We also plotted the result of the comparison using a stacked bar while placing each participant's pre- and post-dance activities side by side. Figure 5.8 shows the dance activity comparison of each participant before and after the study. The length of the bar in Figure 5.8 indicates the number of days a participant danced in a week while the bars indicate each participant's weekly dance activity. Additionally, Figure 5.9 shows the comparison between the minimum mean calorie and the achieved mean calorie. The result of the analysis suggests that our intervention influences the participants to engage in more dance activities during the study period.

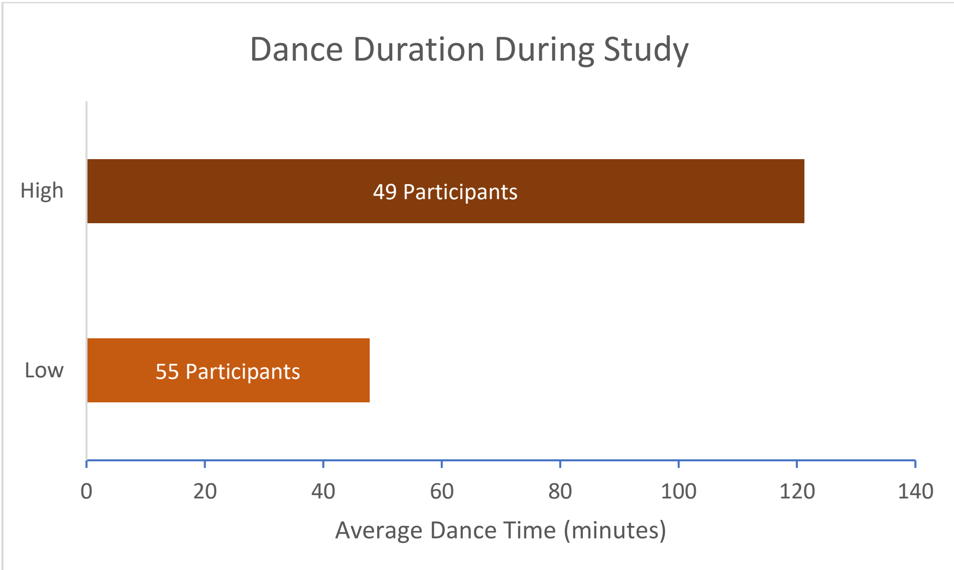

Figure 5.7 Bar chart showing the dance duration during study where participants' performance were categorized into high and low.

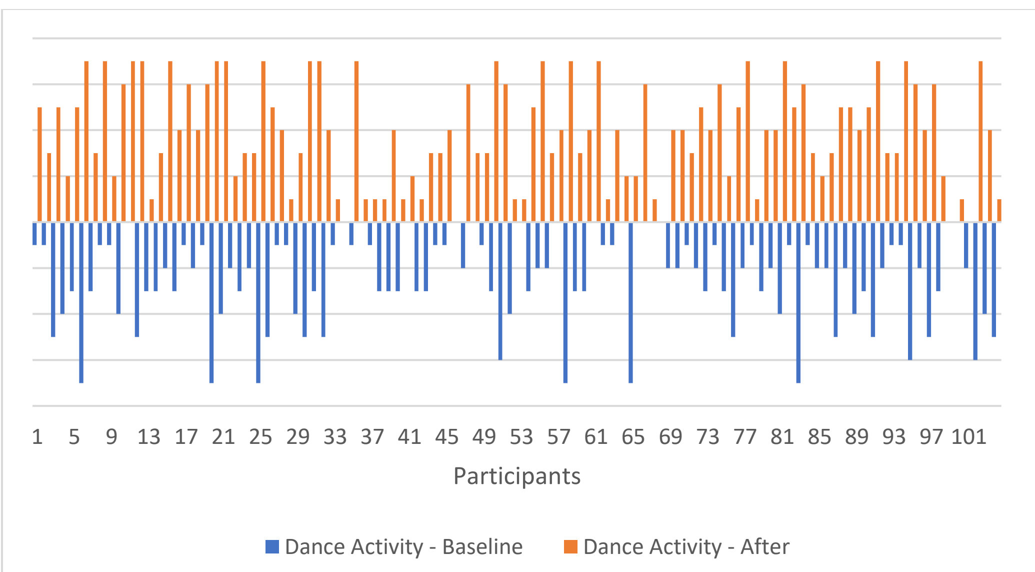

Figure 5.8 Weekly dance activity of each participant before and after the study.

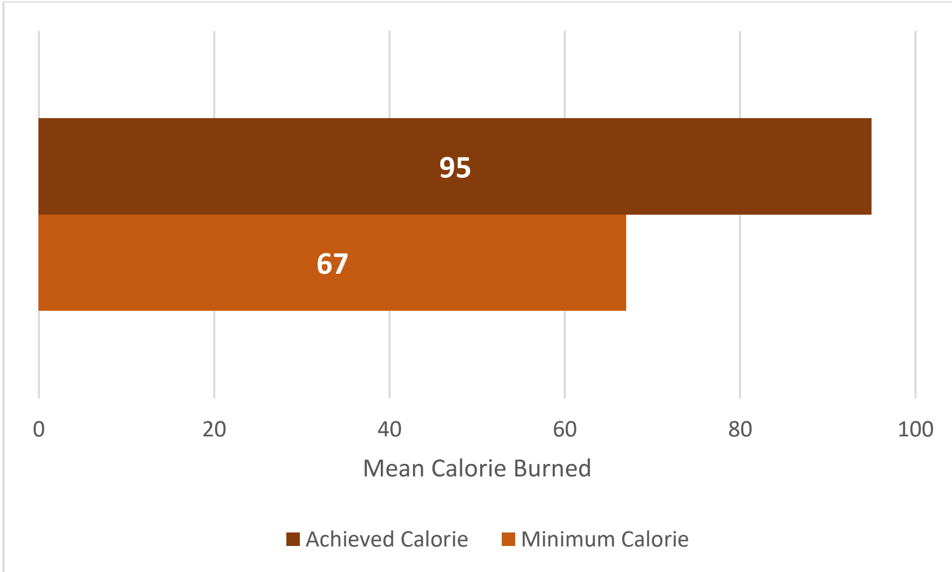

Figure 5.9 Chart comparing the minimum calorie and the achieved calorie.

5.2.4 Analysis of the Perceived Change in Positive Mood

One of the primary objectives of our research is to investigate the potential influence of our intervention on fostering positive mood among participants. To assess this, we employed the PANAS [139] scale to measure the participants' mood both before and after the intervention. The PANAS scale utilizes a 5-point Likert scale comprising 20 words that reflect different aspects of mood. We opted for this scale to capture both positive and negative emotions in order to observe any potential changes in mood and to determine the significance of the mood shift between the pre- and post-intervention phases. The PANAS scale encompasses various words representing positive mood, such as "interested" and "excited," as well as negative mood, such as "distressed" and "guilty." Analyzing the data gathered from participants' responses to the PANAS scale is crucial for addressing our RQ2.

To establish a balanced mood score, considering both positive and negative mood aspects, we performed a reversal of participant responses on all words related to negative mood. This reversal involved subtracting each selected value from the maximum scale value plus one (6 in this case, as it is a 5-point Likert scale). Afterward, we analyzed both pre- and post-intervention data, using a neutral value of 3, which corresponds to the midpoint of the 5-point Likert scale. For a comprehensive view of the perceived change in positive mood at baseline and after the study, the descriptive statistics derived from the data analysis are presented in Table 5.6. These statistics play a vital role in shedding light on the impact of our intervention on participants' positive mood.

Table 5.6 Descriptive statistics of the mood data at baseline and after the study

Scale	Condition	*M*	*SD*
PANAS	Pre	3.89	0.48
	Post	4.07	0.60

The findings presented in Table 5.6 reveal the mean scores of participants' mood at two different points in the study: baseline and after the intervention. Both the baseline and post-intervention mean scores for participants' mood exceeded the neutral score of 3 on a 5-point scale. This indicates that participants' mood scores shifted towards a more positive state during the baseline assessment (M = 3.89, SD = 0.48), and they experienced even greater positivity after engaging with our intervention (M = 4.07, SD = 0.60). To assess the statistical significance of the change in positive mood from before to after the intervention, a paired samples t-test was conducted. The results revealed a significant increase in mood scores from baseline (M = 3.89, SD = 0.48) to post-intervention (M = 4.07, SD = 0.60), $t(103) = 2.992$, $p < .002$. These findings suggest that our intervention had a notable impact on enhancing participants' positive mood.

Furthermore, an additional paired samples t-test was performed to examine whether the intervention not only increased positive mood but also reduced negative mood from pre- to post-intervention. The results showed no significant decrease in negative mood, $t(103) = -1.169$, $p = .123$; however, there was a significant increase in positive mood, $t(103) = 2.516$, $p = .007$, from pre- to post-intervention. These outcomes further support the notion that our intervention was effective in promoting positive mood among users. For a visual representation of the mood analysis results, boxplots were generated in Figure 5.10, displaying the distribution and median values of the pre- and post-study mood data.

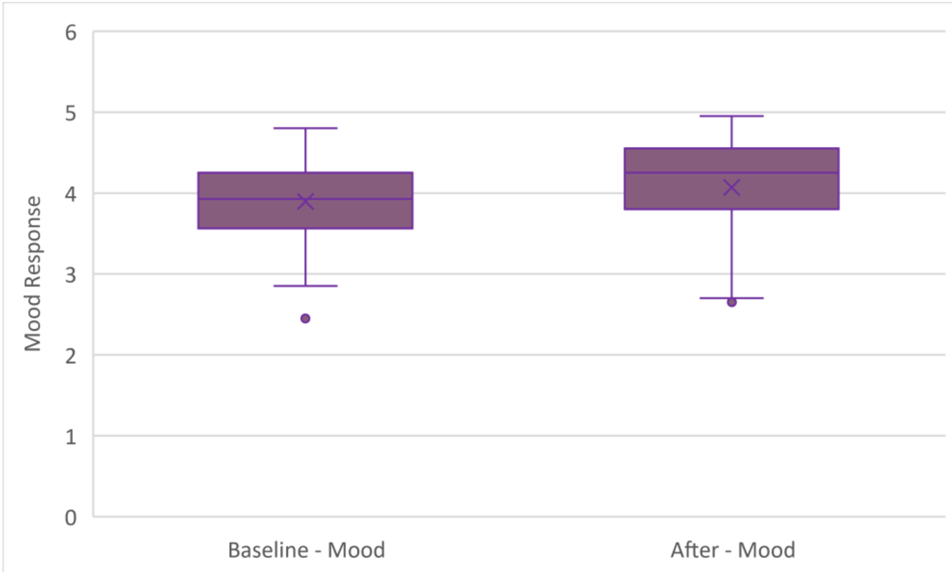

Figure 5.10 Boxplot showing the mean difference in participants' mood at pre- and post-study.

5.2.5 Analysis of Mood Data with Respect to Gender Identity

The findings obtained from the paired samples t-test conducted on the mood data in Section 5.2.4 indicate a statistically significant increase in the overall positive mood of all participants following the implementation of our intervention. However, in addition to assessing the general mood improvement, we sought to explore whether our intervention had a differential effect on positive and negative moods across gender groups. To investigate this, we employed a RM-ANOVA with gender (female, male) as the between-subject factor, time (pre, post-study) as the within-subject factor, and mood as the dependent variable after the assumption of RM-ANOVA on the mood data. The RM-ANOVA revealed that there was no significant main effect of time on mood, F (1,104) = 0.165, $p < 0.685$, $\eta 2 = 0.002$, indicating that the observed changes in mood were not solely due to the passage of time. Furthermore, the interaction between time and gender was also not statistically significant, F (2,104) = 0.117, $p = 0.890$, $\eta 2 = 0.002$), suggesting that the impact of our intervention on mood did not differ significantly across gender groups. However, the results do suggest that the intervention was perceived to be effective in promoting positive moods among the two genders. We also conducted a Mann Whitney U test on the participant genders as groups and their mood state after study as the dependent variable. The result show that the difference in female mood state was not statistically significant compared to the male ($U = 1201.5$, $p = 0.893$), although the mean rank of the male gender (52.53) is higher than the female gender (51.70). Figure

5.11 and Figure 5.12 visually present the outcomes of the analysis, illustrating the main effect of time on mood and the interaction between time and genders, respectively.

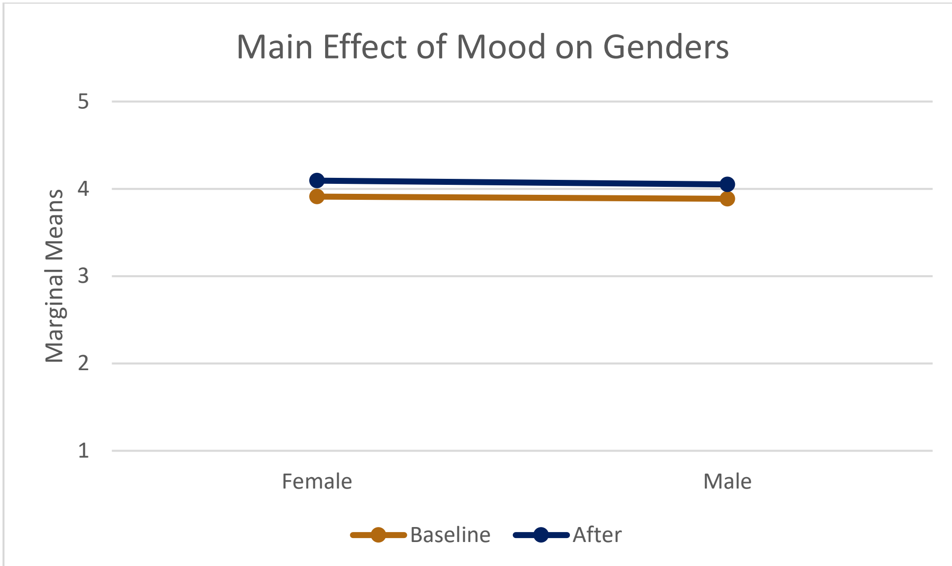

Figure 5.11 Dotted line chart showing changes in mood across genders.

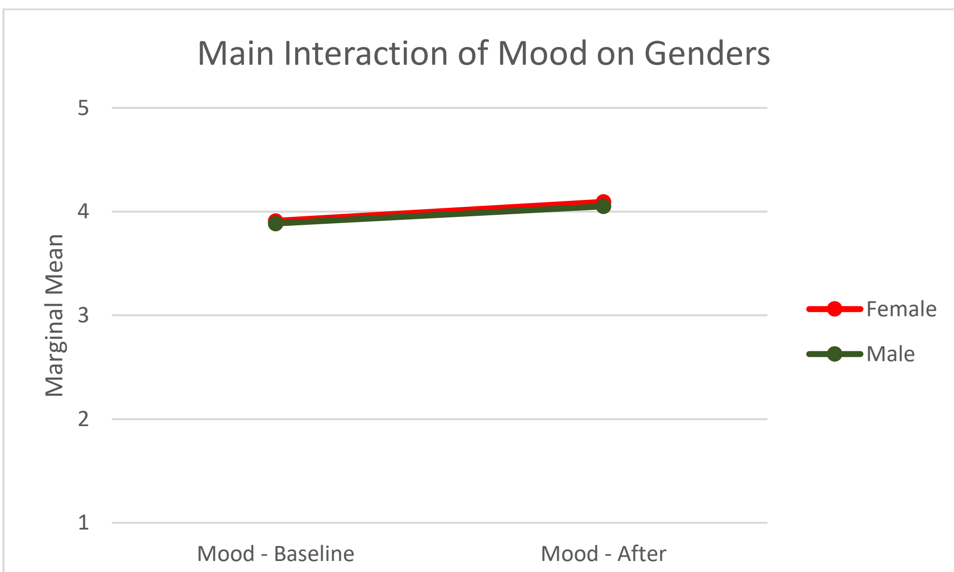

Figure 5.12 Dotted line chart showing the interaction of mood and across genders.

5.2.6 Analysis of the Perceived Daily Mood State During the Study

We sought to assess participants' mood state immediately after their engagement with our dance intervention on a daily basis. The collection of mood state data was of utmost importance as it served to corroborate our preliminary findings concerning mood while addressing RQ2. To measure participants' immediate mood, we integrated a 12-item scale from the IMS [136] into our intervention. This allowed us to prompt participants to report their immediate mood after each dance session. The IMS is a well-established 7-point Likert scale that encompasses dynamic components of mood, specifically designed to capture immediate emotional states. Once the responses were gathered, we computed frequency scores for each point on the Likert scale (ranging from 1 to 7). Subsequently, we categorized these frequency scores into three distinct groups: (1) scores between 1 and 3, denoting a negative mood state; (2) a score of 4, indicating a neutral mood state; and (3) scores between 5 and 7, reflecting a positive mood state.

The results were visually represented using a bar chart, presented in Figure 5.13. As indicated by the findings in Figure 5.13, the positive mood scores surpassed 90%, while the neutral mood scores were below 6%, and the negative mood scores were below 3% across all twelve items included in the assessment. This strongly suggests that participants experienced a significantly more positive mood than negative immediately after engaging in our dance intervention.

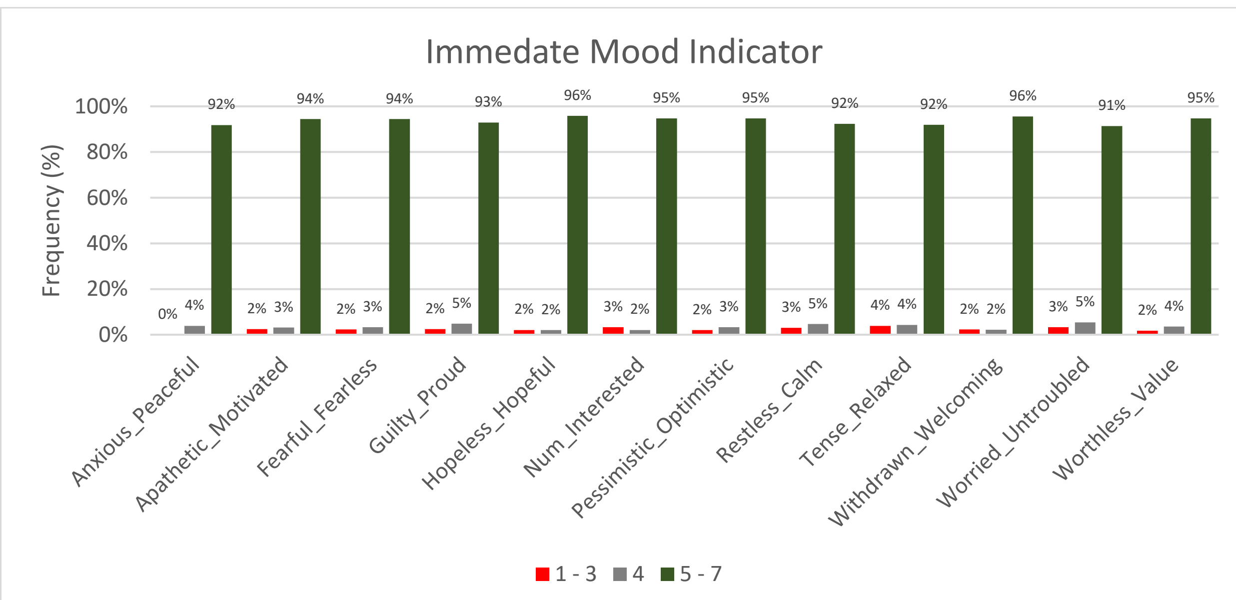

Figure 5.13 Bar chart showing the immediate mood frequency score of participants grouped into three categories.

5.2.7 Analysis of Perceived Persuasiveness of Intervention Features

We made a significant discovery by examining the effectiveness of eleven features used in the intervention. Evaluating how these features were perceived in terms of persuasiveness allowed us to address our RQ3. It's worth noting that each of the 11 features was associated with specific persuasive strategies, and you can find the detailed mapping in Section 3.6 and Table 3.1. Similar to our previous approach, we conducted a descriptive statistical analysis on the collected responses, and the results are presented in Table 5.7. To assess the perceived persuasiveness of the features, we utilized the Perceived Persuasiveness scale [140], which employs a 7-point Likert scale, with the neutral value set at four. The mean values for all features were found to be higher than neutral. The most effective feature was "Dance Rest," with a mean of $M = 6$ and $SD = 1.11$. This indicates that providing users with a resting time option in between dance periods, with the choice to extend or skip the rest, was highly effective. Both the "Dance Activity" and "Leaderboard" features had similar mean values of $M = 5.79$ with $SD = 1.07$ and $SD = 1.13$, respectively. This demonstrates the effectiveness of offering personal dance activity highlights and showcasing other people's dance activity data. By allowing users to see how they performed compared to others while engaging with the intervention, these features suggest to be persuasive. Furthermore, it is essential to consider the high standard deviation values for all the features. This implies that participants' perceptions of the persuasiveness of these features varied significantly. The feature with the highest standard deviation was the Audio Feedback ($SD = 1.33$), indicating that participants had the most mixed opinions about its persuasiveness.

Subsequently, we tried to establish the statistical significance of the neutral mean values pertaining to the intervention features described earlier. To this end, we conducted a one-sample t-test on the data collected from the Perceived Persuasiveness scale, and the corresponding outcomes have been documented in Table 5.7. The results of the statistical analysis indicate that all the assessed features exhibited p-values below 0.05, denoting a significant distinction between their mean values and the neutral value of four on the 7-point scale. Moreover, the computed t-values for each feature were notably high, substantiating the considerable disparity between their respective mean values and the neutral value. Notably, the Dance Rest feature displayed the highest t-value of 18.40, closely followed by the WHO Statement feature with a t-value of 18.25. These two features emerged as the most persuasive during the initial descriptive statistics analysis. For a comprehensive presentation of the persuasiveness analysis of the intervention features, we have employed boxplots, as depicted in Figure 5.14. These visualizations afford a succinct representation of the distribution and variability of the data, further supporting our findings.

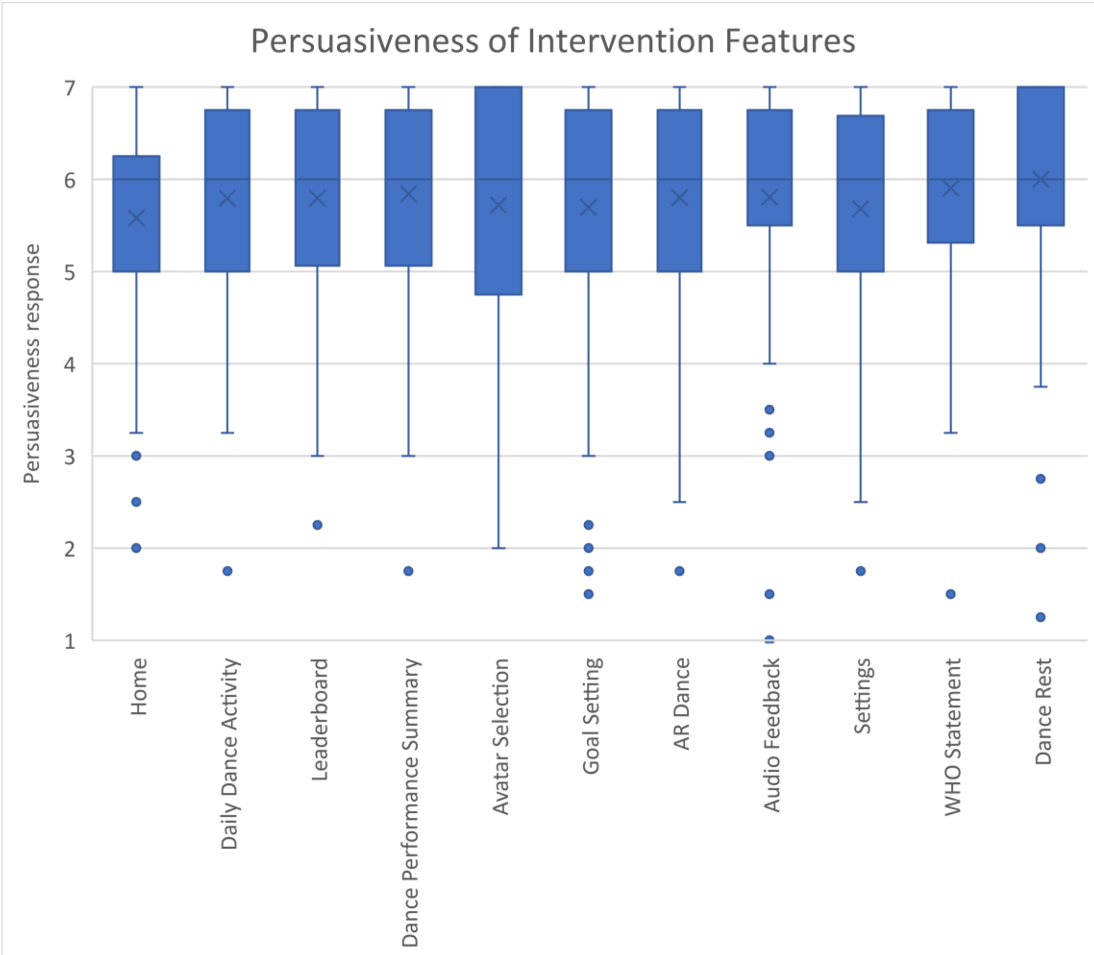

Figure 5.14 Boxplot illustrating the perceived persuasiveness of the intervention.

Table 5.7 Descriptive statistics and One Sample t-test of the perceived persuasiveness of the intervention.

Scale	Feature	*M*	*SD*	*t*	*df*	*p*
PPQ	Home	5.58	1.20	13.378	103	<.001
	Daily Dance Activity	5.79	1.07	17.064	103	<.001
	Leaderboard	5.79	1.13	16.228	103	<.001
	Dance Performance Summary	5.84	1.07	17.513	103	<.001
	Avatar Selection	5.72	1.25	14.038	103	<.001
	Goal Setting	5.69	1.27	13.583	103	<.001
	AR Dance	5.80	1.14	16.095	103	<.001
	Audio Feedback	5.81	1.33	13.864	103	<.001

	Feature	*M*	*SD*	*t*	*df*	*p*
PPQ	Settings	5.68	1.13	15.126	103	<.001
	WHO Statement	5.90	1.06	18.258	103	<.001
	Dance Rest	6.00	1.11	18.404	103	<.001

5.2.8 Differences in the Perceived Effectiveness of the Intervention features

Moreover, during this investigation, a thorough examination was conducted to ascertain whether the persuasiveness of the various intervention features exhibited divergences amongst the participants. It is of particular interest to note that distinct features displayed varying degrees of persuasiveness. This discrepancy in persuasiveness can be attributed to the fact that each feature was implemented with different expected outcomes, resulting in discernible effects. Thus, gaining an understanding of the relative differences in the impact of these features is highly desirable. To analyze these observations, we performed an RM-ANOVA on all the collected responses from the Perceived Persuasiveness scale. The statistical analysis of within-subjects effects yielded noteworthy results, with $F(1,104) = 2.824$, $p < .004$, $\eta 2 = 0.231$. This indicates that the mean scores for the persuasiveness of the intervention features exhibited statistically significant variations.

Considering the notable main effect observed, a subsequent post-hoc pairwise comparison analysis was employed to discern the extent of significant distinctions among the features. The outcome of this post-hoc test revealed a singular notable difference between the Home Screen and Dance Rest features ($p = 0.027$). Notably, all the features exhibited significant levels of persuasiveness in the overall analysis.

5.2.9 Analysis of the Perceived Intervention Usability

Since our study introduces AR Dancee as a novel and innovative intervention, it is imperative to assess its usability. To accomplish this, we employed the SUS [142], a widely accepted measure for evaluating the usability of software applications. Following the completion of the study, participants were requested to respond to the SUS survey. The collected data from the SUS survey, including scores and item means, allowed us to gain a comprehensive overview of the app's usability. Notably, the SUS revealed an average score of 76.54 (*SD* = 14.26), indicating that the overall usability of the AR Dancee app was considered "above average" [154]. Furthermore, we conducted a one-sample t-test on the SUS scores, which were measured on a scale of 0 to 100. The results demonstrated statistical significance $t(103) = 18.986$, $p < .001$, confirming that the participants' responses were not due to chance. This strengthens the credibility of the usability assessment. To provide a visual representation of the distribution of usability and learnability ratings, we grouped the responses and created a bar chart. As depicted in Figure 5.15, the majority of participants selected "agree" or "strongly agree" for statements related to both usability and learnability. These findings highlight a positive inclination towards the intervention, with over 75% of participants falling within this affirmative category. This favorable response further supports the notion that the AR Dancee app possesses commendable usability and learnability attributes.

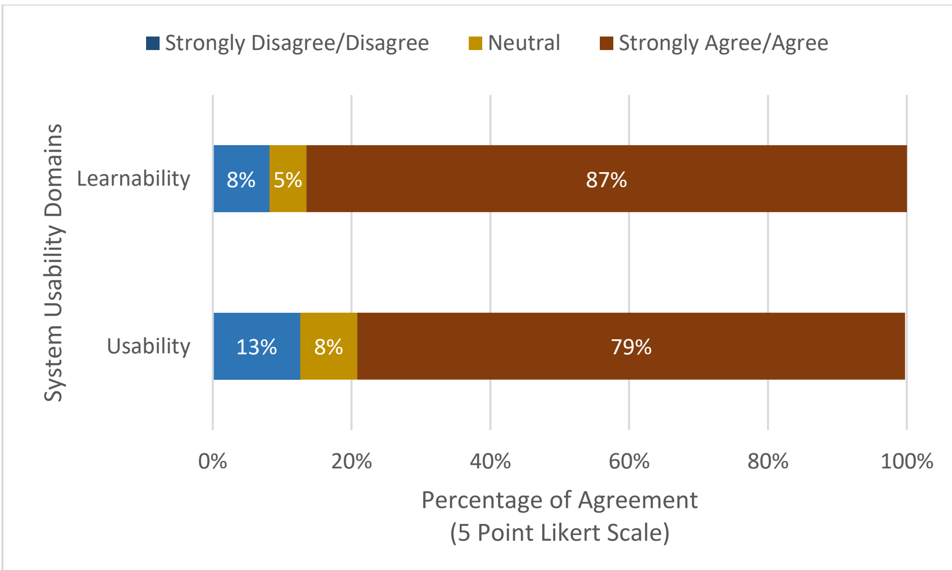

Figure 5.15 Bar chart illustrating the usability and the learnability of the intervention.

5.2.10 Analysis of the Perceived Simplicity of the Intervention

A crucial aspect of our investigation involved assessing the usability of our intervention among a diverse demographic of participants. We recognized the significance of gauging the intervention's user-friendliness, which prompted us to undertake a comprehensive evaluation. To measure perceived simplicity, we administered a post-intervention survey comprising nine questions rated on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). These questions were designed to assess participants' experiences with the intervention's ease of use. To gain insight into the overall simplicity of the intervention, we conducted a one-sample t-test, employing an optimistic neutral score of 3 on the 5-point scale. This allowed us to determine whether the participants' simplicity scores were significantly higher or lower than the established optimistic neutral score of 3. Our analysis revealed that the participants' perceived simplicity scores exhibited a statistically significant difference, $t(103) = -18.432$, $p = .001$, indicating that the overall simplicity of the intervention ($M = 4.10$, $SD = 0.61$) surpassed the optimistic score of 3.

In summary, we incorporated simplicity scale inquiries extracted from three distinct simplicity dimensions, specifically Aesthetics, Organization, and Integration. The graphical representation of the simplicity scale, as depicted in Figure 5.16, reveals the participants' perceptions of our intervention's simplicity, indicating favorable responses in aesthetics (86%), organization (84%), and integration (75%). Consequently, it can be inferred that our intervention proved to be user-friendly and uncomplicated in its application.

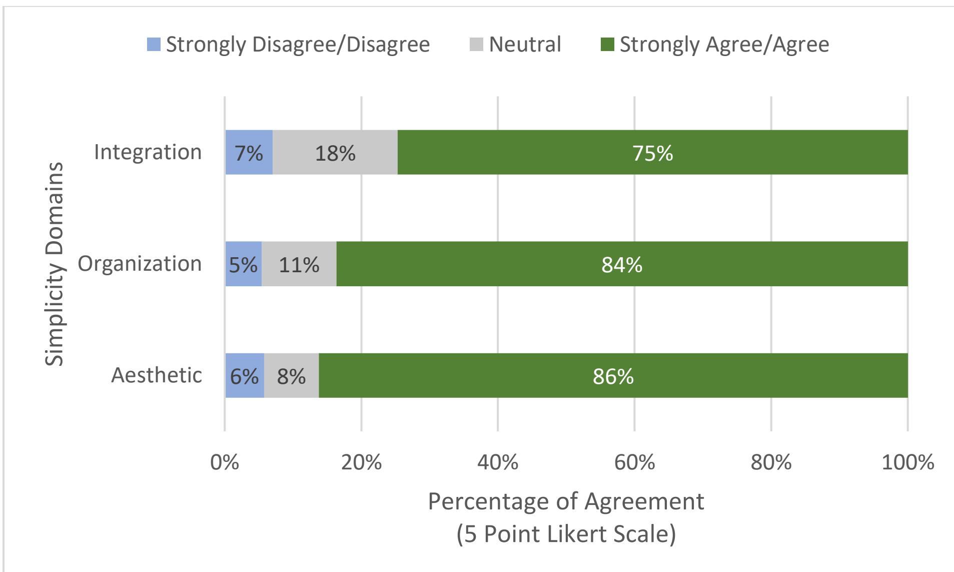

Figure 5.16 Bar chart illustrating the simplicity of the intervention.

5.3 Qualitative Analysis

We employed interviews as a means to gather more feedback from 27 participants. The participants who expressed interest in participating in an interview provided their email addresses at the conclusion of the study. Subsequently, we initiated communication with them to schedule the interviews. Nine participants who were interviewed are male while the remaining 18 participants are female. The analysis of participants' ages from the interview unveiled that 11 individuals fell within the age range of 18 to 25 years, 14 individuals fell within the age range of 26 to 35 years, and 2 individuals were situated within the age bracket of 36 to 45 years. There were 12 semi-structured interview questions (see Appendix H) and the duration for each interview was approximately 20 minutes. The selection of interested participants for the interviews was not governed by any specific criteria; however, our initial plan aimed to conduct interviews with a range of 25 to 30 participants. Throughout the interview process, the feedback obtained from the participants was subjected to analysis with the objective of comprehending the overall reception of the system under investigation and identifying recurring themes in their comments. Following the completion of 27 interviews, we observed that the point of saturation had been reached. This means that no novel themes or insights were being generated from the interviewees' responses, indicating that data collection had achieved a level of data saturation. Consequently, based on the saturation point being reached and the absence of additional themes emerging from subsequent interviews, we made the decision to conclude the interview phase. Subsequently, we transitioned to the phase of analyzing all the feedback data that had been collected, in order to derive meaningful and generalizable conclusions from the gathered information.

A thematic analysis [150] of the interview responses was conducted using NVIVO [150], a qualitative data analysis software [145]. We undertook the thematic analysis in a systematic manner, iteratively going through all the interview responses and coding similar quotes using a coding template analysis approach [155]. This process resulted in the identification of 16 distinct codes representing various aspects of the participants' experiences. Upon reviewing the grouped quotes under each code, it was evident that six of the codes contained related quotes. As a result, these six codes were merged to create a more coherent and comprehensive representation of the underlying themes. Subsequently, 10 codes remained from which a total of 11 themes were extracted. The emergence of these 11 themes shed light on various aspects of the system under investigation, contributing to a better understanding of the overall effectiveness of the intervention. Furthermore, the themes provided valuable insights into addressing the three research questions posed in this study.

In the following subsections, we present the extracted themes along with illustrative quotes that relate to each theme. These quotes serve to provide tangible examples and support for the identified themes, enhancing the credibility and rigor of our findings.

5.3.1 Initial Perception of Dancing as a form of Exercise

Nineteen participants brought up the perception that dancing is merely a recreational activity that one can indulge in during their leisure time. Six of them identified themselves as individuals who never had the luxury of spare time due to their demanding schedules, thus dismissing the idea of engaging in fun activities. Interestingly, although many expressed an interest in PA, they had never considered dancing as a viable form of exercise. Below are a few quotes from participants who experienced our intervention and now recognize dancing as an effective form of exercise, aligning with this viewpoint.

> P229: *"I wouldn't have thought that dancing could be a form of exercise, but right now, yes, they have has given me a reason to think so."*

> P355: *"I have been saying that I'm not this workout person, but when I see something that would push me to do something, it's just amazing how dancing has pushed me to workout the more."*

> P302: *"I'm not an exercise type but found out that I can actually exercising recently through dancing."*

The comments above indicate a noticeable shift in participants' perception regarding dancing activity, which began to be viewed as a viable form of exercise subsequent to their exposure to our intervention. This shift represents a substantial change for many participants who now recognize that dancing offers benefits beyond mere entertainment. Notably, some participants expressed that engaging in the dance intervention provided a comparable level of intensity to conventional exercises, yet they came to appreciate its relative simplicity as an exercise modality. Additionally, several participants reported that the intervention served as a potent source of motivation for them. Below, we present select comments that illustrate how dancing activity transformed into a straightforward and motivational means of exercising.

> P347: *"Yes, it was hard initially when I started dancing. It was, I said. But later at the second phase, it started becoming simple to me. So I knew that I had to be exercising more often in a simple way."*

> P352: *"I noticed that had headache on the first and second day I danced but it became easier and lighter to dance from the third day"*.

Overall, a majority of the participants exhibited a discernible shift in their mindset towards dancing subsequent to the adoption of our intervention. Nevertheless, it is imperative to acknowledge that this transformative change was not universally effortless for all participants. Several individuals reported encountering varying degrees of challenges as their bodies adapted to the novel demands of this altered reality.

5.3.2 Motivation to Exercise and the Willingness to Stay Physically Active

This theme pertains to the heterogeneous experiences and perspectives of participants concerning exercise. During the interview, 14 participants expressed keen interest in increasing their PA levels; however, they faced challenges in allocating sufficient time for such endeavors. Conversely, another subset acknowledged having adopted the belief that engaging in exercise or PA was not compatible with their lifestyle. The introduction of our intervention aimed at catalyzing a shift in the participants' approach towards exercise, prompting them to adopt a more purposeful and deliberate stance. Several noteworthy quotations from the participants, reflecting their heightened motivation towards exercise, are as follows:

> P310: "*And before I started using the app for dancing, exercise routine was like optional routine for me. Sometimes I'll be okay with it but some other days I really want to start exercising frequently. But app like this became the drive I needed. I did find it more motivating.*"

> P355: *"It is rare for me to just wake up and say I wanted to work out. It's very motivating when you have an app that you see an avatar you are dancing with. It's just amazing. So for me it is amazing and it's good."*

Based on the analysis of the provided sample quotes, it is evident that the intervention employed in the study significantly influenced the participants' motivation to engage in PA, even in the presence of varying preconceptions. Notably, certain features integrated into the intervention were perceived by 23 participants as pivotal in stimulating their motivation. Acknowledging the participants' attainment of motivation as a noteworthy milestone, it is equally essential to commend their commitment to sustaining the healthy behavioral changes [5] adopted during the intervention. The participants expressed that witnessing the tangible benefits associated with regular PA played a crucial role in fostering their continued willingness to remain physically active. Below are illustrative comments that highlight the participants' receptiveness towards maintaining their engagement in physical activity.

P18: "*For the period of time I have to use the app, it increased my exercise time. So, what I try to do is I start with the app first you*."

P310: "*I really enjoy dancing with the app and it made me keep fit within those two weeks. I'm not the type that usually exercise but I'm eager to dance now everyday*."

Overall, the formulation of our intervention was carefully devised to address the challenges faced by individuals with busy schedules and those who harbor an inherent aversion to exercise. By tailoring the intervention to cater to these specific groups, participants were afforded the opportunity to contemplate the significance of incorporating PA into their lives. The integration of innovative features, such as a dancing avatar, AR elements, and a diverse selection of music, served to heighten the engagement levels of participants during the exercise sessions.

5.3.3 Daily Experience Due to AR Dancee App

All participants provided feedback on the profound impact of our intervention, the AR Dancee app. The majority of respondents expressed their enthusiasm for the app, highlighting its captivating and engaging nature, along with the positive emotions they experienced while utilizing it. Notably, several participants reported that incorporating the app into their daily routines, particularly by engaging in a dance session in the morning, significantly influenced the trajectory of their day. Presented below are selected comments from participants, exemplifying the prevalent theme of the app's positive influence on their daily experiences.

P23: "*So the app makes me feel relieved and less anxious about everything else. It prepares me for any challenges I'm going to face for the day.*"

P273: "*I feel good about the exercise, it's very interesting and fun.*"

P355: *"It is rare for me to just wake up and say I wanted to work out. It's very interesting when you have an app that you see an avatar, and you are dancing with such an avatar. It's just amazing. So, for me, it's good."*

P147: *"I felt good. It was a very good experience. I felt really motivated to continue living like this. It was really good."*

P241: *"To be frank, I felt good. I used to be very active individual but you know a lot of issues come, so sometimes you will not be able to find time to exercise. But because of this* *research, I deliberately exercise now. So that has actually connected me back to the exercise I used to do before."*

The study participants displayed diverse patterns of engagement with the application, with some incorporating it seamlessly into their daily routines, while others reported rediscovering their commitment to regular exercise. Several participants articulated the profound impact of the intervention, emphasizing the newfound sense of well-being and heightened motivation to engage in physical activity. These observations strongly imply that the intervention transcended the mere promotion of PA, as it also fostered positive emotional experiences and self-perceptions, leaving enduring imprints on their memory.

5.3.4 Factors Influencing Attitude Change in Physical Activity

Seventeen participants experienced a positive shift in their attitudes toward PA as a result of engaging with the features offered by the application. Prior to the commencement of the study, 14 individuals perceived exercise as a time-consuming endeavor, leading them to believe that they could not allocate time to it due to their demanding schedules. Additionally, five participants initially harbored a belief that participation in PA was not aligned with their personal interests or preferences. However, our intervention, which incorporated a variety of distinct features, proved influential in altering the perspectives of most participants regarding physical activity. Among the prominently cited features were the dancing avatar, AR elements, leaderboard functionality, audio feedback mechanisms, and the availability of diverse music options. These elements collectively contributed to the participants' reevaluation of their attitudes towards physical activity. To gain further insight into the impact of the application's features, various comments made by the participants are presented below:

P265: "*Yeah, the music, especially in the advanced stage. I actually like the music, it helped me to remain lively*."

P147: *"I like the augmented reality image that is usually casted on my body while I am dancing. It mimics my dance movements, showing me how flexible I can be."*

P358: *"OK, basically I like the feature of the audio feedback, it really motivates when you're dancing. That voice saying things like, You're almost there. It's really inspiring. I love it because it's inspiring."*

P347: *"Well, it's the fact that you're seeing an image you can imitate. You're not just doing it on your own, so you're imitating something. And then when you are dancing, tells you if you're doing it well."*

P33*: "I love seeing the augmented reality pigment following my body movement. This particular feature actually encouraged me to exercise more."*

Several participants have articulated that our intervention has exerted a profound influence on their behavior, leading them to actively seek music from their playlists to partake in dancing during their leisure time. Notably, nearly all aspects of our intervention have played integral roles in shaping the participants' attitudes towards PA, while the positive emotional experiences they have encountered while utilizing our intervention have emerged as an additional source of encouragement for continued participation.

5.3.5 How Dancing Improved Participants Positive Feelings

The investigation into the relationship between dancing and its effect on positive mood, as well as its impact on participants' daily activities, yielded recurring observations among the respondents. Initially, eight participants expressed reservations about engaging in dancing, citing their self-perceived lack of skill as dancers. Nevertheless, it was noteworthy that a shift in their perspective occurred once they experienced the positive influence on their mood following their participation in the dance intervention. The following excerpts represent some of the feedback received from the participants:

P317: *"Dancing with the app helped me to improve my mood. In some days that I was down, it really helped me because after the physical exercises I felt very positive."*

P129: "*There's something exercise does to the body, it makes you feel light. It also makes you think that you have achieved something."*

P241: *"Sometimes, especially when you wake up in the morning, you usually feel weak. But then when you exercise, it kind of transform your mood."*

All participants recounted their experiences regarding the utilization of our intervention, emphasizing its significance as a pivotal moment in their daily routines. A subset of respondents disclosed commencing their day by engaging with the application through dancing, while others expressed a consistent anticipation of dancing with the app upon returning home from work or school, particularly before dusk sets in. In aggregate, the majority of participants reported experiencing heightened positivity and improved self-perception subsequent to engaging with our intervention for dancing purposes.

5.3.6 How Dancing Has Increased Participants' Overall Physical Activity Level

Notably, the intervention involving dancing has garnered considerable attention from participants, particularly in terms of its impact on their daily PA levels. All participants' feedback consistently indicates a notable increase in their daily PA as a result of engaging in dancing through the intervention. Weight loss and a sense of lightness were commonly reported by several participants, highlighting the potential benefits of dancing as a means of achieving these fitness goals. Of particular interest is the recurring emphasis on the term "flexibility" by 18 participants. They express experiencing enhanced flexibility, enabling them to perform activities with greater ease and adaptability, surpassing their previous capabilities. Moreover, participants reveal that the integration of dancing with the intervention has prompted them to explore other forms of exercise, such as running, thus contributing to their overall fitness levels. The comments provided by the participants collectively demonstrate the perceived positive influence of dancing on their overall PA levels, underscoring its potential significance as an effective approach to fostering an active lifestyle.

> P228: "*I can see that I am open to song like even when I'm not using the app, I am probably listening to a song and doing this same movement which I learned from that app. So even when I'm not actively using the app, I am doing those kinds of physical activity.*"

> P229: *"Yes, I think I did especially around my arms, because I was raising them and shaking them. So I felt like my arms right now feel much more flexible*."

> P18: *"Well, yes, so on my own, I exercise, but then for this period of time I have to use the app, it kind of increased my exercise time. So, what I try to do is to start with the app first so that it can get me ready for other workout. So yeah, it helped me exercise more and well."*

> P21: *"After using the app I always feel my nerves are now relaxed. Especially when I finish dancing with it and go to shower. I feel the same way as though I go to gym."*

P273: "*Yeah, my weight reduced. My body is more flexible than before*.

An intriguing observation pertains to the inquiries made by certain participants to the lead researcher during their interviews, inquiring about the possibility of continuing app usage even after the conclusion of the study. These individuals expressed that engaging with the application had evolved into a habitual practice, serving as a means to monitor and regulate their PA levels. Consequently, they exhibited a keen enthusiasm to sustain their interaction with the app beyond the study's completion.

5.3.7 The Impact of Music as a Key Motivating Factor

The findings of this study indicate that 21 participants expressed a strong sense of enjoyment towards the music employed in the intervention. The act of dancing in sync with the music served as a notable source of encouragement, fostering a motivational ambiance. Remarkably, participants reported that the immersive experience of dancing to the music minimized their perception of physical exertion, rendering the energy expenditure inconspicuous. Evidently, the music played a pivotal role in influencing the participants' emotional state and overall experience during the intervention. Comments below from the participants further underscore the profound impact that the music had on their engagement and positive outlook.

P302: "*And sometimes I may be sad or unhappy. But you know, there is something about music and dancing. Listening to the music and dancing helps take away one's sadness.*"

P229: "*I don't know you could dance your way into happiness when you're listening to music. This encourages you to do some form of physical activity like dancing.*"

P21: *"Dancing while listening to music makes someone who feels somehow tired to be aroused. Because when you are hearing the music, it will be energizing you more and more to dance and to be more focused."*

It is significant to acknowledge that certain participants expressed a preference for an additional feature within the application that would grant them the capability to play music directly from their personal playlists. Conversely, contrasting viewpoints were articulated by other participants who conveyed contentment with the app's current implementation of diverse musical content from various cultural backgrounds, fostering a sense of inclusivity. Notably, our decision to incorporate music from diverse cultural origins was driven by the global scope of our user target demographic.

To illustrate, a participant residing in Nigeria offered a sample comment elucidating their perspective on the richness of the musical diversity, as exemplified below.

> P33: *"Most importantly, I like the fact that Nigeria music was infused into it. It was encouraging for me. Honestly, I look forward to those dance patterns with the music, honestly speaking it is more like a catalyst that kind of encourages you. Yeah. You look forward to it."*

5.3.8 A New Way of Keeping Fit

Nine participants highlighted a notable innovation within our intervention, which led them to explore a novel approach to maintaining physical fitness. The study encompassed two distinct participant cohorts: individuals with a penchant for exercise but constrained by time commitments, and those who had previously perceived physical fitness as incongruent with their interests. Both groups expressed a shared sentiment of having discovered a new and enjoyable means of engaging in exercise, resulting in a noticeable enhancement or sustenance of their PA levels. The incorporation of dancing as a pleasurable activity facilitated an effortless adoption of an exercise routine that was perceived as both enjoyable and effective. Presented below are some noteworthy comments from participants, providing insight into their experiences while partaking in physical activity in an unfamiliar yet rewarding manner.

> P129: "*We see physical fitness as being stressful or like a big work to us, but seeing a positive way where we can be physically fit and laugh over it without the strenuous aspect of physical fitness is something I recently found interesting.*"

> P358: "*I used to see dancing as just a form of exercise., however, I see it in a better view now. I see it in a more friendly way and not a hostile one.*"

> P229: *"I think the fact that you could be having fun and at the same time you don't have to go to the gym, all you're doing is having fun and exercising."*

Based on the observations elucidated in the aforementioned comments, it becomes evident that the discovery of a novel approach to engage in PA holds significant meaning for the involved participants. Among the focal issues raised by certain participants, a prominent aspect pertains to the considerable stress they encountered while striving to maintain physical fitness through conventional means. Nevertheless, a noteworthy transformation emerged in their perspectives, wherein the perception of exercise solely as a stressful undertaking was superseded by a newfound realization of dancing as an enjoyable and gratifying method to achieve physical fitness objectives.

5.3.9 Attractive features in the AR Dancee

Evidently, the intervention's compelling features have elicited positive responses, with 22 participants expressing their enthusiasm for engaging with the intervention due to its captivating features. Noteworthy aspects that garnered particular attention among the participants encompass the leaderboard functionality, the customizable avatar, the provision of audio feedback, and the tracking of calorie expenditure. Some participant comments below shed light on the salient features that held considerable appeal for them.

> P265: "*That's the leaderboard parts, at least helps me to compare my points and calories to other people and how much effort I'm putting compared to other people*."

> P228: "*Seeing myself dancing with augmented reality element and following how the avatar is dancing was really attractive to me. So, I really like these features.*"

> P33: "*It was nice to always hear the audio feedback. It is encouraging and I even look forward to it.*"

> P347: "*I like the avatar, the icon of the person that is dancing that I have to emulate.*"

Considering comments above, it becomes evident that the implementation of an intervention with multiple compelling elements/features is of paramount significance. This necessity arises from the fact that users of exercise applications, such as our intervention, exhibit varying preferences and inclinations. Hence, our intervention has been perceived to encompass a diverse array of features, thereby rendering it capable of appealing to a wide-ranging audience.

5.3.10 Intention to Share the Intervention

During the course of the interviews, all participating individuals demonstrated a keen interest in endorsing the proposed intervention to others. A notable subset of respondents even disclosed that they had already actively recommended the intervention to their acquaintances and family members. However, it is worth mentioning that a two participants expressed reservations about sharing the intervention, not due to its perceived lack of efficacy in promoting physical fitness, but rather out of concern that they could be misconstrued as engaging in body-shaming behavior by their peers. The comments below from the participants further illuminate the extent of their intentions to share the intervention.

> P147: "*Yes, I'll recommend it to my friends. It's user-friendly. Anybody that has a smartphone can use it. Yes, I will.*"

> P229: "*Yes, I did recommend the app to some people already because some of them wanted to lose weight*."

> P23: "*Yes, it's something that you can recommend. I have already recommended it to my close friends. And even the first three days I used the app I felt the need to share it.*"

Overall, the participants conveyed a strong willingness to propagate intervention among individuals within their social circles, with the aim of elucidating how it had influenced their own engagement in PA. Furthermore, a subset of participants conveyed their intention to persist in using the intervention beyond the study period, indicating their perception of its efficacy as a valuable tool for promoting PA.

5.3.11 Recommendations for Improvement

All participants conveyed a sense of optimism regarding the intervention being examined. However, it was also noted that some level of confusion was experienced while using the app. Moreover, valuable feedback was provided by 18 participants regarding potential enhancements to increase the intervention's overall effectiveness. This feedback proved to be crucial in shedding light on various areas where the intervention could be refined for future study. A recurring theme among most participants was the desire for the intervention to incorporate an expanded range of features, specifically the ability for users to select music from their personal playlists for dancing. Additionally, some participants expressed enthusiasm for the idea of incorporating free-style dances, wherein the avatar would mimic the users' unique dance moves. According to their perspective, this interactive feature could serve as a motivating factor, encouraging users to engage more actively with the intervention, as they would have the opportunity to demonstrate their preferred dance styles to the avatar in synchronization with their chosen music. As a result of the participants' valuable insights, some suggestions for improving the AR Dancee app were identified below.

P223: "*I think it would be nice if there was like a free for all mode if you don't have to follow the avatar and freestyle. So, yeah, maybe the avatar can follow what I'm doing instead.*"

P229: "*In terms of function, I think it should allow us to be able to choose our own music and our own type of dance*."

P241: "*I suggest that there is a need to input a video simulation whereby people will see how they use the app. From my own experience, I was contemplating what to do in the app.*"

P358: "*Add those stretches before dancing. Sometimes you would like to stretch, or hear the app telling you to do this or do that or you* can skip to *start dancing.*"

In light of the provided comments, it becomes evident that there exists a pressing requirement for a more all-encompassing intervention that addresses additional facets of dancing exercise to effectively incentivize individuals towards sustained PA. The heterogeneous backgrounds and varying levels of physical activity among participants underscore the necessity for a tailored approach. While some participants perceived the dancing exercise as too facile, others expressed contentment with the current difficulty level. Thus, the introduction of diverse dance patterns with varying intensities could prove instrumental in maintaining the engagement of a broader range of participants.

Notably, the suggestions put forth also attest to the intervention's capacity to cultivate participants' interest, fostering high levels of engagement throughout the study. A sense of connection with the intervention was reported by participants, serving as a motivating factor behind their valuable recommendations for its enhancement and extension. These insights, therefore, furnish us with a multitude of possibilities for augmenting our intervention in future studies, rendering it more sophisticated and comprehensive in its design.

Chapter 6 : Discussion

In this research endeavor, a thorough examination of the data acquired both before and after the study has yielded a multitude of result regarding the efficacy of our intervention. This chapter delves into a comprehensive discussion of the intervention, expounding upon its performance in addressing the research questions posited in Section 3.7. Drawing upon our findings, we additionally present practical recommendations aimed at refining the design of AR-driven mobile interventions to foster physical activity promotion through dancing.

6.1 AR Dancee and Promoting Physical Activity through Dancing

From our analysis on the intervention's effect on promoting PA through dancing, we gathered some interesting findings which will be discussed in the subsections below.

6.1.1 Effectiveness of the Intervention in Influencing Healthy Behavioral Change

Determining whether our intervention is effective in promoting PA is what we wished to answer in RQ1: "*How effective is the AR Dancee app in motivating physical activity in adults through dancing?*". The results derived from the comparative analysis of participants' weekly PA levels before and after implementing the intervention, as detailed in Section 5.2.1, demonstrate a notable increase in PA. This suggests that our intervention effectively influenced the participants to adjust their behavior and engage in more exercise. Notably, even those participants who initially fell considerably short of meeting the recommended weekly PA level of 600 MET experienced a significant overall boost in their PA levels following the intervention. This indicates that the AR Dancee intervention effectively motivated individuals to meet or exceed the minimum recommended PA threshold.

These findings align with previous research by Shin et al. [83], which also reported a marked reduction in the rate of participants failing to meet PA guidelines after using a similar intervention. Similarly, Berg et al. [80], in their investigation of weekly PA performance following an intervention, observed significant changes in PA levels, suggesting that such interventions can directly impact participants' attitudes towards PA. Drawing inference from Berg et al. [80], our analysis reveals a substantial increase in PA levels after the study, further supporting the notion that our intervention played a pivotal role in encouraging greater PA among the participants.

Achterberg et al. [63] have highlighted knowledge improvement as one of the key techniques for promoting healthy behavioral changes. Our qualitative analysis findings corroborate this idea by indicating that enhancing participants' knowledge about various enjoyable ways to exercise and maintain physical fitness is likely to influence them to engage in more PA. Additionally, the results presented in Section 5.3.8 demonstrate that participants using our intervention reported a greater likelihood of participating in PA once they discovered enjoyable ways to be physically active, without compromising the effectiveness of their efforts. Overall, our intervention appears to have had a significant positive effect on enhancing PA levels among the participants, thereby influencing them to sustain a healthy lifestyle through diversified exercise approaches.

6.1.2 Motivation to Engage in Physical Activity is Influenced by Dancing

Based on the comprehensive analysis of participants' interviews and survey responses, it is evident that the intervention had a positive impact on their level of engagement in PA as they increased their involvement in dancing through the app. This outcome aligns with the discussion presented in Section 5.3.2, where several participants expressed that the intervention inspired them to adopt a more intentional approach towards exercise. These findings are consistent with prior research [17][33], which has explored the efficacy of dance in promoting overall health and wellness, particularly in the context of PA. Those studies demonstrated that individuals experienced notable enhancements in their motivation to participate in PA and other activities that contribute to their quality of life after using dance-based interventions.

Additionally, Bastug [13] conducted a study that revealed how exposure to a minimum of 30 minutes of dance sessions per week can lead to increased engagement in PA. The influence of dancing on participants' PA levels is further elucidated in Section 5.2.3 of our analysis. Notably, nearly 50% of the participants who engaged in PA during the 2-week study period incorporated an average of 121 minutes of dance into their routine. While some participants had dance durations below this average, it did not appear to hinder their engagement in PA, as all participants reported heightened involvement in PA after utilizing our intervention. These findings strongly suggest that our intervention played a pivotal role in encouraging participants to pursue additional forms of PA following their dance sessions with the app. This result corroborates our earlier findings and directly addresses RQ1, underscoring the potential effectiveness of our intervention in fostering increased engagement in various PA activities such as dancing.

6.1.3 Gender and Age Differences in the effectiveness of AR Dancee

In examining potential gender and age disparities in the efficacy of our intervention, noteworthy patterns emerged from participants' responses before and after the study. Our intervention was deliberately tailored for adults, without regard to specific age brackets or gender identifications. As outlined in Section 5.2.2, the comprehensive analysis demonstrates that the overall effectiveness of our intervention in promoting PA was consistent across various gender and age groups. This indicates that the majority of participants perceived the intervention as efficacious in enhancing their PA levels, with a relatively uniform degree of improvement. Nonetheless, upon categorizing participants into age groups and comparing the PA level increase among them, it was observed that the age group comprising individuals between 18 and 25 years old exhibited a more substantial increase in PA levels. Consequently, it can be inferred that young adults between 18 and 25 years old perceived the intervention as more impactful compared to other age groups. Despite this, it remains evident that the intervention holds potential effectiveness in promoting PA across diverse age groups, albeit with a stronger influence on younger individuals.

Furthermore, the results of our analysis revealed no discernible disparity in intervention effectiveness between gender groups. The intervention elicited a consistent and positive impact on all participants who identified as male or female. Only one participant did not identify within the traditional binary gender categories; however, the effect of the intervention on this individual cannot be utilized for conclusive analytical inferences. The inclusion of a larger cohort of individuals who identify their gender outside of the binary spectrum could provide further insights into the intervention's effectiveness across gender identities. Nevertheless, it is worth noting that the observed increase in PA levels was evident across all genders, implying that the intervention is perceived as effective across the entire spectrum of gender identities.

In conclusion, we have successfully demonstrated the efficacy of our intervention in stimulating individuals from varied cultural backgrounds, gender identities, and age groups to enhance their PA levels through dancing. The outcomes of this study effectively address our RQ1 and present avenues for investigating additional behavioral techniques beyond mere knowledge enhancement, aimed at sustaining PA as a healthy habit. Remarkably, our intervention not only encouraged participants to embrace a more active lifestyle but also empowered them to explore diverse PA activities. Although some participants initially encountered difficulties with these activities, they later experienced increased adaptability and ease in engaging with them. Several interviewees reported that our intervention played a pivotal role in reigniting their enthusiasm for daily exercise, while others expressed delight in discovering a fun and enjoyable approach to being physically active. The impact of our intervention extended beyond surface-level changes, as it significantly influenced the mindset of the participants regarding exercise. Many individuals shared their transformative thoughts, revealing how the intervention facilitated a shift in their perceptions towards physical activity.

6.2 Effect of the Intervention In Promoting Positive Mood

The secondary objective of this research was to assess the extent of the intervention's efficacy in fostering positive mood among participants. To yield comprehensive and insightful outcomes that effectively address the research question posed in RQ2, our analysis encompassed participants' mood responses before and after the study, immediate mood responses recorded through intervention logs, and responses gathered during the interviews. The subsequent subsections provide a detailed discussion of the findings resulting from the analysis of these three data points.

6.2.1 Significant Effect of the Intervention in Promoting Positive Mood

The analysis, as presented in Section 5.2.4, revealed a statistically significant increase in positive mood after participants were exposed to our intervention. Baseline assessments indicated that participants' overall mood, on average, slightly exceeded the neutral score of 3. Nevertheless, after using our intervention, there was a substantial positive increase in their mood. This suggests that although the participants' mood was initially positive, our intervention further enhanced the level of positivity compared to the baseline. The significance of these findings lies in their contribution to the understanding of the impact of AR Dancee app on positive mood. The results align with prior research, such as the study conducted by Berger et al. [156], which explored the relationship between engaging in PA and positive mood. Their research demonstrated that physical activity directly promotes positive mood among individuals. Given that dancing with our app involves physical activity and is perceived as fun and enjoyable, it is likely to have a direct positive impact on participants' overall mood.

Additionally, insights from the study by Kanning and Schlicht [157] further corroborate our findings. Kanning and Schlicht examined the relationship between mood and PA, specifically focusing on three mood subscales: energetic, arousal, and calmness. Their research highlighted that engaging in PA is likely to induce positive changes in any of these three dimensions of mood. In our intervention, some participants reported feeling more enthusiastic about their day after using the dancing app, while others mentioned being encouraged to engage in dance activities whenever opportunities arose throughout the day, leading to sustained positivity. Notably, Kanning and Schlicht [157] also found that individuals experiencing a more depressive mood before engaging in PA tend to experience greater mood improvement. In light of these results, our analysis suggests that our intervention was effective in promoting a positive mood among participants, and furthermore, it supported them in maintaining a positive outlook throughout the day.

6.2.2 Immediate Mood Measure After Dancing

The assessment of participants' immediate mood played a crucial role in our research, providing valuable insights into their mood states while engaging with the intervention on a daily basis. It is reasonable to assume that the mood state of each participant would vary each time they utilized the intervention for dancing. As detailed in Section 5.2.6, our analysis of the daily mood data allowed us to gain a real-time understanding of the participants' mood states throughout the study. The outcomes of the immediate mood assessment, visually represented in Figure 5.13, revealed that over 90% of participants reported a positive mood immediately after dancing with the intervention. This indicates that utilizing the intervention has the potential to positively influence the mood state of participants. Furthermore, these findings suggest that the intervention's impact on participants' overall mood can be both immediate and long-lasting.

6.2.3 Dancing in a Form of Alleviating Anxiety and Stress

As per the research conducted by Pohjola et al. [158], engagement in dancing not only serves as an enjoyable social and physical activity but also facilitates the evocation of feelings of completeness. Additionally, Bastug [13] observed that dancing provides a means for individuals to express their emotions, thereby offering them an avenue to alleviate anxiety or stress. These scholarly works substantiate our own research findings, which are expounded upon in Section 5.3.5. The results of our study reveal that participants reported a noticeable impact on their daily mood when engaging in dancing with the intervention. Notably, several participants expressed a sense of having accomplished something meaningful following their dance sessions with the intervention. This indicates a potential positive outcome associated with the utilization of our intervention, which was purposefully designed to motivate individuals to dance, ultimately contributing to an ameliorated state of well-being, as opposed to experiencing feelings of depression or anxiety.

In conclusion, our intervention involving dancing provided participants with a platform to express themselves and experience positive emotions. The results of our analysis demonstrate a statistically significant increase in positive mood among participants after engaging in the intervention (p = 0.002) compared to their mood at the beginning of the study, as indicated in Section 5.25. Furthermore, our investigation revealed a notable reduction in participants' negative mood after the intervention, as compared to their mood at baseline. This observation suggests that the intervention exerts a significant positive influence on participants' emotional well-being and effectively mitigates negative emotions. Nevertheless, it is important to note that our analysis did not yield sufficient evidence to establish any significant differences in the impact of the intervention based on participants' gender identity. Addressing our research question, RQ2, "*What is the impact of AR Dancee app in influencing positive mood?*", our current findings provide a clear and affirmative response. The intervention positively affects participants' mood. However, to comprehensively explore the potential variations in the intervention's impact on different genders, further in-depth analysis is warranted in future studies.

6.3 Effectiveness of Persuasive Strategies

The incorporation of persuasive strategies derived from the PSD model [27] constitutes a pivotal element in shaping the framework of our intervention. These strategies were aligned with the eleven distinct features that were purposefully integrated into the intervention, as explicated in Section 3.6 and Section 5.2.7. A comprehensive presentation of these features can be found in Table 3.1. Subsequently, the efficacy of employing these strategies in conjunction with the intervention features is thoroughly examined to address the following RQ3, *"What is the perceived persuasiveness of AR Dancee app features in influencing healthy behavioral change toward physical activity?*".

6.3.1 Persuasive Effect of the Intervention Features

As displayed in Table 5.7, the results indicate that all the eleven features incorporated in our intervention yielded mean values of perceived persuasiveness above the neutral point. Notably, the "Dance Rest" feature received the highest rating, with a mean value $M = 6$, $SD = 1.11$. This feature employed a Suggestion strategy, which guided participants in making decisions regarding whether to take a rest during the dancing session and determining the duration of the rest, or alternatively, to continue dancing without interruption. In prior research, Escalona et al. [21] utilized the Suggestion strategy in a home exercise AR-driven intervention for rehabilitation purposes. The authors emphasized that this approach empowered participants to tailor the exercise intensity according to their preferences and physical capabilities. Consequently, this led to higher engagement levels and a significant reduction in non-adherence to the rehabilitation program. By implementing the Suggestion strategy through the Dance Rest feature in our intervention, we granted participants the flexibility to adjust the dance pace or intensity based on their individual fitness levels. This adaptability likely contributed to increased user engagement with the application.

The second-highest rated feature was the "WHO Statement," which employed an Authority strategy. Previous research by Blakes et al. [85] involved sending text messages containing information from credible institutions to the intervention group participants, emphasizing the importance of regular physical activity. The results indicated that these messages significantly enhanced participants' engagement in physical activity compared to the control group, which did not receive such messages. Similarly, Dzielska et al. [91] found that providing healthy tips from reputable sources persuaded participants to effectively engage with their intervention. Our findings align with these prior studies, as some participants reported during the interviews that the "WHO Statement" feature, displayed before the start of each dance session, reassured them about the health benefits associated with their participation in the activity.

Overall, all the features implemented in our intervention were perceived as persuasive by the participants, answering our RQ3. These results highlight the effectiveness of the intervention in encouraging engagement and adherence, and suggest that the incorporation of specific persuasive strategies, such as Suggestion and Authority, can positively influence user behavior in the context of health-promoting applications.

6.3.2 Transformative Impact of the Intervention Features for Long Term Adherence

The findings derived from the qualitative analysis demonstrate that a majority of the participants experienced a transformative shift in their approach to PA due to the intervention features. This shift was particularly evident in their pre-study PA habits. Participants expressed an inclination towards exploring alternative forms of PA as a direct consequence of the intervention's influence on their engagement with it. Specific details shared in Section 5.3.9 indicated that the intervention features, in certain instances, prompted participants to embrace dance as part of their involvement with the intervention. In Section 5.3.4, noteworthy comments made by participants underscored their heightened enthusiasm towards exercise, largely attributed to the intervention feature that visually presented each dance pattern. The visual cues provided by the intervention appeared to be instrumental in fostering a positive outlook on exercise, thereby fostering anticipation and eagerness for the physical activities.

Moreover, some participants went beyond the stipulated 15-day study period and continued to utilize the intervention. Their motivation to do so stemmed from the intervention's positive influence, encouraging them to adopt a healthier lifestyle through regular participation in daily dance sessions, a behavior they had not typically engaged in before the study commenced. The outcomes of the pairwise comparison analysis, as documented in Section 5.2.8, aimed at evaluating the relative persuasiveness of the intervention features. The statistical analysis revealed that, with the exception of the Home Screen and the Dance Rest features, no significant difference was observed between the other intervention features ($p = 0.027$). This implies that, overall, all the features exhibited a noteworthy level of persuasiveness in motivating the participants to embrace and sustain their involvement in PA.Thus, the results from this study underscore the transformative impact of the intervention features, prompting participants to reevaluate and embrace PA more positively, with dance serving as a pivotal component of their newfound engagement. The intervention's effectiveness was evident through its persuasive influence on sustaining long-term adherence to a healthier lifestyle. These findings offer valuable insights into the design and implementation of PA interventions with potential applications in health promotion and behavior change domains.

6.3.3 Impact of Embedded Musics

An important discovery arising from our study pertains to the influence of music on the persuasiveness of our intervention. Through qualitative analysis of interviews, we observed the remarkable effectiveness of incorporating music into a PA intervention. Given that the intervention predominantly involved dance activities, the selection of music became a crucial consideration to ensure it was relatable, enjoyable, and persuasive enough to motivate participants to engage in dancing. While not explicitly emphasized as a feature of our intervention, music played a central role within the AR Dance feature, which served as the focal point of the intervention. The analysis presented in Section 5.3.7 demonstrated that music significantly contributed to participants' immersion and engagement in the dancing, to the extent that they were less aware of the energy expended during the activity. Some participants even reported continuing to dance to music from their personal playlists after completing the intervention.

These findings are consistent with the research of Chan LL [159], who investigated the impact of music on mood state and PA. The participants' perception of music as an effective persuasive element in encouraging PA participation, however, did not negate some concerns they expressed regarding the current intervention design and its music choices. Certain participants expressed a desire for the intervention to include an option that allows them to select music from their own playlists. They argued that this customization could enhance the intervention's persuasiveness, as individual preferences for music varied greatly based on belief, culture, or current disposition. On the other hand, other participants appreciated the inclusion of music from diverse cultures, which fostered a sense of inclusion and belonging. The intentional incorporation of music from various cultural backgrounds aimed to cater to users worldwide, thereby augmenting the impact of music in our intervention and bolstering its overall persuasiveness.

In summary, the persuasive strategies incorporated as intervention features in our study were found to be perceived as persuasive by the participants. The mean scores for all eleven intervention features, as presented in Table 5.7, were significantly higher than the neutral score of 3. This indicates that each of these features played a role in contributing to the overall effectiveness of the intervention. The boxplot depicted in Figure 5.14, which illustrates the perceived persuasiveness of the intervention features, revealed only a few outliers [160]. This observation suggests that the majority of the participants were influenced by our intervention, particularly in terms of adjusting their health behavior towards physical activity, notably through dancing. Consequently, based on our results, we can confidently assert that our findings provide substantial evidence in addressing our RQ3 concerning the impact and effectiveness of the implemented persuasive intervention in promoting physical activity behavior change, specifically through the medium of dance.

6.4 Usability and Simplicity of the Intervention

The participants' perceptions of the intervention were analyzed in terms of its simplicity and usability. The intervention was regarded as innovative, and to objectively assess its usability, we employed the SUS [142]. The SUS measures two constructs: learnability, which evaluates the ease with which participants could learn to use the intervention without guidance, and usability, which assesses the ease of using the intervention. The results of the analysis, as discussed in section 5.2.9, revealed that the overall usability score of the intervention was above average. Moreover, the data indicated that 87% of the participants found the intervention easy to learn, and 79% perceived it as highly usable. These findings strongly suggest that the intervention was deemed easy to learn and use by the study participants. Some participants expressed a desire for a dance video simulation as an additional aid to understand the intervention better. Nonetheless, it is noteworthy that none of the participants reported finding the app difficult to use or comprehend, indicating that the intervention was generally well-received in terms of usability.

In line with the research theme, the analysis of intervention simplicity presented in section 5.2.10 yielded notable results. The obtained simplicity score for the intervention surpassed the neutral score of three (3), indicating a favorable perception of its simplicity. The mean score ($M = 4.10$, $SD = 0.61$) further supported this finding, signifying that participants perceived the intervention as straightforward. Statistical analysis revealed a significant value of $p = 0.001$, reinforcing the perceived simplicity of the intervention. Moreover, participants' perspectives on three simplicity measures, namely aesthetics, organization, and integration (as illustrated in Figure 5.16), underscored their favorable perceptions. Participants found the intervention to be aesthetically appealing, well-organized, and effectively integrated into their routines. These collective findings strongly suggest that the intervention proved effective in motivating participants to engage in regular physical activity. Consequently, it successfully addressed the research questions (RQ1 and RQ3), demonstrating that the designed features and the persuasiveness of the intervention played crucial roles in influencing participants to adopt healthier behavior, particularly through dancing.

6.5 Design Recommendations

Based on the discussions above, we offer a set of guidelines for designing interventions to promote PA through dancing and encourage positive behavior change.

1. **Incorporate Diverse Dance Patterns to Diversify User Experience:**

   The implementation of diverse dance patterns in a dance intervention aimed at the general public presents several challenges. Our research endeavors to address these challenges by devising dance patterns that encompass both low and medium intensity levels [132], with the intent of enabling widespread participation among diverse individuals. Despite our careful design process, feedback from participants, as documented in Section 5.3.11, indicated that certain dance patterns were perceived as overly simplistic and, consequently, lacked the desired level of challenge. To enhance the overall engagement of participants and cater to varying skill levels, it is crucial to consider the incorporation of high intensity dance patterns. By doing so, we anticipate fostering greater interest and involvement among those individuals who found the existing dance patterns too facile. The inclusion of high intensity variations holds the potential to diversify the experience, accommodating a broader range of participants and ultimately augmenting the effectiveness of the dance intervention as a whole. Therefore, designers should **ensure that most people the intervention targeted are highly engaged by incorporating adaptive dance patterns that will suit the needs of most target users.**

2. **Accommodate Users Dance Patterns to Enhance User Engagement:**

   The present study highlights the importance of extending intervention design to incorporate users' personal dance patterns, thereby facilitating user interaction with the intervention. During qualitative data analysis of interviews, participants expressed their desire to prolong their dancing experience by incorporating their own dance patterns, subsequent to engaging with the predefined dance patterns provided in the intervention. Notably, participants conveyed a preference for the avatar to emulate their personalized dance patterns, mirroring the reciprocation they experienced while following the avatar's dance pattern. One participant articulated their perspective, stating, "*I think it would be nice if there was like a free for all mode if you don't have to follow the avatar and freestyle. So, yeah, maybe the avatar can follow what I'm doing instead*" P223. Integrating users' individual dance patterns into the intervention is likely to enhance user engagement and encourage increased PA through dancing, aligning with the target objectives of the study. Therefore, we suggest that designers need to **extend their intervention to accommodate multiple dance patterns which will help engage the users and give them a sense of agency and control**.

3. **Extend Mechanism to Accommodate Users' Choice of Music:**

Engagement in PA through dancing necessitates the incorporation of music that the target users perceive as danceable and enjoyable. The majority of the participants in our intervention expressed satisfaction with the music provided; however, they expressed a desire for the intervention to offer the option of selecting music from their personal playlists. One participant's comment highlighted this aspect, stating, "*In terms of function, I think it should allow us to be able to choose our own music and our own type of dance*" P229. To enhance user experience and encourage greater participation, it is recommended that the intervention designers implement a mechanism to accommodate users' individual music preferences beyond what has been initially provided. Extensive research supports the notion that people tend to engage more with a system when they are given the opportunity to personalize their experience based on their choices within the system [161][162][163][164]. Designing an intervention that grants users the freedom to dance with music from their personal playlists can be a viable strategy to augment user satisfaction and overall engagement while utilizing the intervention. Such personalization aligns with user-centered design principles and may lead to a more enjoyable and effective experience for the participants. Therefore, designers should consider extending their intervention design to **allow their target users to adapt the content of the intervention or customize it to suit them to enhance their experience within the intervention. For example, in our own case, allowing users to select music from their playlist will enhance their experience with the intervention**.

4. **Include Mechanism to Allow Users to Rehearse Behaviour:**

In order to effectively promote PA through intervention design, it is essential for designers to incorporate a rehearsal video that provides target users with a comprehensive understanding of the intervention's general concept. As elaborated in Section 5.3.11, the inclusion of such a video can significantly mitigate potential confusion that users may face, particularly during the initial stages of using the intervention. Feedback from participants corroborates the importance of this approach. One participant commented, "*I suggest that there is a need to incorporate a video simulation that demonstrates how to use the app. From my own experience, I found myself unsure about what actions to take within the app.*"

P241. This comment underscore the necessity of clear instructional material to enhance user engagement. Indeed, participants who encounter confusion while interacting with an intervention are more prone to losing interest in the intervention altogether. **To avoid this issue and sustain user interest, intervention designers must prioritize the development of a rehearsal video that target users can readily access during the early phases of using the intervention.** By doing so, the potential loss of users due to confusion can be significantly reduced.

5. **Include an Audio Feedback for Users Encouragement:**

   Encouraging participants to sustain their involvement in the dance intervention yields a discernible impact on their overall engagement. As discussed in Section 5.3.9, the provision of audio feedback during participants' dancing sessions emerged as a pivotal element that significantly appealed to them within the intervention. Participants expressed their emotional responses upon receiving feedback from the virtual assistant while dancing. Positive affirmations, such as being commended for their dance performance, evoked feelings of encouragement, while constructive criticism, highlighting areas for improvement, fueled their motivation to enhance their dance skills. For instance, one participant's comment exemplified this sentiment: "*It was nice to always hear the audio feedback. It is encouraging and I even look forward to it*" P33. These emotional experiences played a vital role in sustaining participants' engagement during their dance sessions with the intervention and facilitated their learning process. Therefore, designers should consider **providing audio feedback to the users when they engage in an activity that is measured in real-time**. Designers need to **ensure that the feedback is accurate to avoid discouraging the target users from engaging with the intervention due to inaccurate feedback**.

6. **Add Preparatory Sessions to Help Users Stretch their Body Before Dancing:**

   Interventions aimed at encouraging user engagement in exercise routines should consider the incorporation of a preparatory session, allowing users to engage in body stretching exercises before commencing the primary dance activity. The significance of preparatory sessions within a dance intervention was highlighted by certain participants, as outlined in Section 5.3.11. They expressed the view that such sessions facilitated enhanced flexibility during the subsequent dance routine. For instance, a participant commented "*Add those* *stretches before dancing. Sometimes you would like to stretch, or hear the app telling you to do this or do that or you* can skip to *start dancing.*" P358. Therefore, designers should consider **adding short body-stretching exercises in the intervention such that users can skip or engage with the session before starting the main dance**.

7. **Implement Interactive Augmented Reality Element:**
   Incorporation of augmented reality (AR) elements in dance interventions warrants careful consideration by designers. Numerous studies in the field have highlighted the efficacy of interactive AR components in PA interventions [98][21][165][166]. Our specific intervention leveraged AR elements that generated real-time, 2D representations of participants' poses during their dance routines. Notably, the majority of participants responded positively to the concept of observing a 2D representation of their own poses while engaged in dancing, which, in turn, enhanced their level of involvement in the intervention. For instance, a participant commented "*I like the augmented reality image that is usually casted on my body while I am dancing. It mimics my dance movements, showing me how flexible I can be.*" P147. Therefore, intervention designers should **consider implementing interactive AR elements in their intervention especially dance-based interventions**.
8. **Incorporate Game Elements to Spur Users' Motivation:**
   Incorporating game elements into a dance intervention warrants consideration, as it has the potential to enhance its persuasive impact. Orji et al. [15] have observed that the incorporation of game elements in interventions can effectively stimulate greater engagement, especially for individuals who may not be sufficiently motivated by persuasion alone. Our study conducted a qualitative analysis, which revealed compelling findings regarding participant motivation. Specifically, some participants expressed increased enthusiasm to participate in PA due to their desire to accumulate dancing points, enabling them to secure a place on the coveted leaderboard table. Additionally, other participants displayed heightened dedication to the intervention, aiming to conquer all three dance challenges it presented. Remarkably, irrespective of the efficacy of conventional persuasive strategies employed, our results demonstrate that the gamification of the intervention substantially amplified its persuasive influence. This underscores the potential benefits of integrating game elements into dance interventions for more persuasive

outcomes. Therefore, we suggest that designers should **implement game elements that would likely attract more users who may not be persuaded by other non-game based persuasive strategies that are adopted in an intervention.**

6.6 Limitations and Future Work

Our findings show that our intervention was successful in meeting the goals of this research, however, there are some shortcomings that create opportunities for future research directions. We offer six limitations of our intervention and suggestions for future improvement which are discussed in the paragraphs below.

First, the primary objective of the study was to implement an intervention utilizing a trained ML model capable of detecting fifteen specific dance patterns, as designed by the research team. Although the intervention demonstrated successful detection of dance poses, it was noted that the achieved detection precision fell within the range of 80% to 85%. This level of precision had an impact on the intervention's ability to accurately compare the participants' poses with the expected poses derived from the predefined dance patterns. During the study, some participants reported instances of receiving false feedback from the virtual assistant that provided feedback on their dance performance. This feedback inconsistency posed a challenge as it had the potential to confuse participants during their dance routines. To address these limitations and enhance the intervention's performance, one potential approach is to retrain the ML model using a more extensive dataset.

Second, in pursuit of promoting diversity and inclusivity among our target audience, a deliberate effort was made to curate music selections from various cultural backgrounds. This approach aimed to foster engagement with participants worldwide, as it provided them with an opportunity to dance to music that resonated with their cultural familiarity or personal connection. The findings in Section 5.3.7 of our study demonstrate the significant impact of music in motivating participants to actively participate in dancing. Nonetheless, it was noted that certain participants expressed a desire for greater autonomy in choosing the music they would dance to during the intervention. To address this feedback, we acknowledge the importance of personalization in our future interventions. As a result, we intend to implement a more tailored approach, granting the target audience the freedom to select music that aligns with their individual beliefs, cultural affiliations, preferences, or current emotional state.

Third, it should be noted that the intervention featured a restricted set of fifteen dance patterns. Although all participants expressed their enjoyment in engaging with these dance patterns, some of them conveyed concerns regarding potential monotony that may arise from repeatedly using the same dance pattern over an extended period. To address this limitation, our future research endeavors aim to enhance the intervention by incorporating a more diverse dance patterns. Furthermore, valuable insights were gleaned from the participants, with several individuals suggesting the inclusion of a free-style mode within the intervention. This novel proposition would enable users to dance according to their own unique patterns and witness the dancing avatar mirroring their movements. The prospect of this free-style mode was met with enthusiasm and deemed potentially transformative. As such, our forthcoming investigations will focus on the implementation and assessment of this innovative feature, particularly concerning its capacity to foster PA promotion among the target users, with a specific emphasis on dance-related activities.

Fourth, the study's sample population demonstrated an imbalance in gender representation, with 63% female participants, 36% male participants, and a mere 1% comprising individuals identifying with other genders. To enhance the generalizability of the findings and to ensure a more comprehensive representation of the public, it is recommended to include a more diverse range of gender identities in future research endeavors. Based on the observed data, no statistically significant distinction emerged between the responses of female and male participants to the intervention. Consequently, it can be reasonably inferred that the intervention exhibits effectiveness for both genders. However, caution should be exercised when extending these conclusions to individuals belonging to other gender categories, as the study's sample size for such populations is limited. Hence, to gain further insights into the effectiveness of the intervention among gender categories beyond female and male, it is recommended to conduct dedicated analyses on the data collected from individuals identifying with other genders in future investigations. Such an approach will contribute to a more comprehensive understanding of the intervention's impact across diverse gender identities.

Fifth, we incorporated various components of our intervention design into a mobile app, eliminating the need for external gadgets. However, it is essential to note that the proper functioning of the intervention relies on a reliable internet connection. Throughout the study, we encountered challenges wherein some participants faced difficulties due to the lack of steady internet service. Consequently, their ability to engage with the intervention, particularly in dance activities with the app, was negatively impacted. In light of these findings, we recognize the significance of addressing this limitation in future studies. To enhance accessibility and user engagement, we plan to implement key features of the intervention with reduced dependency on internet service. By doing so, we aim to provide the target users with greater flexibility to engage with the mobile app regardless of their location and the stability of their internet connection. This improvement will likely result in a more comprehensive evaluation of the intervention's effectiveness and better overall user experience.

Lastly, the present study was conducted over a 15-day period, without implementing a follow-up evaluation design to assess the extent of adherence to the newly adopted healthy behavior among the participants. Nonetheless, our findings have provided valuable insights in response to RQ1. To enhance the intervention's effectiveness in promoting sustained healthy behavior change, we propose incorporating alternative forms of behavioral change techniques [63], which may amplify the intervention's impact on PA maintenance for the participants. Notably, Odenigbo et al. [5] have emphasized the significance of consistent practice of healthy lifestyles over time for maintaining positive behavioral changes. As a result, we intend to extend the duration of future research to include a post-study evaluation, thereby enabling us to gauge the long-term effects of the intervention. By doing so, we aim to gain a comprehensive understanding of the intervention's lasting influence on participants' adherence to healthy behavior patterns.

Chapter 7 : Conclusion

The primary objective of this research entailed an assessment of the efficacy of an innovative mobile dance intervention, known as AR Dancee, designed as a persuasive system aimed at promoting healthy behavior within the general public. Specifically, the intervention sought to foster and sustain PA levels by encouraging individuals to partake in dance-related activities. An additional investigation was conducted to ascertain whether this dance intervention could positively influence users' mood. To realize these goals, the AR Dancee intervention was implemented as a mobile application, integrating cutting-edge technologies such as AR and ML. Notably, the combination of AR and ML to construct a mobile intervention with the purpose of promoting PA through dancing represents a novel approach to engaging the public, particularly adults. The significance of this research lies in the potential it holds for the broader scientific community to explore alternative, enjoyable, and effective avenues for promoting healthy behavioral changes among individuals. By inspiring individuals to initiate or sustain their physical activity endeavors, this research contributes valuable insights to the pursuit of healthier lifestyles and the overall improvement of public health.

Furthermore, the present study contributes significantly to the domain of technology for health and wellness, particularly in the context of physical and mental health. The research provides valuable insights and design recommendations that can be of immense benefit to future researchers seeking to develop interventions that encourage individuals to engage in PA in an enjoyable and entertaining manner. The results of this investigation indicate that the dance intervention effectively promoted PA among adults, irrespective of their gender identity or age groups. Additionally, the intervention demonstrated the capacity to improve participants' mood, thereby enhancing their overall well-being. Notably, a key outcome of the intervention was the transformation of participants' perception of PA from a burdensome task to a pleasurable and enjoyable activity. This shift in perspective had a direct impact on encouraging and sustaining healthy behavioral changes, as participants became more motivated to be physically active.

While the dance intervention showcased effectiveness in this research, it is recommended that future studies incorporate diverse and flexible dance patterns into their interventions to cater to users from varied cultural backgrounds, beliefs, and environments. Moreover, implementing a mechanism that enables participants to select music from their personal playlists on their phones, synchronizing it with the intervention, could significantly enhance overall engagement in PA and contribute to a more positive user experience.

Finally, this investigation has laid the groundwork for the development of novel dance interventions utilizing cutting-edge AR and ML technologies. The primary objective is to foster constructive behavioral change by stimulating increased physical activity among individuals. By capitalizing on these innovative approaches, people can be encouraged to adopt more physically active lifestyles, thereby promoting overall health and well-being. Drawing upon the insights garnered from our research, the implementation of interventions based on our proposed concepts holds promise in facilitating positive emotional states and advancing both physical and mental health among participants. The implications of our findings extend beyond the immediate scope of this study, as they may serve as a valuable resource for future researchers seeking to explore diverse avenues for influencing individuals to engage in PA in a manner that is not only enjoyable but also highly effective.

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Appendices

Appendix A

Research Ethics Board Approval Letter

Social Sciences & Humanities Research Ethics Board
Letter of Approval

December 01, 2022
Ifeanyi Paul Odenigbo
Computer Science\Computer Science

Dear Ifeanyi Paul,

REB #: 2022-6376
Project Title: AR Dancee: An augmented reality-based mobile persuasive app for promoting physical activity through dancing.

Effective Date: December 01, 2022
Expiry Date: December 01, 2023

The Social Sciences & Humanities Research Ethics Board has reviewed your application for research involving humans and found the proposed research to be in accordance with the Tri-Council Policy Statement on *Ethical Conduct for Research Involving Humans.* This approval will be in effect for 12 months as indicated above. This approval is subject to the conditions listed below which constitute your on-going responsibilities with respect to the ethical conduct of this research.

Sincerely,

Dr. Megan Bailey
Chair, Social Sciences and Humanities Research Ethics Board
Dalhousie University

Appendix B

Recruitment Notice

Project title: AR Dancee: An augmented reality-based mobile persuasive app for promoting physical activity through dancing.

Lead researcher: Ifeanyi Paul Odenigbo

Faculty of Computer Science, Dalhousie University.

Hello there,

We are recruiting participants to take part in a research study that evaluates a gamified augmented reality- (AR) driven mobile app, called ***AR Dancee***, that promotes physical activity through dancing and would appreciate your help. The study will contribute to the research area of Persuasive Technology for Healthy Behavior Change. No prior experience with using the app or dancing in any capacity is necessary, but experience with using a smartphone is required. The study is 15 days long and you will be asked to dance with the app for at least 10 minutes each day. The app will NOT record any of your dance videos or transmit it to any online server. At the end of the 15-day period, you will be asked to complete a questionnaire about your experience using the app.

To participate in this study, you must be at least 18 years and own an android or iPhone (iOS).

If you have any questions about this study or are interested in participating, kindly contact me at: Ifeanyi.odenigbo@dal.ca.

Your participation is highly appreciated and is completely voluntary. The compensation is $10.00 for participating in the study (after you have used the mobile app for a 15-day period and responded to the post-study survey). Whether you choose to participate in the post-study optional interview or not, you will receive compensation. All data will be treated confidentially and for research purposes only.

Thank you and I look forward to hearing from you.

Kindest regards,

Ifeanyi.

Faculty Supervisor: Dr. Rita Orji (rita.orji@dal.ca), Faculty of Computer Science

Ethics Clearance ID: Project Number 2022-6379

Appendix C

Consent Form for the Study

Project title: AR Dancee: An augmented reality-based mobile persuasive app for promoting physical activity through dancing.

Lead researcher: Ifeanyi Paul Odenigbo, Faculty of Computer Science, Dalhousie University

Academic supervisor: Dr. Rita Orji, Faculty of Computer Science, Dalhousie University

Contact person: Ifeanyi Paul Odenigbo, Email: Ifeanyi.odenigbo@dal.ca

Introduction
You are invited to participate in our research study. Your participation in this research study is voluntary. The study details are described below. The description summarizes about what is involved in the research and the nature of your participation: what you will be asked to do and about any benefit, risk, inconvenience, or discomfort you might experience. You can withdraw from the study at any time without penalty simply by emailing the lead researcher (Ifeanyi.odenigbo@dal.ca) to inform that you would like to withdraw. If you have any other questions about this study, please contact Ifeanyi Paul Odenigbo (Ifeanyi.odenigbo@dal.ca).

Purpose and Outline of the Research Study
The purpose of the study is to evaluate the effectiveness of an app (AR Dancee) for promoting physical activity through dancing. In general, the study will evaluate if the app has the potential to improve the user's health behavior towards physical activity and positive mood.

Who Can Take Part in the Research Study
You need to be 18 years old or above and own an Android or iPhone (iOS) with internet connection to be able to participate in this study. The survey has been developed in English, so you should be able to read and understand the English language.

What You Will Be Asked to Do
If you choose to participate in this study, you will be required to respond to the pre-study questionnaire about your demographic characteristics and your physical activity level (which will take approximately 10 minutes). Thereafter, you will receive a link with an instruction on how to download, setup, and use mobile app for a period of 15 days. During the 15-day period, you will be asked to dance with the app daily (which will take at least 10 minutes) and no basic/professional knowledge in dancing is required. After the 15-day period, you will be asked to respond to the post-study questionnaire (which will take approximately 25 minutes) regarding your experience with using the app. If you would like to be contacted for an interview to provide additional feedback, you will have an option to provide your email-id for being contacted by the lead researcher. This is optional, and the interview will be audio recorded and will happen over Microsoft Teams. All your survey responses would be anonymous, and you would be provided with a participant id that you need to note down to be able to access the mobile app during the 15-day period.

Possible Benefits, Risks and Discomforts
The main goal of our study is to explore the potential of augmented reality technology to influence healthy behavior towards physical activity through dancing. Hence, there are no known risks from the study. The direct benefit for participating in this study is that you may be influenced to start maintaining your physical activity level intentionally. You might also gain a positive mood while using the app to dance. An indirect benefit is that you would be contributing to new knowledge that would be helpful in designing better mHealth apps especially towards promoting physical activity. At the end of the study, you can continue using the mobile app if you wish to.

Compensation / Reimbursement
To thank you for your time, we will give you a compensation of $10.00 after you have used the mobile app for a 15-day period and responded to the post-study survey. Whether you choose to participate in the post-study optional interview or not, you will receive the compensation.

How your information will be protected:
Your responses to the survey will be anonymous. This means that there are no questions in the survey that ask for identifying details such as your name. All responses will be saved on a secure Dalhousie server and password-protected computers to be used for analysis. The mobile app will transmit the total point, total calories burn while dancing, and total time you spent using the app when dancing to an online server located in Canada daily. The app data will be downloaded and saved on a secure Dalhousie server and password-protected computers to be used for analysis alone. Only the Lead Researcher and Research Supervisor (i.e., Ifeanyi Paul Odenigbo and Dr Rita Orji) will have access to the data (including your email-id to forward the participant ID and the compensation amount). The collected data would be retained for the period until the data is analyzed, and results are shared in the thesis report and conference or journal publications. The Lead Researcher (i.e., Ifeanyi Paul Odenigbo) will destroy all the survey responses and app data after 3 years of reporting the study results to ensure that all study-related publications are completed. During the optional interview, your voice, or the information you provide might be identifiable only by the Lead Researcher and such identifiable information would not be disclosed.

If You Decide to Stop Participating
Your participation in this research study is voluntary. However, once you begin, you can withdraw from this study by no longer using the app to dance or by not filling the survey at any point. Partially completed surveys will be discarded. Note that if you completed the survey and then decide to withdraw, your data can only be removed within two (2) days of submission, else it will be impossible to know which data is yours. This is because the data will be analyzed.

Questions or concerns
If you have any questions, concerns, or need clarification about this study, please do not hesitate to contact me (Ifeanyi Paul Odenigbo) via Ifeanyi.odenigbo@dal.ca.

If you have any ethical concerns about your participation in this research, you may also contact Research Ethics, Dalhousie University at (902) 494-3423, or email: ethics@dal.ca (and reference REB file # 2022-6379).

Consent
I have read the explanation about this study. I have been given the opportunity to contact and discuss any question related to study and my questions have been answered to my satisfaction.

I agree to take part in this study. My participation is voluntary, and I understand that I am free to not complete the survey if I choose.

I understand that my responses during the post-study optional interview will be audio recorded.

I agree that direct quotes from my responses may be used without identifying me:

☐ No

☐ I consent, and I agree to participate.

Appendix D

Consent Form for the Optional Interview

Project title: AR Dancee: An augmented reality-based mobile persuasive app for promoting physical activity through dancing.

Lead researcher: Ifeanyi Paul Odenigbo, Faculty of Computer Science, Dalhousie University

Academic supervisor: Dr. Rita Orji, Faculty of Computer Science, Dalhousie University

Contact person: Ifeanyi Paul Odenigbo, Email: Ifeanyi.odenigbo@dal.ca

Introduction
You are invited to participate in our research study. Your participation in this research study is voluntary. The study details are described below. The description summarizes what is involved in the research and the nature of your participation: what you will be asked to do and about any benefit, risk, inconvenience, or discomfort you might experience. You can withdraw from the study at any time without penalty simply by emailing the lead researcher (Ifeanyi.odenigbo@dal.ca) to inform you that you would like to withdraw. If you have any other questions about this study, please contact Ifeanyi Paul Odenigbo (Ifeanyi.odenigbo@dal.ca).

Purpose and Outline of the Research Study
The purpose of the study is to evaluate the effectiveness of an app (AR Dancee) for promoting physical activity through dancing. In general, the study will evaluate if the app has the potential to improve the user's health behavior towards physical activity and positive mood.

Who Can Take Part in the Research Study
You need to be 18 years old or above and understand the English language. The interview is conducted in English. You are also expected to have used the AR Dancee app for about 15-day period.

What You Will Be Asked to Do
If you choose to participate in this interview, you will be audio recorded and will happen over Microsoft Teams. You will be asked to describe your experience with using the app, which will take approximately 45 minutes. The researcher will use their Dalhousie University credentials for the Microsoft Teams meeting, which will ensure that the Teams meeting recordings are securely stored in Canada. During the live Teams meeting, audio and video content is routed through the United States, and therefore may be subject to monitoring without notice under the provisions of the US Patriot Act while the meeting is in progress. After the meeting is complete, meeting recordings made by Dalhousie are stored in Canada and are inaccessible to US authorities. All your survey responses would be anonymous, and you would be provided with a participant id that you need to note down to be able to access the educational material.

Possible Benefits, Risks and Discomforts
There are no known risks from the study. An indirect benefit is that you would be contributing to new knowledge that would be helpful in designing better mHealth apps especially towards

promoting physical activity. At the end of the study, you can continue using the mobile app if you wish to.

Compensation / Reimbursement
There is no compensation at this stage of the study.

How your information will be protected:
Your responses to the survey will be anonymous. This means that there are no questions in the survey that ask for identifying details such as your name. During the optional interview, your voice, or the information you provide might be identifiable only by the Lead Researcher and such identifiable information would not be disclosed. All responses will be saved on a secure Dalhousie server and password-protected computers to be used for analysis. Only the Lead Researcher and Research Supervisor (i.e., Ifeanyi Paul Odenigbo and Dr Rita Orji) will have access to the data. The collected data would be retained for the period until the data is analyzed, and results are shared in the thesis report and conference or journal publications. The Lead Researcher (i.e., Ifeanyi Paul Odenigbo) will destroy all the survey responses after 3 years of reporting the study results to ensure that all study-related publications are completed.

If You Decide to Stop Participating
Your participation in this research study is voluntary. You can withdraw your participation at any time. However, after two (2) days the interview is done, we will not be able to remove your responses as they would have been analyzed.

Questions or concerns
If you have any questions, concerns, or need clarification about this study, please do not hesitate to contact me (Ifeanyi Paul Odenigbo) via Ifeanyi.odenigbo@dal.ca.

If you have any ethical concerns about your participation in this research, you may also contact Research Ethics, Dalhousie University at (902) 494-3423, or email: ethics@dal.ca (and reference REB file # 2022-6379).

Consent
I have read the explanation about this study. I have been given the opportunity to contact and discuss any question related to study and my questions have been answered to my satisfaction.

I agree to take part in this study. My participation is voluntary, and I understand that I am free to not complete the survey if I choose.

I understand that my responses during the post-study optional interview will be audio recorded.

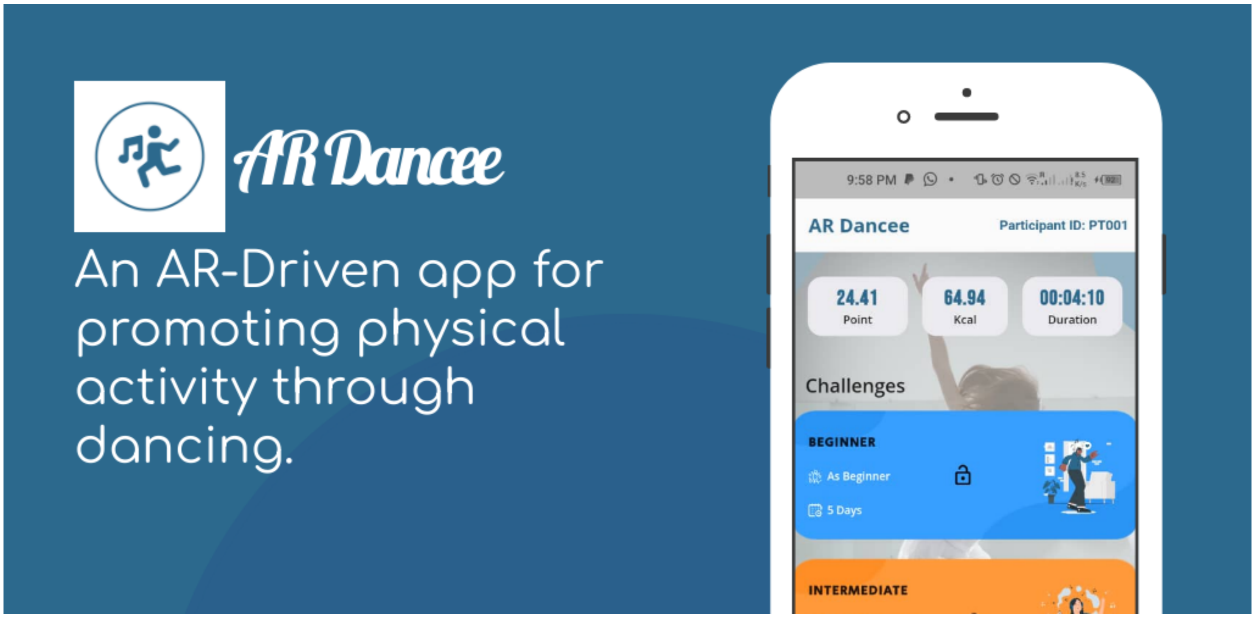
I agree that direct quotes from my responses may be used without identifying me:

☐Yes, I consent, and I agree to participate.

Appendix E

Recruitment Notice (Social Media)

Hi! I am a master's student at Dalhousie University, and I am conducting a study to evaluate an Augmented Reality (AR) driven mobile application for promoting physical activity through dancing. You are invited to participate in our study. Please DM me or email me at ifeanyi.odenigbo@dal.ca if you are interested.



Appendix F

Pre-Intervention Questionnaire

Demography

Please enter your participant ID: _____________

Please choose your age group
☐ 18-25
☐ 26-35
☐ 36-45
☐ Over 46

Please choose your gender
☐ Male
☐ Female
☐ Other (please self-describe): _______________
☐ I prefer not to say.

Please choose the highest level of education you have completed:
☐ Less than high school
☐ High school equivalent
☐ College diploma
☐ Bachelor's degree
☐ Master's degree
☐ Doctoral degree
☐ Other (please specify): ___________________

Please choose your marital status
☐ Single
☐ Married
☐ Widowed
☐ Divorced
☐ Separated
☐ Registered partnership
☐ Other (please specify): ___________________

What is your current employment status?
☐ Employed (full-time)
☐ Employed (part-time)
☐ Unemployed
☐ Student
☐ Other (please specify): ___________________

Physical Activity Questions

1. In a typical week, on how many days do you do moderate-intensity activities (such as walking) as part of your work?

- Everyday
- 6 days
- 5 days
- 4 days
- 3 days
- 2 days
- 1 day
- Never

2. In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places?

- Everyday
- 6 days
- 5 days
- 4 days
- 3 days
- 2 days
- 1 day
- Never

3. In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational (leisure) activities (e.g., dancing)?

- Everyday
- 6 days
- 5 days
- 4 days
- 3 days
- 2 days
- 1 day
- Never

4. In a typical week, on how many days do you do vigorous-intensity sports, fitness or recreational (leisure) activities (e.g., running)?

- Everyday
- 6 days
- 5 days
- 4 days
- 3 days
- 2 days
- 1 day
- Never

5. How much time do you usually spend sitting or reclining on a typical day (i.e., total time spent sitting at work, in an office, reading, watching television, using a computer, doing hand craft like knitting, resting etc.)?
___ Hours
___ Minutes

Users' Mood and Emotion Questionnaire (PANAS)
This scale consists of several words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you GENERALLY feel this way, that is how you feel ON AVERAGE. Use the following scale to record your answers.

	Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
Interested	□	□	□	□	□
Distressed	□	□	□	□	□
Excited	□	□	□	□	□
Upset	□	□	□	□	□
Strong	□	□	□	□	□
Guilty	□	□	□	□	□
Scared	□	□	□	□	□
Hostile	□	□	□	□	□
Enthusiastic	□	□	□	□	□
Proud	□	□	□	□	□
Irritable	□	□	□	□	□
Alert	□	□	□	□	□
Ashamed	□	□	□	□	□
Inspired	□	□	□	□	□
Nervous	□	□	□	□	□
Determined	□	□	□	□	□
Attentive	□	□	□	□	□
Jittery	□	□	□	□	□
Active	□	□	□	□	□
Afraid	□	□	□	□	□

Appendix G

Post-Intervention Questionnaire

Physical Activity Questions

1. In a typical week, on how many days do you do moderate-intensity activities (such as walking) as part of your work?

☐ Everyday
☐ 6 days
☐ 5 days
☐ 4 days
☐ 3 days
☐ 2 days
☐ 1 day
☐ Never

2. In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places?

☐ Everyday
☐ 6 days
☐ 5 days
☐ 4 days
☐ 3 days
☐ 2 days
☐ 1 day
☐ Never

3. In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational (leisure) activities (e.g., dancing)?

☐ Everyday
☐ 6 days
☐ 5 days
☐ 4 days
☐ 3 days
☐ 2 days
☐ 1 day
☐ Never

4. In a typical week, on how many days do you do vigorous-intensity sports, fitness or recreational (leisure) activities (e.g., running)?

☐ Everyday
☐ 6 days
☐ 5 days
☐ 4 days
☐ 3 days

☐ 2 days
☐ 1 day
☐ Never

5. How much time do you usually spend sitting or reclining on a typical day (i.e., total time spent sitting at work, in an office, reading, watching television, using a computer, doing hand craft like knitting, resting etc.)?
___ Hours
___ Minutes

Users' Mood and Emotion Questionnaire (PANAS)
This scale consists of several words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you GENERALLY feel this way, that is how you feel ON AVERAGE. Use the following scale to record your answers.

	Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
Interested	☐	☐	☐	☐	☐
Distressed	☐	☐	☐	☐	☐
Excited	☐	☐	☐	☐	☐
Upset	☐	☐	☐	☐	☐
Strong	☐	☐	☐	☐	☐
Guilty	☐	☐	☐	☐	☐
Scared	☐	☐	☐	☐	☐
Hostile	☐	☐	☐	☐	☐
Enthusiastic	☐	☐	☐	☐	☐
Proud	☐	☐	☐	☐	☐
Irritable	☐	☐	☐	☐	☐
Alert	☐	☐	☐	☐	☐
Ashamed	☐	☐	☐	☐	☐
Inspired	☐	☐	☐	☐	☐
Nervous	☐	☐	☐	☐	☐
Determined	☐	☐	☐	☐	☐
Attentive	☐	☐	☐	☐	☐
Jittery	☐	☐	☐	☐	☐
Active	☐	☐	☐	☐	☐
Afraid	☐	☐	☐	☐	☐

The System Usability Scale
Please rate your level of agreement or disagreement with each of the following statements:

Statements	**Strongly disagree**	**Disagree**	**Neither**	**Agree**	**Strongly agree**

1.	I think that I would like to use this system frequently.	☐	☐	☐	☐	☐
2.	I found the system unnecessarily complex.	☐	☐	☐	☐	☐
3.	I thought the system was easy to use.	☐	☐	☐	☐	☐
4.	I think that I would need the support of a technical person to be able to use this system.	☐	☐	☐	☐	☐
5.	I found the various functions in this system were well integrated.	☐	☐	☐	☐	☐
6.	I thought there was too much inconsistency in this system.	☐	☐	☐	☐	☐
7.	I would imagine that most people would learn to use this system very quickly.	☐	☐	☐	☐	☐
8.	I found the system very cumbersome to use.	☐	☐	☐	☐	☐
9.	I felt very confident using the system.	☐	☐	☐	☐	☐
10	I needed to learn a lot of things before I could get going with this system.	☐	☐	☐	☐	☐

Simplicity

Please rate your level of agreement or disagreement with each of the following statements below:

	Statements	Strongly disagree	Disagree	Neither	Agree	Strongly agree
1.	The screen design is neat.	☐	☐	☐	☐	☐
2.	The screen design is modern.	☐	☐	☐	☐	☐
3.	The screen design is well-balanced.	☐	☐	☐	☐	☐

4.	The app provides content systematically.	☐	☐	☐	☐	☐
5.	The app is designed to provide functions consistently.	☐	☐	☐	☐	☐
6.	Information in the app is well structured and systematic.	☐	☐	☐	☐	☐
7.	The app groups similar menu items in the same category.	☐	☐	☐	☐	☐
8.	The app offers one-step function to run certain menus.	☐	☐	☐	☐	☐
9	The app offers one-step function to change settings.	☐	☐	☐	☐	☐

Perceived Persuasiveness Questions

The four questions below apply to all the persuasive strategies. The idea is to create visually appealing mock-ups for all 11 persuasive strategies. Each mock-up will consist of two or three screen designs representing the strategy as a scripted interaction between the user and the proposed AR Dancee app. Afterwards, the participant will answer the questions below for that strategy. 24

	1-Strongly Disagree						**7- Strongly Agree**
This strategy would influence me.	1	2	3	4	5	6	7
This strategy would be convincing.	1	2	3	4	5	6	7
This strategy would be personally relevant for me.	1	2	3	4	5	6	7
This strategy would make me reconsider my physical activity habits.	1	2	3	4	5	6	7

I agree to take part in the optional interview. My participation is voluntary, and I understand that I am free to not participate if I choose.

☐Yes

☐ No

Thank you for your time. If you are interested in participating in an optional interview, please enter your email address below and the researcher will email you more information.

Email address: ______________________________

Appendix H

Interview Questions

1. How do you feel about your experience with the ***AR Dancee*** app?
2. What specific features or functionalities do you like about the app? Why?
3. What specific features or functionalities do you dislike about the app? Why?
4. Was there anything that you found confusing with the app? Can you provide an example?
5. What would you recommend for improving the app in terms of its content? How about its functions?
6. Is there anything you would recommend for improving the app's interface? What?
7. Did you feel or notice any change in your overall physical activity level? Please explain.
8. Did anything from the app cause an attitude change to you towards physical activity?
9. Regarding your mood, did you feel positive after dancing with the app?
10. Is there any feature of the app that attract you most in using the app? What?
11. Will you recommend the app to someone else? Why or why not?
12. Do you have anything else you would like to share regarding your experience of the study in general that I have not asked you?

Appendix I

Online resources used for developing our intervention.

Resource Item	**Resource Link**
Pose detection ML kit model by Google	Click to see link
Dance pose model training environment by Colab	Click to see link
Music audio editing with Adobe	Click to see link
Music video editing with AudioTrimmer	Click to see link
Image dataset compress with iLoveImg	Click to see link
Dance video-to-image conversion with mConverter	Click to see link
Avatar model design with DeepMotion	Click to see link

Appendix J

15 Dance Patterns

Dance 1

Dance 2

Dance 3

Dance 4

Dance 5

Dance 6

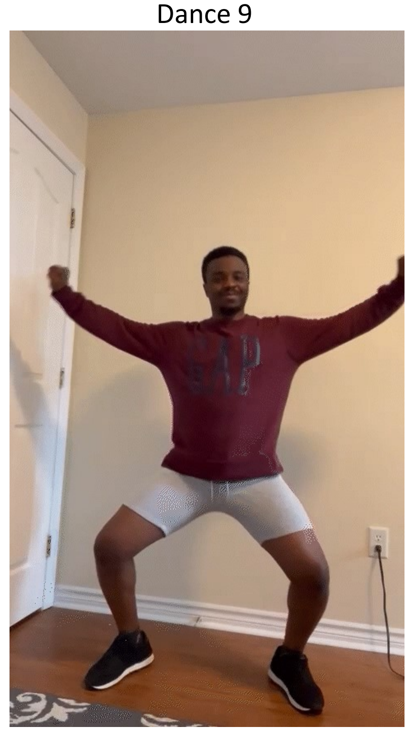
Dance 7

Dance 8

Dance 9

Dance 10

Dance 11



Dance 12

Dance 13

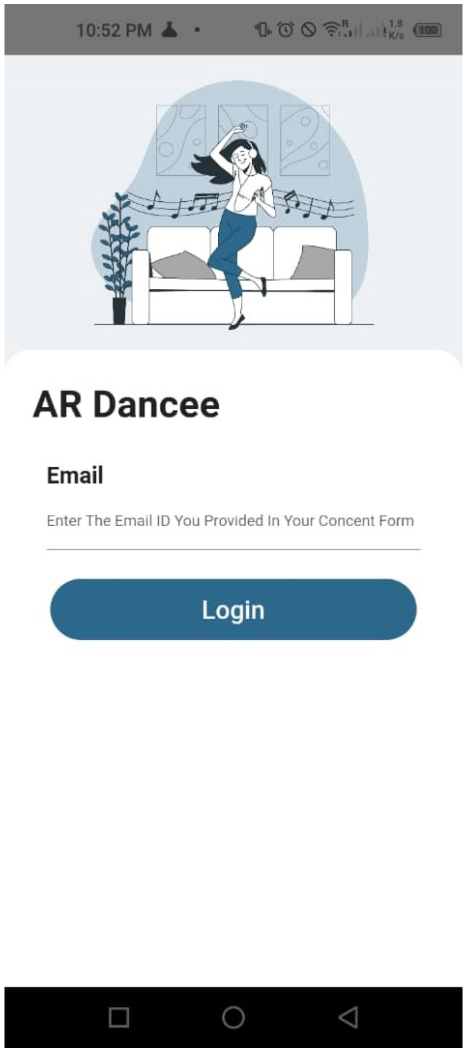
Dance 14

Dance 15

Appendix J

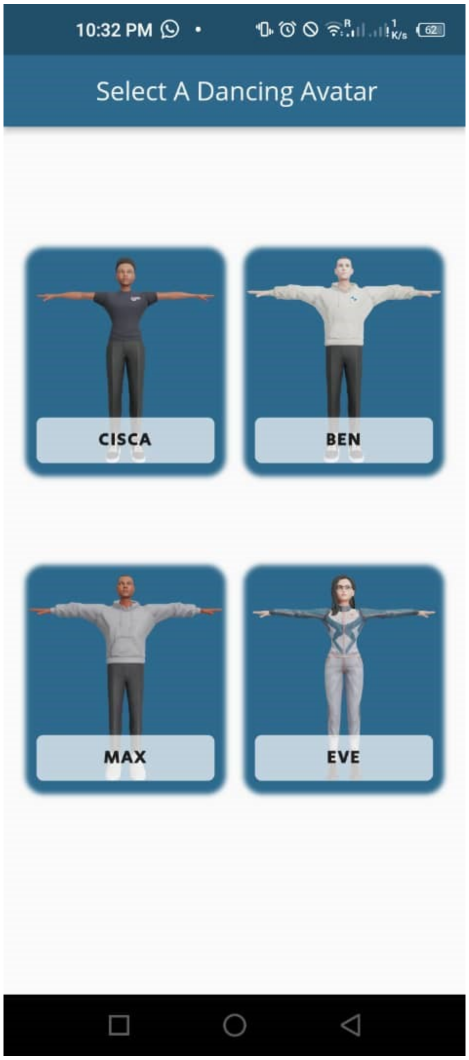
Some Intervention Screenshots

Splash Screen

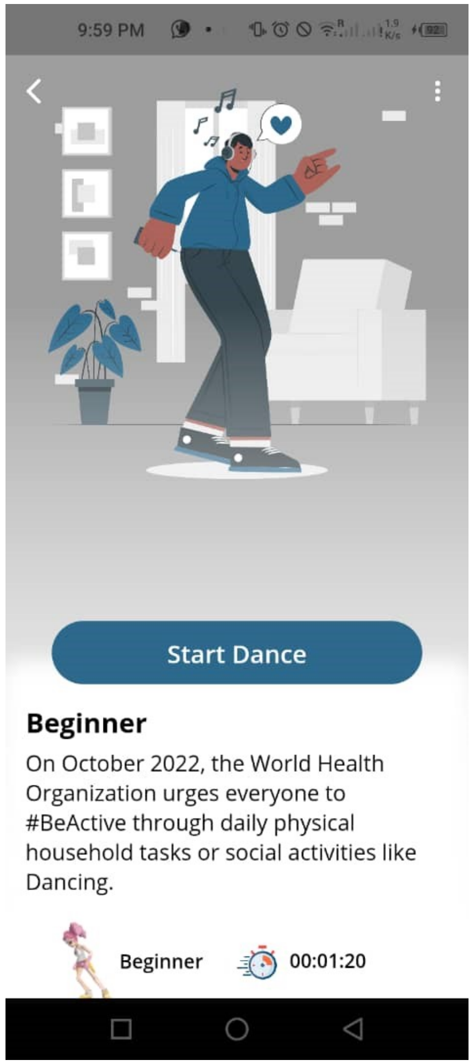


Login Screen

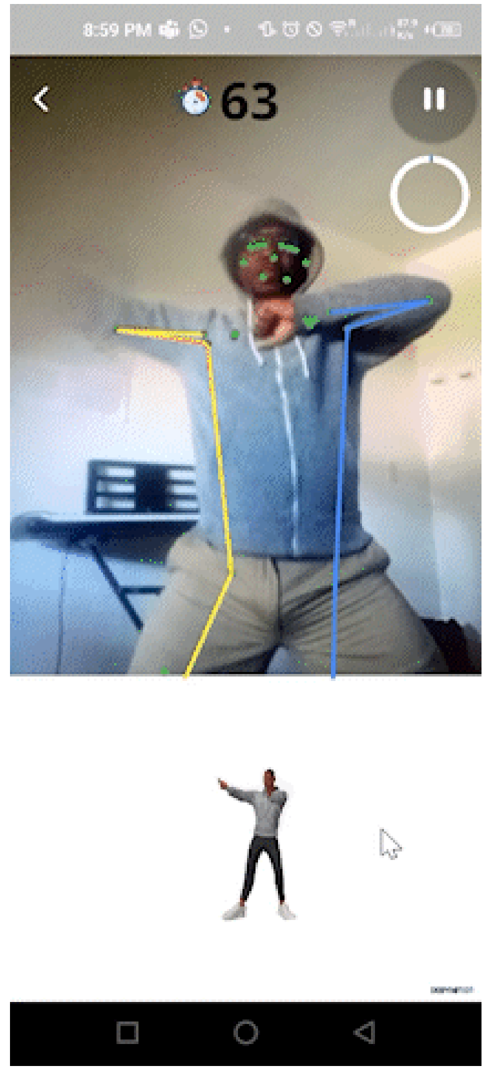
Home Screen



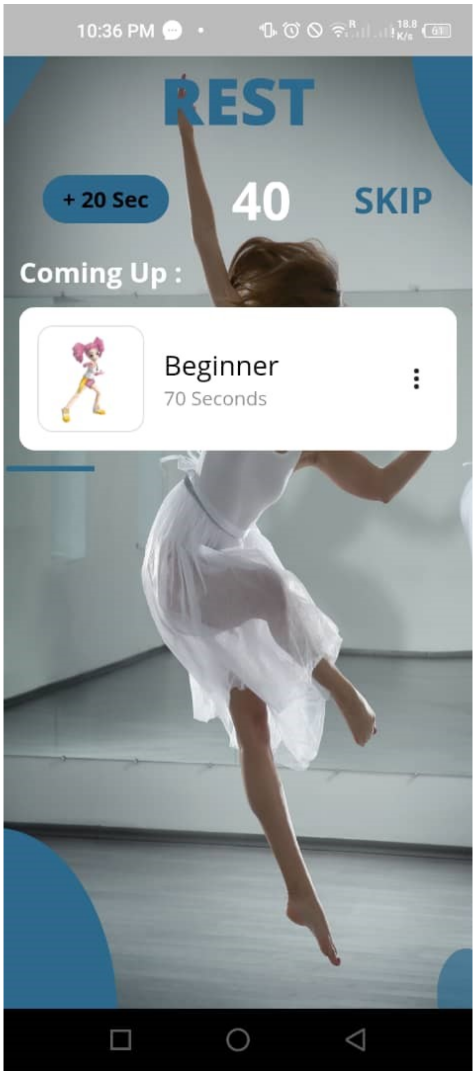
Avatar Selection Screen



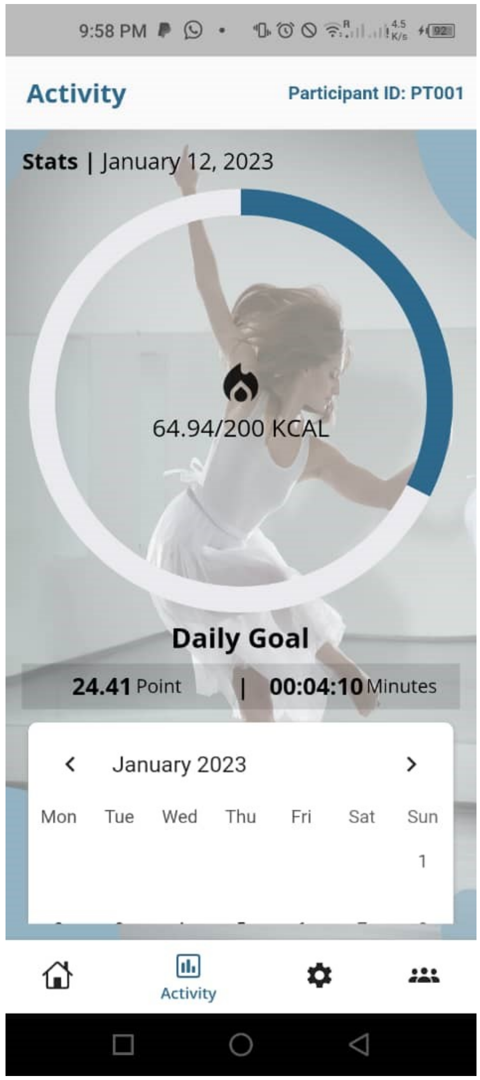
WHO Statement Screen



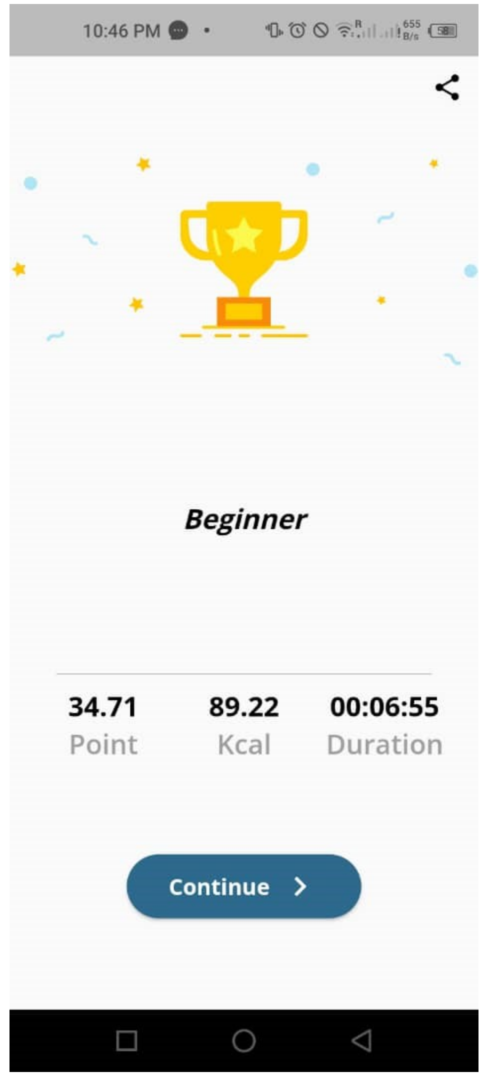
AR Dancee Screen



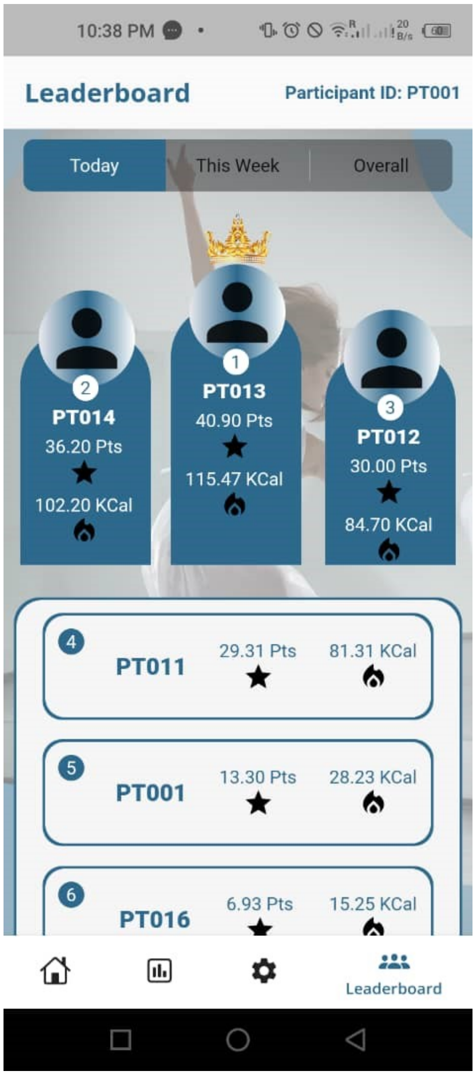
Rest Screen



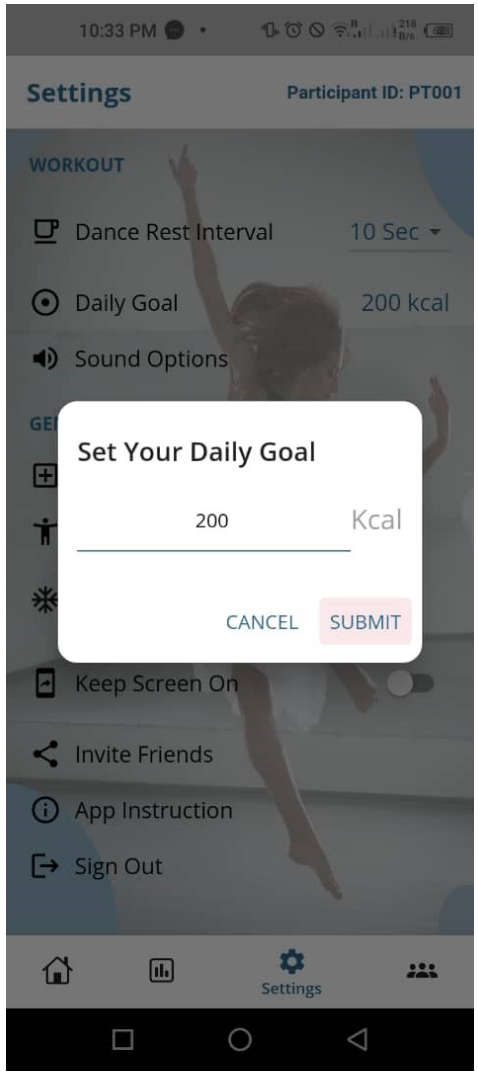
Daily Activity Screen



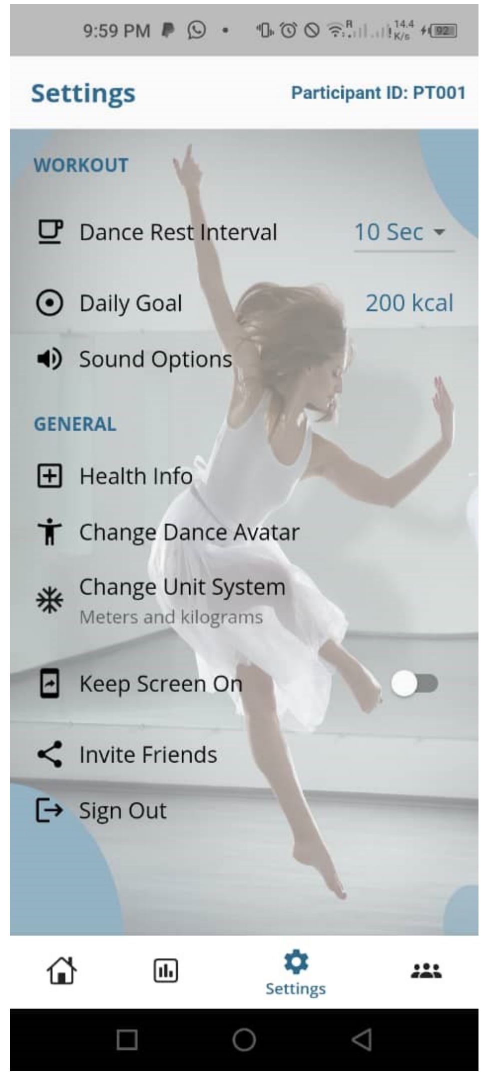
Dance Summary Screen



Leaderboard Screen



Goal Setting Screen



Settings Screen