

# Gamification in Physical Activity: State-of-the-Art

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**Abstract**—Physical activity is decreasing globally, and more people are becoming sedentary, which is associated with numerous adverse health outcomes. To counter this trend, gamification emerges as a promising strategy for enhancing participation in physical activity interventions. The review investigates the influence of gamified systems on the promotion of physical activity and examines associated behavioral and psychological outcomes. The analysis incorporates empirical studies focused on adult participants, published in peer-reviewed English-language journals over the last five years. Several critical aspects are considered in the analysis, including specific types of physical activity targeted, employed gamification systems, involved motivational features, and behavioral and psychological outcomes, thus offering a state-of-the-art overview of gamification and physical activity. Findings confirm that gamification serves as an effective mechanism for promoting physical activity. To address gaps in existing research, recommendations for future work include broadening the range of metrics used for measuring physical activity and investigating the psychological benefits of gamification in physical activity interventions. Moreover, future research could benefit from leveraging addictive game design elements and utilizing artificial intelligence and computer vision models to monitor user progress and suggest appropriate challenges. In conclusion, the review outlines the considerable potential of gamification to positively affect participation in physical activity, highlighting the need for additional research to fully realize this potential.

**Keywords**—Physical activity; gamification; gamified systems; gamification and motivation; state-of-the-art

## I. INTRODUCTION

The increase in sedentary behaviors and lack of physical activity have significantly impacted global health, highlighting the growing problem of obesity [1]. Obesity is associated with various health risks, particularly cardiovascular problems [2]. Research has shown that weight loss can effectively reduce these cardiovascular risks [3]. Furthermore, obesity-related complications are serious and can lead to severe outcomes such as heart attacks and strokes [4]. In addition, obesity is often associated with comorbid conditions such as diabetes, a metabolic disorder that increases blood glucose levels and can lead to various complications like nerve damage, kidney failure, and vision loss [5]. Moreover, being overweight increases the likelihood of experiencing problems such as osteoarthritis [6]. There is also evidence linking obesity to various types of cancer [4]. Additionally, obese individuals are at increased risk of obstructive sleep apnea due to airway blockage caused by excess fat tissue [6]. Obese individuals have a higher incidence of depression, along with challenges in social interactions and stigma [7]. Obesity has significant implications for mental health. Moreover, obesity places a heavy burden on healthcare systems, leading to increased healthcare costs and reduced productivity in the workforce [8],

[9].

Maintaining a regular exercise routine can be challenging for many individuals despite its numerous benefits in terms of health and well-being [10]. Time constraints have been identified as one significant obstacle to consistent physical activity [10]. Another notable barrier is the concern about potential injuries during exercise, which has been emphasized [11]. Inadequate knowledge regarding effective workout strategies also contributes to inconsistent engagement in physical activity [12]. Additionally, societal pressures and cultural norms can negatively influence exercise habits [13]. Given the prevailing sedentary lifestyle prevalent today and its associated risks to health, there is an urgent need for viable solutions.

The concept of gamification offers a unique and positive approach to promoting behavioral change. By incorporating game design elements like points, rewards, and challenges, gamification enhances user engagement and motivation in non-game contexts [14]. There are mainly two ways to implement gamification. The first way is to infuse game-like features into an existing system, like incorporating a point system in physical activity programs. The second involves designing the activity as a game from scratch, which requires a more comprehensive resource commitment but offers a compelling avenue to control and manipulate the game mechanics to drive specific behaviors and outcomes. Research in various sectors has shown differing degrees of success with gamification. For instance, a study conducted on the implementation of gamification in healthcare discovered that integrating game elements into the system enhanced the collection and analysis of data, increased patient involvement and knowledge, promoted professional growth and reputation, as well as improved care for both practitioners and patients [15]. Evidence from a separate study suggests that incorporating game elements into a computer programming course can strengthen students' motivation and overall learning journey [16]. Moreover, a thorough examination of 103 existing gamified fitness tracker apps revealed promising potential for innovative approaches that seamlessly blend game mechanics in engaging and enjoyable manners instead of solely relying on conventional gamification elements and leaderboards [17]. Moreover, a research study examined the impact of gamification on users' adoption of personal finance management applications and discovered that incorporating game elements fulfilled users' desires for competence and autonomy, resulting in an increased intrinsic motivation to use gamified apps [18]. Furthermore, research on the utilization of gamification in luxury goods revealed that incorporating elements and mechanisms of game design into experiences resulted in elevated levels of brand recognition, customer loyalty, and sales [19].

Understanding the role of gamification as a tool to boost physical activity is crucial. The theoretical groundwork that guides the creation, roll-out, and evaluation of such gamified interventions falls into three main categories [20]. The first is the principle of motivation and impact, which pulls from a range of theories, including self-determination, flow, goal-setting, and self-efficacy. This principle stresses the need for developing gamified interventions tailored to the user's motivational triggers and interests. The second guiding principle focuses on behavior, drawing upon theories like activity, reinforcement, reasoned action, and planned behavior, to name a few. This aspect emphasizes the critical role of creating interventions that effectively drive behavioral outcomes. Lastly, the principle of learning incorporates theories such as experiential learning, constructivist learning, and cognitive load and highlights the importance of developing interventions that facilitate learning. A thorough examination was carried out to analyze theories related to motivation and effectiveness, providing valuable insights into the potential impact of gamification in promoting physical activity. A comprehensive evaluation was conducted on these principles and their practical implementations.

The remainder of the paper is organized as follows:

- **Theoretical Background:** Provides foundational theories and principles that guide the use of gamification in promoting physical activity.
- **Literature Review:** Dive into previous research on the subject, covering different aspects such as types of physical activity, technological platforms, and psychological outcomes, among others.
- **Limitations and Shortcomings:** Discusses the limitations of the review.
- **Discussion:** A discussion of the findings and their implications.
- **Conclusion and Future Work:** The key findings and suggestions for future research.

The provided framework intends to thoroughly evaluate how gamification contributes to the promotion of physical activity, pinpointing areas where current research is lacking and proposing potential future paths for exploration.

## II. THEORETICAL BACKGROUND

Gamification is a concept that draws inspiration from motivational psychology and seeks to leverage both intrinsic and extrinsic motivators. Incorporating game elements into a non-game intervention stimulates user participation in specific activities. Intrinsic motivation is driven by an individual's internal desires, such as the innate urge to explore, learn, and derive pleasure from the activity. This form of motivation enables self-regulation, as individuals are guided by their interests without needing external rewards [21]. On the other hand, extrinsic motivation is characterized by the pursuit of external rewards like financial incentives or social recognition [22]. Self-determination theory has provided valuable insights into these motivational aspects. This theory posits that the psychological needs for autonomy, competence, and relatedness are fundamental to enhancing motivation and, by

extension, well-being [23]. Within this framework, autonomy relates to individual control over actions, competence focuses on the individual's effectiveness in their pursuits, and relatedness involves feeling supported and connected to others [24], [25]. Game elements have been extensively studied in the context of gamification, offering insights into how game mechanisms can boost motivation and engagement [26], [20].

Gamification has the potential to impact users' experiences in numerous ways, with one of the most noteworthy being the flow experience [27]. Flow experience stems from psychology and refers to a mental state where individuals become fully absorbed in an activity that they lose awareness of time passing and external distractions [28]. In order to achieve a state of flow, certain conditions must be met. There needs to be an appropriate level of challenge that aligns with the individual's skill level. This balance ensures that the person remains engaged in the activity without feeling bored or overwhelmed [29]. Using gamified interventions is crucial in attaining and sustaining the state of flow. These interventions are emphasized due to the various elements present, such as points, badges, leaderboards, and challenges. Each element is designed specifically to maintain user engagement. With advancements in game engines, these interventions have evolved further by dynamically adjusting to challenge levels and providing immediate rewards. Ensuring that participants stay fully engaged and motivated throughout their experience, making the gamified intervention more enjoyable and effective [30], [31].

In the realm of gamification, game elements such as badges, progress bars, and levels are not merely decorative features but vital motivational tools. These elements serve to inspire users, compelling them to engage more deeply with the activity and work steadily towards accomplishing a goal [14], [32]. This motivational structure is intrinsically goal-oriented. It provides users with a roadmap, offering clear objectives to pursue or granting them the freedom to set their own goals [33]. The adoption of a goal-oriented approach is backed by the widely recognized goal-setting theory, which posits that specific and challenging goals can substantially improve performance and motivation [34], [35]. The goal-setting theory has been effectively deployed for over two decades to enhance outcomes in work-related tasks [33]. Several principles must be observed to maximize the effectiveness of goals within a gamified environment. Firstly, the goals should be explicit and well-defined to remove ambiguity. Secondly, they should be sufficiently challenging to engage the users. Thirdly, these goals should resonate with the users' interests or aspirations to ensure acceptance. Fourthly, continuous feedback mechanisms must be in place to keep the users informed about their progress. Lastly, an optimal level of complexity should be maintained to keep users intrigued and prevent disengagement [36]. It is important to note that game elements are routinely utilized to implement these principles effectively. For instance, badges and levels act as unmistakable indicators of progress, rewarding the user and providing motivation. Progress bars, on the other hand, offer real-time feedback, enabling users to gauge their advancement toward set objectives [37], [38].

Motivating users is a common objective in gamification, and one concept that enriches our understanding of motivation is self-efficacy [39], [40]. Self-efficacy refers to an individual's

belief in their capability to successfully complete specific tasks or achieve particular goals. This belief significantly contributes to encouraging and sustaining positive behaviors, especially within health-related contexts. When individuals have a strong sense of self-efficacy, they are more willing to take on challenges and develop strategies for overcoming them. Their confidence in their abilities inspires them to tackle complex tasks with focus and resilience, even in the face of obstacles [41]. Importantly, self-efficacy goes beyond just the skills needed for task completion; it also includes an individual's conviction in their ability to successfully perform the task [42]. The theory provides individuals with a framework for what they can potentially achieve, irrespective of their current skill level or perception [35]. Gamification often employs game elements such as levels, badges, and progress bars to foster self-efficacy. Research has shown that setting both short-term and long-term goals within a gamified system can significantly enhance an individual's self-efficacy [43]. Such game elements offer users a tangible measure of their progress, bolstering their confidence and spurring them to continue participating in the gamified experience [44].

Achievement goal theory provides essential insights into how game elements can effectively motivate users [45]. Achievement goal theory differentiates between two primary types of goal orientation: mastery-approach and performance-approach [46], [47], [48]. The former prioritizes skill development and focuses on avoiding failure, while the latter is more concerned with self-esteem and demonstrating ability relative to others, all while steering clear of perceived incompetence. By employing achievement goal theory, designers of gamified interventions can better understand and target the unique motivational needs of different users. One practical application of achievement goal theory in gamification is the customization of interventions to align with a user's specific goal orientation. Game elements such as badges, feedback, and challenges can be adapted to foster a sense of achievement, tailored to mastery or performance-approach orientations [49]. Goal customization enhances the motivational aspects of gamified experiences, making them more effective and engaging. Furthermore, understanding achievement goal theory can help recognize factors that might negatively impact intrinsic motivation [50]. For example, excessive focus on social comparison, particularly among individuals with performance-avoidance goals, can be detrimental. In such instances, gamified intervention designers often employ leaderboards and other game elements cautiously to encourage competence without fueling harmful social comparisons [50].

Social comparison theory suggests that individuals have an innate tendency to gauge their opinions and abilities by contrasting them with those of others [51]. Social comparison framework allows people to validate their perception of reality and serves as a basis for self-evaluation [52]. In the context of gamification, leaderboards serve as a practical tool that enables this form of social comparison. Leaderboards, which prominently display the performance and ranks of participants, serve as tangible representations of social comparison in gamified environments [53]. Game elements encourage individuals to evaluate or enhance specific aspects of their abilities through comparison, particularly with others they deem similar. However, the utility of leaderboards

and other status-indicating elements is nuanced. Research has indicated that such features can have a dual impact: either boost or hinder motivation and performance [54], [55].

### III. LITERATURE REVIEW

The purpose of this literature review is to explore the potential of gamification as a tool to promote physical activity. The focus is primarily on empirical studies published in peer-reviewed journals. This exploration will shed light on the existing evidence and indicate areas that require further research.

#### A. Step 1: Previous Literature

The increasing interest in gamified interventions, specifically in the context of physical activity interventions, has opened up avenues for research and academic exploration. A comprehensive study evaluated the impact of gamified interventions on physical activity and sedentary behavior [56]. Through an analysis of 16 randomized controlled trials, the results indicated that gamification had a small to medium effect on modifying physical activity behavior. These interventions were found to be more effective compared to control groups without gamified approaches. However, it was also observed that the long-term sustainability of these behavioral changes posed a challenge, as they tended to diminish over time. The study emphasized the need for standardized methodologies and further research in addressing sedentary behaviors alongside physical activity interventions.

The effectiveness of longitudinal Active Video Game interventions in maintaining increased physical activity levels was examined by [57]. Their review included 25 studies and highlighted the role of AVGs in promoting a moderate increase in overall physical activity. Consistent with previous research, their findings emphasized the inconsistencies in methodologies and called for more standardized approaches. The study also recommended further exploration of long-term effects and complexities involved in AVG interventions, indicating a need to revisit and improve research strategies.

On the other hand, another study examined the different aspects of gamification implemented in interventions and their resulting effects [58]. The research involved a thorough analysis of 16 studies, all of which emphasized the effectiveness of gamification in promoting physical activity. Key elements such as points, feedback systems, leaderboards, and challenges were found to significantly influence positive behavioral changes. However, limitations such as age group exclusions and the need for stronger research methods were identified by this study.

Another study explored the design features of gamified fitness tracker apps [59]. By examining 103 different applications, they discovered that certain game elements, such as goals, social influences, and challenges, were prevalent in these apps. However, their findings indicated that there is room for innovation by combining different game mechanics to create more captivating and impactful fitness applications.

The importance of incorporating gamification in health and well-being applications was discussed in a recent study [60]. Through a comprehensive review of 19 papers, the

researchers found that gamification does have a positive impact on health-related behaviors, but the level of empirical evidence supporting its benefits is moderate. The study calls for further high-quality research to determine the effectiveness of gamification across different outcomes.

The existing literature presents a positive yet complex depiction of gamified interventions. The clear advantages are undeniable; however, there remain uncertainties surrounding long-term effects, varying research approaches, and unexplored areas. This review aims to explore the potential of gamification in promoting physical activity by analyzing empirical studies published in peer-reviewed journals. By doing so, it offers a more nuanced interpretation of gamified interventions.

### B. Step 2: Database Search

An extensive search was carried out using the Scopus database to conduct a comprehensive search on the implementation of gamification in physical activity. The Scopus database was chosen for its reputation as a reliable source of high-quality, peer-reviewed articles covering various disciplines. A systematic and well-structured strategy was employed to filter through the Scopus database. Specific parameters revolved around gamification's influence on physical activity to ensure the search was both targeted and exhaustive. The search was conducted using keywords such as "gamif\*" which encompassed variations like "gamification" and "gamified" in addition to terms like "fitness," "physical activity," and "exercise". The selection of these keywords was done diligently, ensuring a balance between including relevant studies and maintaining a strong alignment with the objective of this review.

### C. Step 3: Focused Result

The systematic search was conducted on 09/2022 and yielded 1347 records from the Scopus database. During Stage 2, this number decreased to 676 after excluding duplicates, conference papers, and books. Subsequent date restrictions were implemented in Stage 3, resulting in 338 records. In Stage 4, articles written in languages other than English were eliminated, leaving behind 212 records. During the initial screening process, titles and abstracts were carefully reviewed. At the end of Stage 5, 153 articles were excluded for various reasons, such as unavailability for download or needing to be empirical studies. As a result, there were 59 remaining records after this selection process was completed. During Stage 6, a comprehensive evaluation of the full-text documents was conducted. Forty-three articles were excluded as they needed to meet certain criteria, such as having study populations below 18 years of age or failing to adhere to the specified framework stating that motivational affordance leads to psychological and behavioral outcomes [61]. After this thorough assessment, only sixteen records remained for further consideration. In the end, only 12 records remained after excluding educational articles. These remaining articles were carefully selected to ensure that only the most relevant and reliable findings could contribute to understanding how gamification can promote physical activity. (See Fig. 1).

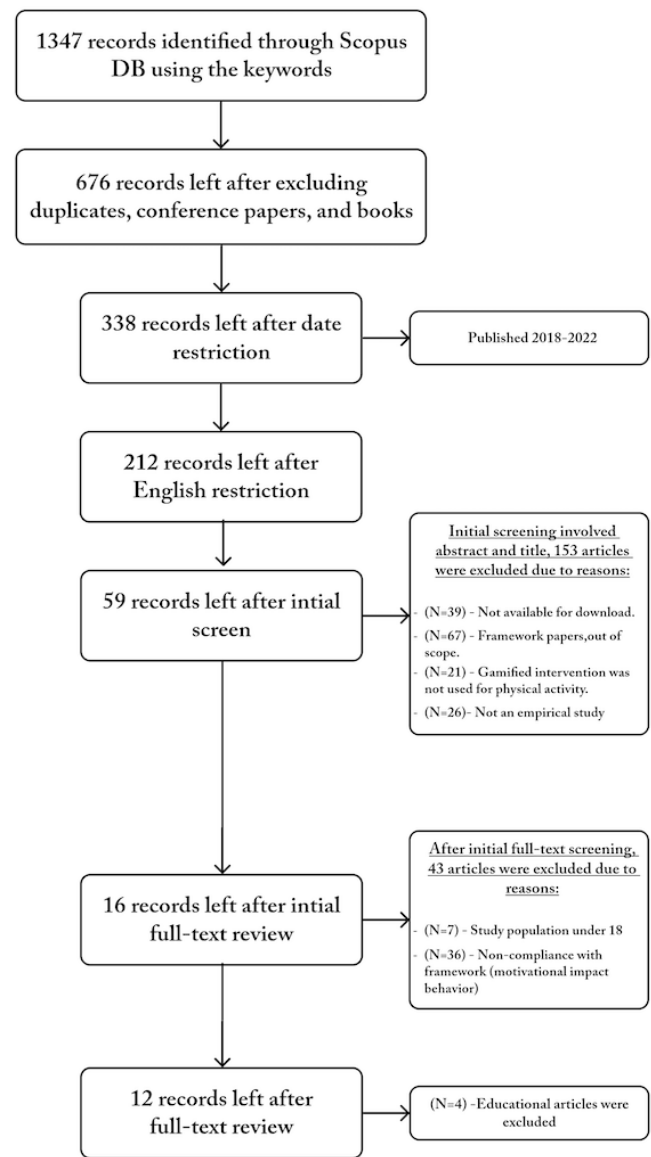


Fig. 1. Flowchart of the review process.

### D. Step 4: Analysis and Categorization

To effectively assess the impact of gamification on physical activity, this study considers six key aspects:

- 1) Types of Physical Activity: The analysis includes different sorts of exercises.
- 2) Technological Platforms: The research examines the types of technology used, such as mobile apps or wearables.
- 3) Motivational Elements: Key gamification elements like badges, leaderboards, and stories are given priority to find out what motivates users the most.
- 4) Psychological and Behavioral Outcomes: The review assesses the impact of interventions that incorporate gamification on psychological and behavioral aspects.
- 5) Incentive Mechanisms: Both tangible and intangible rewards are evaluated to gauge their role in user engagement.

- 6) Reported Outcomes: The review also considers the tangible results from the studies analyzed.

This focused examination helps in understanding not only the current state of the field but also offers directions for future studies.

#### E. Types of Physical Activity

In the reviewed studies, walking emerged as the dominant focus, with 9 out of 12 studies aiming to boost daily step counts [62], [63], [64], [65], [66], [67], [68], [69], [70]. Other activities that have been gamified include cardio, 2 out of 12, have allowed the users to choose from a wide range of activities, such as running and swimming, which is a popular approach used in the market by companies like Fitbit and Apple [71], [72]. Finally, one study has adopted cycling as the physical activity of interest to investigate the long-term effectiveness of gamification in physical activity interventions [73] (See Fig. 2). The analyzed studies tended to rely on increasing step counts, distance traveled, and other cardio-related metrics as the main outcomes of interest. The means of collecting the data were also quite different across the studies. Some of the studies relied on in-device sensors such as accelerometers and pedometers, which are popular among the current wearables and phones. Other studies have relied on self-reported data assessed online or through a paper application.

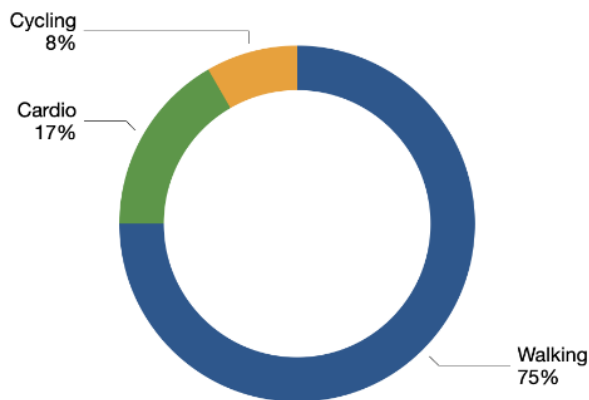


Fig. 2. Type of physical activity measured.

#### F. Technological Platforms

The reviewed studies employed varying systems for gamification interventions. These systems were categorized in terms of the utilization of an existing system, such as WeChat, Playpluse, and Way to Health, to gamify physical activities. Likewise included in this category was the utilization of technology to create a new system, such as through building games or fitness trackers to promote physical activity. While

the majority of the studies, 7 out of 12, have utilized the technology to create a custom system for the purpose of the study [62], [65], [66], [67], [69], [71], [72]. 5 out of 12, have utilized existing platforms and services to gamify physical activities [64], [63], [68], [70], [73]. Most of the analyzed studies utilized technology in the form of a watch as an extension of the system deployed [62], [65], [64], [63], [66], [67], [68], [71], [72], [73]. Others relied on phones to feed the system data related to the user's physical activity [69], [70] (See Fig. 3). Most studies that were analyzed have created their custom system, which gave them advantages when designing the gamification interventions. It allowed them to tailor the experience to the needs of the target population. This precision maximizes motivation and engagement with the game or activity. Also, it allowed for better integration of the system with other aspects of users' lives, such as social media and work-life balance. Ultimately, it allowed for better tracking and monitoring of user data, which can provide valuable insights for researchers.

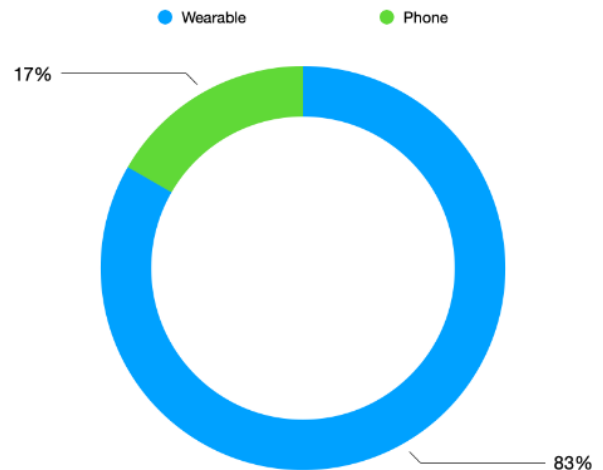


Fig. 3. System used.

#### G. Motivational Elements

In the reviewed studies, points were featured in 9 out of the 12 examined studies [62], [65], [64], [63], [66], [69], [70], [71], [72]. Points are generally awarded for completing certain tasks or goals and can be redeemed for rewards. They provide a sense of progress to users and can help keep them engaged in the game or activity. The progress bar is the second most popular motivational element used in the studies. It was used in 5 out of 12 studies as a way to motivate individuals to be physically active, and within those studies, it was often paired with points or other elements [62], [69], [71], [72], [73]. The progress bar is an indicator of the percentage of completion of a task or goal. It represents how close users are to earning rewards or reaching a milestone. Challenges are the third motivational element used in the studies. It was used in 4 out of 12 studies as a mechanism to encourage

individuals to be physically active, and within those studies, it was often paired with points or other elements [62], [67], [71], [72]. Challenges are tasks or goals one must complete to gain rewards or reach milestones. Levels are the fourth motivational element used in the studies. It was found in 4 out of 12 studies to encourage physical activity [65], [64], [63], [70]. Levels are milestones one must reach by accumulating a certain number of points or completing a specific challenge (e.g., completing three tasks on Level 1 unlocks Level 2). The leaderboard is the fifth motivational element used in the studies and was found in 3 out of 12 studies as a way to encourage individuals to be physically active [62], [66], [71]. It ranks users based on their progress toward reaching certain goals or milestones. Feedback is the sixth motivational element used in the studies and was found in 3 out of 12 studies to motivate individuals to be physically active [65], [63], [70]. It is a mechanism to help users make sense of their progress and give them insight into how they can improve. Competition is the seventh motivational element used in the studies and was found in 3 out of 12 studies to motivate individuals to be physically active [63], [68], [69]. It is a technique developed to encourage users to outperform their peers by beating them at certain tasks or goals, which can be facilitated by different game elements such as leaderboards, points, and a progress bar. Rewards are the eighth motivational element used in the studies, which was found in 3 out of 12 studies to motivate individuals to be physically active [62], [68], [71]. Rewards can be tangible or intangible and can be given once a particular task, goal, or milestone is completed. They can be given for each task or goal accomplished based on cumulative points (See Fig. 4). It is worth noting that only a few studies comment on the underlying mechanism of the game elements they employed, with most focusing more on the outcomes rather than the actual design process.

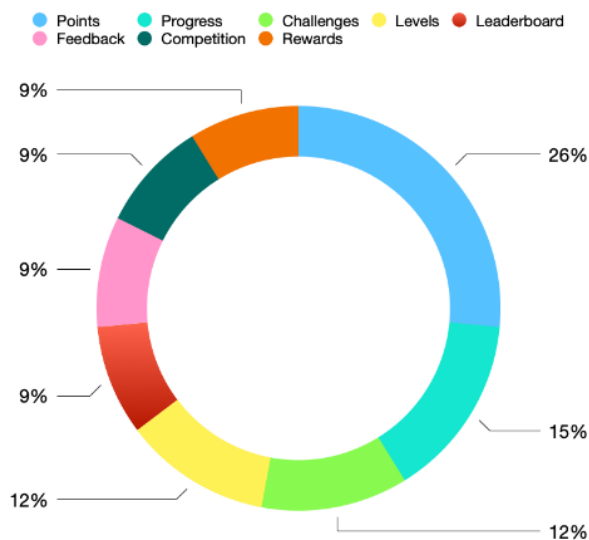


Fig. 4. Game elements used.

## H. Psychological and Behavioral Outcomes

The review also encompassed the categorization of outcomes into behavioral and psychological dimensions. Behavioral outcomes in physical activities can be easily measured with activity time, distance traveled, number of steps taken, and calories burned. These results are beneficial because they provide concrete evidence of the positive effects of the game elements on users' physical activity. Psychological outcomes are subjective outcomes that are more challenging to measure, such as users' self-esteem, level of satisfaction, improved mood, reduced stress, and self-confidence. However, they are also important outcomes because they help us determine how much users were motivated by the game elements to be active, how enjoyable it was for them, and whether or not they will continue engaging in physical activity. Overall, the studies we analyzed measured only the behavioral outcome of the game elements' effect on physical activity via various sensors such as pedometers, GPS, and accelerometers or via self-reported measures [62], [65], [64], [63], [66], [67], [68], [69], [70], [71], [72], [73]. The studies did not discuss the psychological outcomes that could provide insight into the users' attitudes and beliefs in relation to being physically active.

### I. Incentive Mechanisms

In the review studies, incentives or rewards were examined and categorized as either tangible or intangible. Tangible incentives, which consist of monetary or material rewards, were employed in 5 out of 12 studies [62], [65], [64], [69], [70]. Intangible incentives, such as points and badges, were utilized in 7 out of 12 studies [63], [66], [67], [68], [71], [72], [73]. The preponderance of intangible rewards is attributable to their lower cost and ease of implementation, as they do not necessitate additional financial resources. However, it is crucial to recognize the potential downsides of tangible rewards. Among the studies utilizing tangible rewards, 40% reported that these failed to maintain engagement in follow-up periods, while 20% did not evaluate long-term impacts. The remaining 40% observed enduring positive effects, potentially due to the intermittent provision of rewards until the study's conclusion (See Fig. 5).

### J. Reported Outcomes

The outcomes of the studies were closely reviewed, revealing that 33% of the analyzed papers focused on participants who were overweight or obese [64], [63], [66], [70]. This could be due to the fact that researchers usually use this population as a proxy for participants with low levels of physical activity, which is a limitation of the existing studies. However, this could also be explained by researchers' intentions to help people who are more likely to suffer from health problems due to their being inactive. In addition, we found that 58% of the studies did not have a follow-up period. The lack of a follow-up period is likely due to the difficulty in getting participants to return for a follow-up session. Even if researchers can get participants to complete the follow-up session, it may only be for a short period, making it difficult to discern how effective the intervention was in the long term. However, one study was the exception, which investigated the impact of their intervention over two





Fig. 5. Long-term effect of tangible rewards.

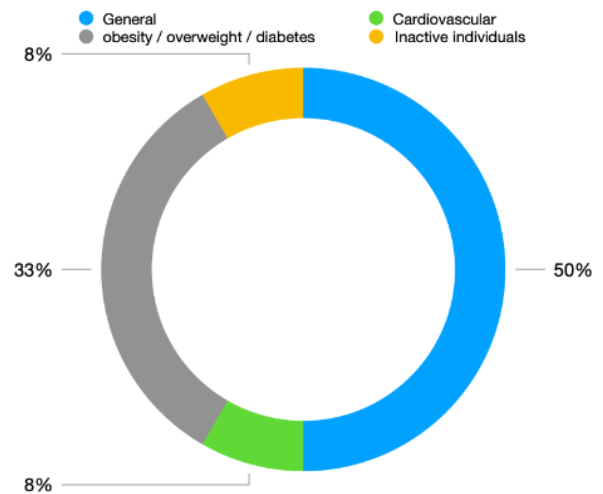


Fig. 6. Participant characteristics.

years [69]. They designed the game to have a challenge at six-week intervals, which can encourage participants to join for one interval and then stop and rejoin the next interval. Furthermore, it is critical to recognize that in the exceptional study, financial rewards were periodically given to participants to maintain the intervention's impact over an extended duration, which could clarify the intervention's sustainability(See Fig. 6). Regarding short-term, the results were classified into two categories in the analyzed studies: positive and no effects. Positive results can be determined by the game elements' effect on behavioral outcomes, whereas a lack of behavioral outcomes change indicates no effects. As reported in the 3.4 section, none of the studies measured the psychological outcomes that could provide insight into how the game elements may have influenced users' attitudes and beliefs in relation to physical activity. Therefore, we could not determine whether the psychological outcomes were positive or negative. Out of 12 studies that measured behavioral outcomes, four reported no effects [63], [70], [71], [73], and eight reported positive effects [62], [65], [64], [66], [67], [68], [69], [72]. Overall, the reported results of the studies indicate that using game elements to promote physical activity can lead to positive outcomes for participants. While some studies did not report any effects, the preponderance of evidence supports positive outcomes, indicating that this method could stimulate individuals to increase their physical activity. To ensure the long-term sustainability of physical activity interventions that incorporate game elements, researchers must measure the psychological impact of such interventions. By doing so, a better understanding of the long-term effects can be obtained, which can help maintain individuals' motivation to remain physically active over time.

#### IV. LIMITATIONS AND SHORTCOMINGS

In the review of the existing literature, several limitations and shortcomings in the approach become apparent. First,

the context of this review was limited to physical activity interventions incorporating gamification elements. However, the results may not be generalized to other contexts and areas. Additional reviews in varying fields like mental well-being are advised for a more comprehensive understanding of gamification's influence on physical activity. Second, due to a lack of empirical evidence, the analysis did not involve theoretical frameworks, which may help to understand the findings of this review better. Other theories and frameworks may provide further insight into how game elements influence physical activity. Third, linguistic constraints are evident as the focus was solely on English-language articles. This limitation potentially omits valuable research published in other languages. Fourth, for quality assurance, only articles from peer-reviewed journals were considered. This criterion excludes other types of scholarly work, such as reports or theses, thus narrowing the review's breadth. Fifth, the review is exclusive to studies targeting adults 18 years of age or older due to their unique psychological characteristics. Hence, the findings may not be applicable to younger demographics, including adolescents and children. Sixth, accessibility issues arise due to the utilization of articles available through Iowa State University Library's Scopus database license. Articles inaccessible through this source may exist but were excluded from the present study. Ultimately, the examination is constrained by time and focuses solely on articles that have been published in the past five years. This means that valuable older research may be disregarded despite its potential significance. Though this review has acknowledged its limitations, it serves as a foundational study that explores the potential of gamification as a tool to promote physical activity.

#### V. DISCUSSION

By analyzing the studies, the review brings forth important findings regarding various aspects such as the different types of

physical activities conducted, technological platforms utilized, motivational factors involved, psychological and behavioral results, incentive strategies employed, and reported outcomes. The review of existing literature indicates that current gamified interventions mainly concentrate on step counts as a parameter for measuring physical activity [62], [63], [64], [65], [66], [67], [68], [69], [70]. The narrow focus on step counts suggests that other types of physical activities still need to be thoroughly investigated. Although step counting is convenient, the step count approach has its limitations. The step count approach may not comprehensively assess an individual's overall activity level, particularly if step-tracking devices are not consistently used. Additionally, relying solely on step counts may not be the most effective way to achieve optimal calorie expenditure or overall health benefits through exercise. Accordingly, the reviewed studies revealed that technological platforms can influence the effectiveness of gamification interventions. The reviewed studies have shown a preference for wearable devices over smartphones in the gamified interventions [62], [65], [64], [63], [66], [67], [68], [71], [72], [73]. While the findings overall were positive, highlighting the effectiveness of game elements in short-term physical activity promotion, they were not without limitations. Moreover, to effectively promote long-term physical activity, it is crucial to have a comprehensive understanding of the psychological processes underlying behavioral metrics. Furthermore, It is worth noting that while tangible rewards can be effective in motivating individuals, they also have the potential to negatively impact intrinsic motivation over time. Therefore, gamified interventions should carefully consider a balanced approach. Lastly, although the reviewed studies did not incorporate advanced technologies such as artificial intelligence or machine learning models, their integration could provide promising opportunities to personalize gamification features. By using artificial intelligence or machine learning models, dynamic and personalized challenges could be created, resulting in increased user engagement and overall effectiveness of the gamified intervention.

## VI. CONCLUSION AND FUTURE WORK

The current state of gamification within physical activity interventions is still in its nascent stages, and further development is necessary. The existing literature reveals limitations, especially when relying on constant positive reinforcement and motivation. Such strategies eventually deplete the will to continue and blunt sensitivity to rewards. To create more sustainable interventions, learning from digital game design is essential, particularly regarding reward systems. Emphasis should also be on the strategic deployment of both positive and negative feedback mechanisms to sustain user engagement. The future of this field could benefit greatly from the incorporation of artificial intelligence and computer vision models, not only for optimizing difficulty and rewards but also for tracking various metrics. In terms of the types of physical activities considered, most studies primarily target metrics related to cardio exercises like step counts and distance traveled. These studies often employ in-device sensors, such as accelerometers and pedometers, or rely on self-reported data collected either online or via paper applications. This suggests an opportunity for broadening the scope of research to include activities like weightlifting and

other forms of resistance training using a computer vision model to monitor the progress. Moreover, the studies largely bypass any discussion of psychological outcomes. Attitudinal and belief systems related to physical activity offer invaluable insights and should be incorporated into future research efforts. These metrics can help inform the creation of interventions that are not only physically effective but also psychologically motivating.

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## DISCLOSURE OF INTEREST

The authors report there are no competing interests to declare.

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