Gamification of physical activity: A systematic literature review of comparison studies

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Abstract. Gamification is commonly implemented with the goal of transforming activities, systems and services to afford similar experiences and motivational support as games do. In health and exercise contexts, the motivational support drawn from games is considered to encourage performing these activities that commonly lack motivation. However, an empirically rigorous body of literature examining the effects of gamification has been lacking. This is especially problematic in health contexts where unfounded claims can have detrimental effects.

This systematic literature review of 16 comparison studies on gamification of physical activity examines what kinds of gamification have been studied in the pursuit of which outcomes, and what results the studies have attained. The results show that gamification of physical activity has provided positively oriented results; however, with more rigorous study designs the results are less optimistic. Research is focused on measuring performed physical activity, but mostly relies on self-reported data instead of objective measurement.

Keywords: gamification, physical activity, literature review.

1 Introduction and background

Health and exercise are among the most common contexts for gamification ventures, both in research and in practice [1][18][21]. Gamification refers to transforming activities, systems and services towards affording similar experiences as games are considered to afford [17]. As motivational benefits are perceived to be at the core of games [13][28][35], gamification is commonly employed in contexts where people commonly lack motivation such as education, work and healthcare [21][24][30][43][41][27].

Gamification presents an especially interesting technology in the area of physical activity as games are sometimes perceived to encourage a sedentary lifestyle (see e.g. [29][32][38]). However, there has been an in-flux of location-based games (such as Pokémon Go) [22][25] as well as exergames [32] that further have made gaming relevant in terms of physical health. Beyond physical activity becoming a way to play games, intentional gamification further attempts to adopt the motivational facets of gaming and implementing them into pursuits with direct health outcomes in mind.

However, while gamification has been popularly and academically predicted to be a powerful technology for engagement and behavioral change (e.g. [11]), the field has still lacked an empirically rigorous body of literature examining its effects [21][31][34]. This has especially been the case for the health sciences where the thresholds for scientific rigor in terms of research design can be considered higher than in the transdisciplinary mother fields of game studies [1][18][21][33].

Therefore, this study presents a systematic literature review of existing comparison studies (16 studies) examining the effectiveness of gamification on physical activity-related outcomes. The focus of this review is on studies conducted with adult participants; that include a gameful intervention and a comparative study setting meaning that the intervention results are contrasted to parallel conditions or a baseline measurement; and that report subjective or objective outcomes related to physical activity. The review investigates how gamification of physical activity has been implemented, what outcomes have been addressed with the gameful interventions, and what results have been attained regarding these outcomes.

2 Review procedure

The literature search was conducted in 11/2018 in Scopus, Web of Science, and PubMed databases. The searches were conducted using search terms covering the terminology presented in Table 1. The search strategies presented by Schoeppe et al. [36] were used as reference for physical activity –related search terminology. The specific search strings were formulated according to the search logic of each database, but containing the same terminology. Table 1 also reports the number of records retrieved from each database.

Table 1. Search terms used and amount records received from databases.

Search terms	
gamif* AND health* AND "physical activity" OR walk* OR "physical fitness" OR "physical health" OR "leisure activity" OR "motor activity" OR exercis* OR sport* OR sedentary OR sitting OR inactiv* OR step* OR pedomet* OR acceleromet*	
Database	Number of records retrieved
Scopus (search limited to Title-Abstract-Keywords)	198
Web of Science (searches conducted as Topic searches)	88
Pubmed	70
TOTAL	356

The literature searches resulted in a total of 356 records. After removal of duplicates and records not containing a study (e.g. proceedings books), the remaining 243 records were screened for inclusion based on the predetermined PICOS-criteria (see Table 2). The full literature identification, screening and eligibility evaluation process is reported in Figure 1.

Table 2. Review questions and inclusion criteria (PICOS-criteria).

Review questions	Inclusion criteria
Population	Adults (≥18 years); participant mean age ≥18 years
Intervention	Game or gamification intervention targeting physical activity
Comparisons	No intervention, an active control intervention, baseline measurement, or standard treatment/rehabilitation
Outcomes	Quantitatively measured user-related subjective and objective outcomes
Study design	Quantitative comparison study written in English

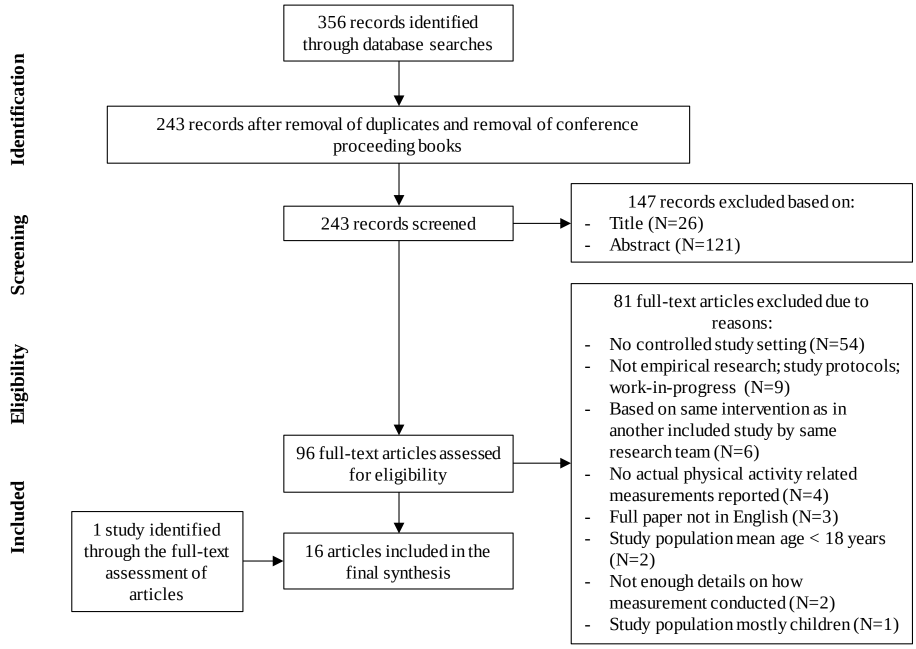

Fig. 1. A flowchart describing the study selection procedure.

After the rigorous screening and eligibility evaluation of titles, abstracts, and finally, full-text articles, 15 studies were identified as eligible for the final synthesis. In addition, one record was identified based on a reference in another full-text article, evaluated as eligible for inclusion, and thus, included to the review. Therefore, the final number of studies included in the synthesis is 16.

The literature selection process was carefully documented using Refworks reference management tool and Microsoft Excel for transparency. The analyses were conducted using the guidelines provided by Webster and Watson [42].The literature selection process and analyses were conducted by the main author.

3 Analysis

A clear majority of the reviewed studies were published in journals (12/16) instead of conferences (4/16).

The gameful interventions for increasing physical activity have mainly relied on the same affordances as the gamification field in general [21][37] (see Table 3). Point-based mechanics and activity goals were identified in half of the reviewed studies, accompanied often with performance rankings and visualizations of one's performance. Interestingly, the health gamification field has also included collaboration-based mechanics in their interventions as indicated by the high frequency of teams as a gameful affordance. Noteworthy, however, are also the less common but innovative affordances included in the studies, for example, real-world activity, e.g. steps, being transformed into a game currency in a virtual world [40], and social contracts and duel competitions between individuals for engaging individuals in physical activity [39].

Table 3. Affordances included in the reviewed studies.

Affordance	Studies including	Freq.
Points, score	[2][5][7][8][16][23][39][44]	8
Goals	[7][8][9][16][23][26][39][44]	8
Leaderboard	[2][7][14][40][44]	5
Progress visualization	[5][7][16][26][39]	5
Teams, leagues	[8][14][16][23][26]	5
Virtual rewards	[2][14][26][39]	4
Full game, thus affordances not identified	[3][4][12][19]	4
Badges	[2][5][7]	3
Messaging with users/team/clinician	[5][8][26]	3
Levels	[7][23][39]	3
Team progress visualization	[8][16][26]	3
Quizzes	[2][7]	2
Real-world rewards	[2][16]	2
Challenges	[7][14]	2
Personalized feedback/messages	[14][39]	2
Virtual losses	[14]	1
Virtual reality (VR) environment	[9]	1
Shadowing (comparing current to earlier performance)	[9]	1
Virtual environment with city building/management	[40]	1
Virtual tracking based on real-world action	[14]	1
Duel-type competitions	[39]	1
Game currency based on steps	[40]	1
Social contracts	[39]	1

Table 4. Outcome measures studied in the reviewed studies.

Outcome measure	Subjective/ objective	Studies including	Freq.
Physical activity*	S	[2][3][7][16][19][26][39][40]	8
Duration of usage, active time etc.*	O	[4][12][14][44]	4
Physical activity/performance*	O	[5][14][23][44]	4
Engagement/adherence with app/solution	O	[8][26][44]	3
Knowledge related to condition, health, physical activity etc.	S	[2][7]	2
Energy expenditure*	O	[4][12]	2
Enjoyment of physical activity	S	[12][40]	2
Healthcare utilization	S	[2]	1
Medication overuse	S	[2]	1
Empowerment	S	[2]	1
Perceived benefits of game on health	S	[3]	1
Perceived exertion*	S	[4]	1
Affect	S	[4]	1
Duration of activity*	S	[19]	1
Messaging within service	O	[5]	1
Self-efficacy	S	[7]	1
Glycated hemoglobin (HbA1c) levels*	O	[8]	1
Expired gases*	O	[9]	1
Oxygen uptake capacity*	O	[9]	1
Intrinsic motivation	S	[9]	1
Subjective vitality	S	[9]	1
Future exercise intentions	S	[9]	1
Heart rate*	O	[12]	1
Perception of game	S	[14]	1
Outdoor time	S	[19]	1
Weight data*	O	[23]	1
Quality of life	S	[26]	1
Gaming motivation	S	[19]	1

*Measurement related to actual physical activity or actual physical outcomes

Most of the reviewed studies focused on physical activity or the duration of the activity as the outcome measure of the intervention (see Table 4). Half of the reviewed studies were mainly based on subjectively and half on objectively measured data. The most commonly used self-reported measurement instrument in the reviewed literature was the International Physical Activity Questionnaire (IPAQ) [6]. Objectively measured data was in most cases retrieved from an app or an activity tracker tool, e.g. FitBit, used in the intervention.

In total, only 11 outcome measurements of the total 28 were related to the actual physical activity or actual physical outcomes. Rest of the outcomes were either other health-related behavioral or psychological measurements, or behavioral or perception measurements related to the solution used in the intervention. A clear majority of the outcomes have been studied only in one study each.

Details of the study designs are reported in Table 5. 10 out of the 16 studies were randomized controlled trials (RCT), 3 studies reported a partially randomized study design, and 3 were categorized as comparison studies without an actual experimental setting. Only one of the RCT studies was reported to be fully blinded, while 4 studies reported single-blinded or partially blinded designs. The remaining RCT studies provided no information about blinding procedures with the exception of one study stating that the setting was not blinded.

8 of the 16 studies reported either fully or partially positive results from the gameful interventions related to the physical health outcomes. However, 7 of the 16 studies reported that the gameful intervention did not show statistically significant improvements compared to the comparison conditions or report equally positive and negative results regarding the effects of the gameful intervention on physical activity –related outcomes.

Table 5 reports also the study designs regarding the comparison. The analysis suggests that the studies with more rigorous study designs, i.e. fully controlled settings, have less positive results regarding the physical activity –related outcomes than study settings with baseline measurements as comparisons. Furthermore, in four studies the intervention was a full commercial game and thus individual affordances were not identified or studied.

4 Discussion

This systematic review focused on examining how gamification has been implemented for the goal of increasing physical activity, what outcomes this body of literature has examined, and finally, what kinds of results the comparison studies on gamification physical activity have attained. Only 16 comparison studies were identified for the review, which is surprising given the prevalence of gamification in physical activity [21].

The affordances implemented in the gameful interventions for increasing physical activity have followed the common patterns identified in gamification literature in general [21][37]. Points and leaderboards are the most common elements implemented alongside goals and progress visualization tools. Goals concretize the target behavior, progress visualizations provide support and indicators of progression toward the health goal, and points act as a virtual reward for the target behavior. Interestingly, for example, collaborative affordances were quite often implemented within the body of literature [8][14][16][23][26][39], which is not such a common approach within the gamification research field in general [21].

Table 5. Study details.

	Intervention	Study participants	N[1]	Timeframe	Study design	Intervention compared to	Results[2]
[2]	Developed web-based intervention for rheumatoid arthritis patients	Rheumatoid arthritis patients Mean age 57.95, SD 12.29 54.2% male, 45.8% female	155	4 months	Randomized controlled trial, single-blinded study design	Control group without access to intervention	Fully +
[3]	Pokémon Go	Players of Pokémon Go Player mean age 26.8, SD 8.2 193 males, 265 females, 3 transgenders	461 (baseline)	3 months	Comparison study with a repeated measures design	Non-players of Pokémon Go	Null or equal +/-
[4]	Dance Central game for Xbox Kinect	Students and university staff Mean age 26.5, SD 7.1 56.8% male	44	1 session	Randomized controlled trial; no information on blinding	Control group with same intervention, primed as non-game	Partial -
[5]	Developed mobile fitness application that connects to FitBit	Students and university staff Age mainly 20-30 years 15 males, 21 females	36	10 days	Randomized controlled repeated measures study; no information on blinding	Baseline measurement	Fully +
[7]	Developed app for promotion of physical activity connected to FitBit	Healthy employees Age ≤ 35 30%; 36 to 45 30%; ≥ 46 40% in IG 61.3% male in IG	144	6 weeks	Randomized controlled trial, no information on blinding	Control group without access to intervention	Partial +
[8]	Developed mHealth tool connected to FitBit	Veterans with type 2 diabetes Mean age 67.56, SD 5.81 26 males, 3 females (of initial 29 participants)	27	13 weeks	Randomized controlled trial, not blinded	Standard care for type 2 diabetes patients	Partial +
[9]	VR-solution for a HIIT cycling exercise	Sedentary or recreationally active adults Mean age 22, SD 4 8 males, 8 females	16	4 sessions	Partially randomized cross-over study (order of sets randomized), no information on blinding	Non-gamified VR ergometry as control measurement	Partial +
[12]	Experimental games for a stationary bike and a rowing machine	Fitness center customers Mean age 31.5 9 males, 15 females	24	1 session	Partially randomized cross-over study (order of exercises randomized), no information on blinding	Control measurement without games	Partial +

[14]	Developed mobile health game used with FitBit	Sedentary office workers Mean age 40,6. SD 11,7 in IG 79.2% female in IG	144	10 weeks	Randomized controlled trial, at least partially blinded	Control group using FitBit only	Null or equal +/-
[16]	Developed location-based game with an online platform for self-reporting physical activity	Town residents 62,6% over 18 years 38.0% of participants male	329	7 days	Comparison study	Baseline measurement before intervention	Fully +
[19]	Pokémon Go	Pokémon Go players Mean age 23.4, SD 5.88 50.75% male, 49.3% female	444	6 weeks	Comparison study	Baseline measurement	Fully +
[23]	Developed research platform used alongside Withings scale and Withings app.	Overweight adults Mean age 41.4 85.7% of participants female	196	36 weeks	Randomized, controlled trial, fully blinded study design.	Control group without access to intervention	Null or equal +/-
[26]	Developed physical activity intervention delivered via a Facebook app	Insufficiently active adults Age 18 to <25 23.6%; 25 to <35 29.1%; 35 to <45 26.4%; 45 to 65 17.3% 70.9% female	110	20 weeks	Randomized controlled trial, single-blinded study design	Control group having teams and health monitoring, no access to intervention	Null or equal +/-
[39]	Developed online, interactive physical activity tool	Healthy adults Mean age 55.3, SD 11.2; 11 males, 10 females	21	3 months	Randomized controlled trial, single-blinded study design	Control group without access to intervention	Null or equal +/-
[40]	Developed web-based social game connected to Fitbit	Adults Mean age 37.7, SD 10.18 17 male, 44 females (of initial survey respondents)	50	30 days	Partially randomized repeated measures study (order of conditions randomized), no information on blinding	Control group using FitBit only	Null or equal +/-
[44]	Developed prototype promoting active walking	Undergraduate communications students Mean age 23.39, SD 1.40 44 females, 15 males,	59	10 days	Randomized controlled trial, no information on blinding	Control using quantified version of the app without gamification	Null or equal +/-

[1] Both intervention and control groups included in N, if the study was controlled. IG = intervention group, CG = control group.
[2] Fully + = fully positive results, Partial + = partially positive results, Null or equal +/- = no effects or an equal amount of positive and negative results reported, Partial - = partially negative results, Fully - = fully negative results

The gameful interventions studied in the current body of literature mainly included several affordances simultaneously rather than having investigated the effects of singular gamification affordances individually. Thus most of the studies were not able to identify which affordances were more effective than others regarding the physical health –related outcomes. Furthermore, a few studies examined the effects of a full commercial game on physical activity behavior [3][4][12][19]. For example, Broom and Flint [3] and Kaczmarek et al. [19], focused on the effects of Pokémon Go on the physical activity of the users. When the gameful intervention is based on a full game with various features, it is similarly impossible to identify which aspects of the game have lead to the detected results. Thus, studying isolated game elements is encouraged [21]. Similarly, Schoeppe et al. [36] has suggested that the research on health and fitness apps should seek to study effects of singular features in order to identify the effective app features from the ineffective ones.

The analysis of the current body of literature indicates that most of the studies measured performed physical activity as the outcome measurement. However, many of the studies also relied on subjective self-reported data instead of objective measurement. The most commonly implemented self-report measurement instrument for physical activity was the International Physical Activity Questionnaire (IPAQ) [3][7][16][19][40]. While gathering self-reported data is often a more cost-efficient way of data gathering compared to, for example, collecting sensor data, more reliable results would be gained with triangulation of data combining both, subjective and objective measurement.

Previous research on gamification has also identified novelty effects to impact the outcomes of the gamification solutions [20][10][15]. The results presented by Gremaud et al. [14] provide further evidence of the decline of the effects with time. Data triangulation could provide important insights in future research also about reasons for the declining effects.

As shown by the analysis of the outcomes measured in the reviewed literature, the variety of different outcomes is large and many outcomes are examined only in one isolated study. Therefore, the current body of literature still lacks in cumulation of research on the same outcome measures and replication. Previous literature reviews on gamification have suggested that the research field would benefit from seeking to use validated measurement instruments in order to accumulate the knowledge regarding specific outcomes [21].

The results of the reviewed literature provide support for prior findings, that on a general level, the results regarding the effectiveness of gamification on the outcome variables are positively oriented [21]. However, when scrutinizing the results and contrasting them with the study designs in the reviewed papers, the more rigorous study settings seem to provide more neutral results. The fully positive findings have been reported mainly in studies with baseline measurements as comparisons [5][16][19] instead of study settings including a randomized design with control conditions. These findings suggest that gamification of physical activity provides promising results of its effectiveness, but more research with controlled study settings would be needed to substantiate the promises.

Study designs with full randomization and control conditions are especially important in the context of health-related activities to indicate whether the interventions can provide health benefits. The requirements for the study designs are even stricter when examining the benefits of a gameful solution as part of clinical healthcare. For this review, a full quality assessment of the studies was not conducted, mainly because not all of the studies were RCTs. The analysis indicated, however, that the studies lack in e.g. blinding procedures. In order to be able to provide convincing results to justify use of gameful interventions, for example, as part of healthcare practices, the quality of the study setting and designs would benefit from improving. Similar suggestions for study designs have been provided by Schoeppe et al. [36] for research on health and fitness apps.

As noted in literature discussing the development of the research on gamification [24][31][21], it has taken some years for the research field to develop the methodological approaches to include more comparative research designs. Thus, the fact that a literature review focusing solely on comparison studies on gamification of a specific topic can today be conducted can be considered a sign of the maturation of the field.

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