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PHYSICAL ACTIVITY

Autonomous Motivation as a Mechanism of Change in a Gamified Digital Physical Activity Intervention: A Randomized Controlled Trial

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Abstract

University students have been noted to have a drop in their levels of physical activity due to their academic transitions. When it comes to moderate-to-vigorous physical activity (MVPA), digital methods have shown to work inconsistently. This randomized controlled trial aimed to find out if a digital intervention that is gamified promotes more behavioral and motivational changes than a digital intervention that is prompt-based and if statistically motivational changes of an autonomous nature explain the differences. PATHFIT2 students (N=180) from the Philippines were assigned to either a gamified digital intervention or a non-gamified, standard digital intervention for a duration of eight weeks. Both conditions were directed to use MyFitnessPal to log their exercise and were given daily activity prompts. The gamified condition was given additional stimulation in the form of rewards for points, streaks, bonus badges, and leaderboard feedback. At pretest and posttest, MVPA (verified activity logs for MVPA) and motivational regulation (using the BREQ-3) and cardiovascular endurance (3-minute step test), muscular endurance (a push-up test), and body

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mass index were assessed. The mixed-design ANOVA showed significant changes in MVPA over time with the gamified condition resulting in the more pronounced changes (η^2p = .11, d = 0.67). The gamified condition showed significant increases in both identified and intrinsic regulation. Improvement of both cardiovascular and muscular endurance were noted to be more substantial in the gamified condition although the changes in BMI were quite mild. Changes in intrinsic regulation were shown through bootstrapped mediation analyses to statistically account for part of the relationship between intervention condition and MVPA (indirect effect \u03b2 = .15, 95% CI [.07, .27]). This means that gamified digital interventions improve the level of physical activity participants engage in, beyond increasing it through digital prompts, and that alterations in autonomous motivation account for a large portion of the relationship. A university program that includes autonomy-supportive gamification may be an effective and widely applicable method for enhancing participants' behavioral and functional health.

Introduction

Engagement in physical activity means having a regular routine of movement that uses energy and meets the recommended levels of frequency, duration, and intensity (World Health Organization, 2020) of the activity. This is not just exercising, but it is behavioral consistency that helps sustain one's mental and physiological health. Lack of physical activity is correlated to an increased risk of suffering from cardiovascular disease, metabolic disorders, and decline of mental health (Pfisterer et al., 2022). For all the benefits, physical inactivity is still a major risk to health globally (Johannes et al., 2024). Due to academic pressures and sedentary lifestyle, university students especially are at a greater risk of falling activity levels and have a significant number not following the recommended levels of activity (Verma et al., 2022). Physical inactivity has been so common in higher education that it has practically become the norm and more behavioral patterns of this kind are calling for well planned interventions that can adapt to the given context.

A body of international research consistently points out the adjustment to university life as a notably vulnerable behavioral period.

For example, Kwan et al. (2020) illustrated in Canadian longitudinal studies a marked drop in activity as individuals transitioned from secondary school to post-secondary institutions. Similar research conducted in New Zealand documented a change in motivational orientation which resulted in an activity drop (Wilson et al., 2021). Zhang et al. (2022) found large-scale studies conducted in China, and even early years of university, a large number of participants did not even approach the minimum recommended levels of physical activity. Research conducted in Germany documenting increased sedentary behavior and the variable discipline specific increased further suggested that the academic environment has a direct impact on the movement behaviors of individuals (Edelmann et al., 2022). A systematic review from several countries has documented a number of barriers in to exercise in the university age population which includes lack of time, lack of motivation, an unsupportive environment, and a change in behavior or priorities (Brown et al., 2024; Ferreira Silva et al., 2022). Overall, evidence shows physical activity neglect in the university population is not just a lack of knowledge; it is a complex relationship with motivational and physical barriers.

Engagement in varying degrees in physical activity within the higher education system in the Philippines is similarly expressed across regions. In the case of Metro Manila, male students showed more of physical activity as well as higher fitness levels than female students. (Pituk & Cagas, 2019). In Bulacan, motivational orientations are sex-based with males being motivated socially with some level of competition while females have an avoidance health motivation (Tullao, 2025). In Pampanga, the primary motivational barrier related to health and strength development is the perception of poor health and strength coupled with a time and motivational barrier to engagement (Manasan et al., 2023). In Region III, the perception of physical fitness is a significant predictor of health-related behavioral control (Masagca, 2025). There is a need for behavioral structure and motivational quality based interventions as the motivational variability coupled with the contextual constraints is the major determinant of the observed physical activity behavior of the respondents.

Digital health innovations are great ways to solve problems like inactivity among university students. Regular digital approaches that are used in health innovations include things like smartphone

apps, fitness trackers, and text message services. They all work by providing prompts, feedback, and self-monitoring tools. In college students, digital health innovations result in increased step counts and increased overall physical activity levels (Bi et al., 2024; Peng et al., 2023). Due to the text messages, some students increased their physical activity (Smith et al., 2020), while in university students, the overall physical activity increased (Favieri et al., 2023). The increase in these studies was mainly attributed to the increase in step counts, while little was done to increase the amount of time spent in higher levels of physical activity or to sustain the behavior changes in students. Most digital interventions will increase physical activity because they increase routine adherence, but that does mean that they also increase motivation. In higher education in the Philippines, the use of smartphone prompts and digitally delivered low-dose interventions led to students becoming more active and also a positive increase in their academic well-being (Martin, 2026). Though we cannot conclude that was due to the method used, without a control group, we are still unsure if these interventions also helped to increase motivation, or if it was just behavioral compliance.

Gamification of physical activity interventions has shown improvement in activity levels of participants, especially young adults. Elements of games such as leaderboard, tracking, and rewards have shown an increase in average daily steps and moderate physical activity in comparison to non-gamified interventions (Sanudo et al., 2024). When gamified interventions are compared to both active and inactive control groups, they reveal small to moderate improvements in physical activity (Mazeas et al., 2022). Gamified interventions in higher educational institutions have shown considerable improvements in participants' fitness levels and adherence to physical activity guidelines compared to non-gamified educational interventions (Mora-Gonzalez et al., 2020).

This gap within the literature will be drawn on using Self-Determination Theory (SDT) and behavioral self-regulation frameworks. The theory of self-determination suggests that in order for someone to sustain being physically active, the needs of their autonomy, competence, and relatedness needs to be satisfied. Gamified interventions can improve someone's feeling of competence through feedback on their performance, provide them with more autonomy

through the ability to set their own goals, and improve feelings of relatedness through either competition or collaboration. Standard digital interventions, on the other hand, tend to work mainly through self-regulation prompts and self-monitoring, which stop the action/behavior from being initiated and create loops (habits) that are difficult to break, but do very little to improve the quality of a person's intrinsic motivation. Looking at it from the behavioral standpoint, what activity frequency interventions are likely to achieve may be on the basis of motivation, but it is also likely that the internalization of motivation varies. Most interventions are likely to improve behavioral change to some degree, but understanding the mechanisms is important to determine the "why" and "how" for the motivation behind the change. Therefore, this study aims to answer the question, do gamified digital interventions for physical activity lead to an increase in motivation and increase in behavior more than standard digital interventions for physical activity in a university setting? By developing a hypothesis and structure for this study, creating boundaries for behavioral and motivational pathways. The theories of behavioral changes in the digital sector will be advanced, and a foundation will be laid for the university setting to improve active behavior using digital means based on behavior change principles.

Methods

Research Design

This investigation utilized a quantitative randomized controlled trial with a two-group parallel pretest–posttest design to analyze the differing impacts of a gamified digital physical activity intervention versus a standard digital physical activity intervention on motivational regulation and physical activity behavior of university students. The design of randomized controlled trials is considered the gold standard for assessing impact because of the increased internal validity and reduction of systematic allocation bias (Hariton & Locascio, 2018).

Students were randomly assigned within each class to (1) a gamified digital physical activity intervention or (2) a standard digital physical activity intervention through a computer-generated random allocation sequence. One of the research assistants created the sequence to avoid bias from allocation. Randomization was assigned

on an individual basis within a given class to ensure an even distribution across different academic programs and to reduce potential confounding at the program level. Although randomization was not stratified by sex, baseline equivalence testing showed no significant differences in sex distribution across groups. Assignments to groups was done post-baseline assessments to ensure pre-test data was collected prior to any grouping. Lists of intervention groups were given to individual Messenger administrators by group condition to ensure no prior exposure to the intervention.

The trial was not formally preregistered in a public registry. Study hypotheses and analytic approaches were formulated *a priori* and based on Self-Determination Theory and prior digital behaviour change literature. All primary and secondary outcomes detailed correspond to the initially outlined aims of the intervention.

Allocation Concealment and Blinding

The allocation of groups was hidden until baseline data collection was finished. Given the behavioral nature of the intervention, participant blinding was not possible, since participants knew whether they were in a gamified condition or not. Objective assessments of fitness (step test, push-ups, and some anthropometric measurements) were done according to protocols that were not explicitly tied to group assignments. Analysts performed statistical analyses using codes to identify groups (Group A and Group B) and unblinded group identities only after completing primary analyses to reduce any bias.

Respondents and Sampling

The research was carried out in a public higher educational institution located in the Mindanao region of the Philippines. The participants in the study were PATHFIT2 students from the three (3) academic colleges: Computing Studies, Engineering, and Teacher Education.

The academic programs included were: (1) Associate in Computer Technology–Major in Application Development, (2) Associate in Computer Technology–Major in Networking, (3) Mechanical Engineering, (4) Geodetic Engineering, (5) Bachelor of Secondary Education–Major in Social Studies, and (6) Bachelor of Secondary Education–Major in Values Education. Each of the courses had ap-

proximately 30 students making the accessible population approximately $N = 180$.

In each of the courses, students were randomly assigned based on a computer-generated randomization sequence to (1) the gamified intervention group or (2) the conventional digital intervention group, with about 15 students assigned to each group per course. This form of randomization within a course was stratified to ensure even distribution of the intervention conditions across the academic programs and to reduce confounding at the level of the academic program.

The inclusion criteria were that participants had to: (1) be PATHFIT2 students, (2) own a smartphone with the MyFitnessPal application and Facebook Messenger notifications enabled, and (3) provide a written informed consent. Those who had medical conditions that inhibited them from engaging in moderate-intensity physical activity were excluded from the study. Given a total estimated sample size of $N = 180$ (about 90 subjects per group), the study had sufficient power to identify medium effect size differences in mixed-design ANOVA models (Faul et al., 2009). Available sample size was sufficient to conduct mediation analyses as mechanism-oriented tests.

Research Instrument

Physical activity behavior was assessed using two complementary indicators.

Weekly Moderate-to-Vigorous Physical Activity

The main behavioral outcome was measured by the weekly minutes of moderate-to-vigorous physical activity (MVPA) noted by participants in their exercise logs on the MyFitnessPal mobile application over the 8-week intervention period. Participants were asked to log only activities performed above a moderate intensity, which in the public health definition, refers to activities that are likely to cause a noticeable increase in breathing and/or heart rate (World Health Organization, 2020). From the exercise summary reports submitted during the week, minutes of MVPA and the total number of active days were calculated.

Verification and Data Quality Procedures

In order to improve accuracy in self reporting and to mitigate editing entries after the fact, participants were asked to submit screenshots of the activity summary from MyFitnessPal on a weekly basis, using a secure Google Form. Their reporting was evaluated for (1) consistent reporting for MyFitnessPal activity summaries over the weeks of the intervention, (2) plausibility regarding the duration of physical activity that was reported, (3) reporting was evaluated for lack of excessive and suspicious reporting. A reporting activity of over 600 minutes of MVPA was flagged for sensitivity analysis as it would be considered an outlier . Although entries within MyFitnessPal are self-reported, participants are able to self-verify and entry their information so that it provides a background of reporting accuracy and integrity.

Additionally, the International Physical Activity Questionnaire–Short Form (IPAQ-SF) (Craig et al., 2003) was used at the beginning of the intervention and at the end of the intervention, to capture self-reported data regarding physical activity of walking, moderate and vigorous activity levels in the past 7 days. The IPAQ-SF has been shown to possess reliability and validity in various settings. The internal consistency of the instrument in this study was adequate (Cronbach's $\alpha \approx .80$).

Convergent Validity Assessment

The IPAQ-SF was implemented as a convergent behavioral indicator and a means of assessing change consistency against logged MVPA minutes. Agreement denoting both direction and proportion of MyFitnessPal-derived MVPA and IPAQ-SF MVPA provided reassurance that the behavioral changes were due to more than a single measurement modality.

The Motivational Regulation for Physical Activity was evaluated using the BREQ-3. This comprises intrinsic regulation, identified regulation, introjected regulation, external regulation, and amotivation. Strong factorial validity and reliability have been demonstrated for the BREQ-3 in university settings. In this study, Cronbach's alpha coefficients were observed to lie between .76 and .89 across the subscales.

In order to present objective evidence of behavioral change, some selected health-related fitness components were evaluated at both pre and post testing. These were: (1) Body Mass Index (BMI) which was calculated from height and weight measurement and then interpreted using the Asian-Pacific classification guidelines; (2) cardiovascular endurance was estimated using the 3-minute step test; and (3) muscular endurance was evaluated using a 1-minute push-up test. All evaluations followed standard protocols which ensured consistency across test administrators during scheduled PATHFIT2 sessions.

Intervention Protocol

The intervention took place over eight consecutive weeks during the academic semester. Both intervention groups received structured daily prompts via Facebook Messenger at times 7:00 p.m. and 8:00 p.m. The 7:00 p.m. message is a reminder to set aside time to do some physical activity. The 8:00 p.m. message asks to do some moderate-intensity exercise.

The aim is to help participants reach the 150 minutes moderate-intensity physical activity goal established by the World Health Organization. For the duration of the intervention all participants used the MyFitnessPal app to track exercise.

To maintain documentation of adherence to intervention protocol and exercise data quality, participants sent a weekly MyFitnessPal exercise summary screenshot to a secure Google Form on Sundays at 9:00 p.m.. The screenshots were used to calculate weekly adherence metrics such as total minutes of activity and total number of active days. To limit attrition bias, all participants who completed the post-intervention evaluations were counted, regardless of adherence to intervention protocol.

Intervention Conditions

Participants in the standard digital intervention condition received constructed prompts and used MyFitnessPal to log their physical activities. This condition focused on behavioral cueing and self-monitoring with no other motivational enhancement.

Participants in the gamified digital intervention condition received the same prompts and logging instructions. However, a gamification structure was also embedded in the Messenger system,

which included (1) accrual of points for logged activity, (2) streak bonuses for logged activity on consecutive days, (3) weekly digital badges for logged activity, and (4) public rankings on a weekly activity leaderboard. All gamification features were based solely on logged activity. Apart from the gamified motivational architecture, the other no-system variations were participant activity levels.

Intervention Fidelity and Contamination Control

Different Messenger groups were made for each intervention condition for each course to reduce the risk of cross-condition contamination. Participants were directed not to discuss or post intervention materials, screenshots, or content from the leaderboards, and they were given specific timeframes for each intervention. Informal peer communication outside the platform could not be completely controlled given that participants were taking the same courses. No participants placed condition-specific limits on Messenger groups, and no participants placed limits on the use of cross-posting gamification elements. To reduce expectancy, coercion, and competitive academic pressure, participation was decoupled from course grading.

Statistical Analysis

Baseline variables and demographic characteristics were analyzed with descriptive statistics (means, standard deviations, and frequencies). Considering group (gamified vs standard) as the between-subject factor and time (pretest vs posttest) as the within-subject factor, a mixed-design ANOVA was performed. To understand the differences in changes throughout the intervention period, the Time x Group interaction was analyzed. Assumptions of statistics were considered following analytical standards (Field, 2018; Tabachnick & Fidell, 2019), and effect size was indicated as partial eta squared ($\eta^2 p$).

Since participants were located in academic courses, some exploratory intraclass correlation coefficients (ICCs) were calculated for main outcomes using unconditional random-intercept models with course as the grouping factor. ICC values were low (< .02), showing that clustering effects were negligible, and supporting the use of individual-level analyses.

Besides complete-case analyses, intention-to-treat (ITT) analyses were performed with multiple imputation with five datasets to estimate missing posttest values. Findings from the ITT models were aligned with complete case findings, showing that attrition did not significantly affect intervention outcomes.

Sensitivity Analyses

As MVPA data is self-reported, sensitivity analyses were run to test the impact of this attribute on the analyses. Accordingly, the Time × Group analysis was run again using the IPAQ-SF MVPA data, and a second analysis was run removing any MVPA values of over 600 minutes to see the impact of extreme values on the analyses. Additionally, the changes in logged MVPA were compared to changes in objective fitness levels (cardio and muscle endurance) to see if a change in behavior was linked to a change in fitness.

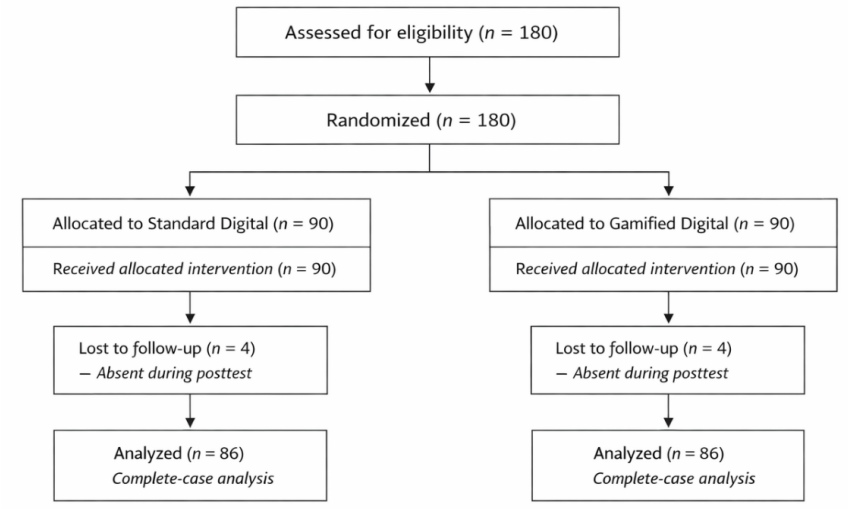
Mediation analyses were run to test motivational pathways using JASP with 5000 bootstrapped bias-corrected confidence intervals to estimate indirect effects of the condition on physical activity changes through changes in motivational regulation. Significance was set at $p < 0.05$ and all analysis was done using JASP version 0.18.3.

Ethical Considerations

Ethical approval was obtained from the institutional research ethics committee prior to data collection. Participants were informed of the study's purpose, procedures, potential risks, and voluntary nature before providing written informed consent. Participation in the intervention did not influence academic grading, and students were informed of their right to withdraw at any time without penalty. Data were anonymized using coded identifiers and stored in password-protected files accessible only to the research team. All recommended physical activities were moderate in intensity and self-paced to minimize risk.

Results

Figure 1
CONSORT Flow Diagram of Participant Enrollment, Randomization, Follow-Up, and Analysis



Participant Flow and Baseline Characteristics

Of the 180 enrolled participants, 172 (95.6%) finished both pretest and posttest assessments. Loss to follow-up was minimal ($n = 8$; 4.4%) and did not significantly differ between the gamified ($n = 4$) and standard digital ($n = 4$) groups ($\chi^2 = 0.00$, $p = 1.00$).

Equivalence of groups at baseline was assessed using independent samples *t*-tests and chi-square tests. Standardized mean differences (SMD) were calculated to evaluate balance between conditions.

Table 1 presents demographic and baseline study variables for both intervention groups.

Physical Activity Behavior

Weekly Moderate-to-Vigorous Physical Activity (MVPA)

Table 2 presents pretest and posttest weekly MVPA minutes derived from MyFitnessPal logs, including mean change scores across the 8-week intervention period.

Table 1

Baseline Characteristics by Intervention Condition (n = 172)

Variable	Standard (n = 86)	Gamified (n = 86)	p-value	SMD
Age (years)	19.6 (1.2)	19.7 (1.1)	.64	0.08
n (%)	52%	49%	.71	0.06
BMI (kg/m²)	23.6 (3.2)	23.8 (3.4)	.72	0.06
Weekly MVPA (min)	118.45 (42.30)	121.10 (39.85)	.58	0.06
Intrinsic Regulation	3.10 (0.58)	3.08 (0.60)	.79	0.03
Identified Regulation	3.42 (0.55)	3.40 (0.57)	.82	0.04
3-Min Step HR (bpm)	112.5 (8.4)	111.8 (8.7)	.61	0.08
Push-Ups (reps)	18.2 (5.1)	17.9 (5.3)	.74	0.06

Note: All standardized mean differences were below 0.20, indicating adequate baseline balance between intervention conditions.

Table 2

Weekly MVPA Minutes by Group (Pretest and Posttest)

Group	Pretest Mean (SD)	Posttest Mean (SD)	Mean Change
Standard Digital	118.45 (42.30)	156.70 (48.12)	+38.25
Gamified Digital	121.10 (39.85)	198.55 (52.44)	+77.45

Participant's weekly MVPA increased in both intervention conditions, but the gamified group showed a much more significant improvement.

A mixed-design ANOVA showed a significant main effect of Time, $F(1,170) = 84.62$, $p < .001$, $\eta^2 p = .33$, showing average increases in physical activity. More importantly, there is a significant Time × Group interaction, $F(1,170) = 21.48$, $p < .001$, $\eta^2 p = .11$, showing the gamified architecture had much more improvement associated than the standard digital group. The between-group posttest difference had a moderate effect size (Cohen's $d = 0.67$).

In the standard condition, the % of participants who met the thresholds of 150 minutes of moderate-intensity physical activity rose from 41% to 63%, and in the gamified condition, it increased from 44% to 81%. Compared to the standard digital group, At posttest, participants in the gamified group were 2.48 times more likely to meet the international guidelines of physical activity ($\chi^2 = 7.92$, $p = .005$). Levene's test showed a lack of significant MVPA between-group posttest variance differences, $F(1,170) = 0.84$, $p = .36$, suggesting the spread in MVPA across conditions was the same.

Motivational Regulation (BREQ-3)

Descriptive statistics for all five motivational regulation subscales are presented in Table 3.

Table 3
Motivational Regulation Scores by Intervention Condition (Pretest and Posttest)

Subscale	Group	Pretest Mean (SD)	Posttest Mean (SD)
Intrinsic	Standard	3.10 (0.58)	3.28 (0.55)
	Gamified	3.08 (0.60)	3.64 (0.52)
Identified	Standard	3.42 (0.55)	3.55 (0.53)
	Gamified	3.40 (0.57)	3.78 (0.51)
Introjected	Standard	2.85 (0.60)	2.90 (0.59)
	Gamified	2.88 (0.58)	2.95 (0.57)
External	Standard	2.40 (0.63)	2.35 (0.60)
	Gamified	2.42 (0.65)	2.20 (0.61)
Amotivation	Standard	1.85 (0.70)	1.80 (0.66)
	Gamified	1.88 (0.72)	1.60 (0.64)

Mixed-design ANOVA results for motivational regulation are summarized in Table 4.

Table 4
Mixed-Design ANOVA Results for Motivational Regulation

Subscale	F (1,170)	p-value	η^2p
Intrinsic	17.92	< .001	.10
Identified	6.42	.012	.04
Introjected	1.58	.21	.01
External	1.79	.18	.01
Amotivation	2.91	.09	.02

Significant Time × Group interactions were observed for intrinsic and identified regulation, indicating stronger internalization effects in the gamified condition. No significant differential effects were observed for introjected or external regulation.

Objective Health-Related Fitness Outcomes

Descriptive pretest and posttest values for BMI, cardiovascular endurance, and muscular endurance are presented in Table 5.

Table 5

Objective Fitness Outcomes by Intervention Condition (Pretest and Posttest)

Outcome	Group	Pretest Mean (SD)	Posttest Mean (SD)	Mean Change
BMI (kg/m²)	Standard	23.6 (3.2)	23.4 (3.1)	−0.2
	Gamified	23.8 (3.4)	23.5 (3.3)	−0.3
3-Min Step HR (bpm)	Standard	112.5 (8.4)	107.3 (7.9)	−5.2
	Gamified	111.8 (8.7)	102.4 (7.5)	−9.4
Push-Ups (reps)	Standard	18.2 (5.1)	21.5 (5.4)	+3.3
	Gamified	17.9 (5.3)	25.8 (6.1)	+7.9

Inferential analyses for fitness outcomes are presented in Table 6.

Table 6

Mixed-Design ANOVA Results for Objective Fitness Outcomes

Outcome	F (1,170)	p-value	$\eta^2 p$
BMI	1.23	.27	.01
3-Min Step HR	9.84	.002	.06
Push-Ups	14.27	< .001	.08

Significant Time × Group interactions were observed for cardiovascular and muscular endurance, indicating superior physiological improvements in the gamified condition. No significant interaction was observed by BMI.

Weekly Adherence Trajectory

To evaluate behavioral persistence across the intervention period, weekly adherence rates were examined. Table 7 presents adherence percentages for each week.

Repeated-measures ANOVA indicated significant effects of Week, Group, and a Week × Group interaction (all $p < .001$). Effect sizes were small-to-moderate (Week: $\eta^2 p = .10$; Group: $\eta^2 p = .12$; Week × Group: $\eta^2 p = .02$), indicating greater adherence stability in the gamified condition across the intervention period.

Table 7
Weekly Adherence Rates (%) by Intervention Condition

Week	Standard Digital	Gamified Digital
Week 1	78%	88%
Week 2	74%	87%
Week 3	72%	86%
Week 4	69%	84%
Week 5	66%	83%
Week 6	65%	81%
Week 7	63%	80%
Week 8	59%	77%
Average	68%	82%

Mediation Analysis

To test the hypothesized mechanism of change, a bootstrapped mediation analysis (5,000 resamples) was conducted. Standardized coefficients (β) are presented in Table 8.

Table 8
Bootstrapped Mediation Model Coefficients (n = 172)

Path	β	SE	*p*	95% CI
a (Intervention → ΔIntrinsic)	.42	.08	< .001	[.26, .58]
b (ΔIntrinsic → MVPA)	.35	.07	< .001	[.21, .49]
c (Total Effect)	.51	.09	< .001	[.33, .69]
c′ (Direct Effect)	.36	.08	< .001	[.20, .52]
Indirect Effect (ab)	.15	—	—	[.07, .27]

The intervention condition was coded as 0 = Standard Digital and 1 = Gamified Digital. The indirect effect was interpreted as changes in intrinsic regulation having a statistically significant effect on the relationship between intervention condition and logged MVPA. Changes in intrinsic regulation explained 29% of the total effect, signifying that motivational internalization may moderately explain the behavioral differences.

Correlational Analysis

Pearson product–moment correlations among posttest study variables are presented in Table 9.

Table 9
Pearson Correlations Among Posttest Study Variables (n = 172)

Variable	1	2	3	4
1. Weekly MVPA	—			
2. Intrinsic Regulation	.41***	—		
3. Adherence Rate	.36***	.38***	—	
4. Δ Cardiovascular Endurance	.29**	.22*	.24**	—

Note. *$p < .05$, **$p < .01$, ***$p < .001$.

Intrinsic regulation was moderately associated with both weekly MVPA and adherence, while improvements in cardiovascular endurance were positively associated with activity volume, further supporting the behavioral validity of logged activity data.

Discussion

Participant Flow

A total of 180 students agreed to participate and completed a baseline assessment. Participants were evenly randomized to either the gamified digital intervention (n=90) or standard digital intervention (n=90) after baseline measurement. Eight participants (4.4%), four in each group, were lost to follow-up due to no-shows at posttest assessments. No participants were excluded in analyses after randomization for non-adherence. Final analyses were conducted with complete case data for participants who were pretest and posttest completers.

Trial Integrity and Baseline Equivalence

The test conveyed elevated retention (95.6%) alongside the lowest attrition being equal across the intervention conditions. From this we can gain confidence in the analytic sample's stability. We made no baseline comparisons across demographic, behavioral, motivational, or fitness variables, and from this there were no statistically significant differences, noting also, all standardized mean differences resided well below the threshold for imbalance (SMD < 0.20). These numbers demonstrate that randomization achieved group differences prior to intervention exposure. Achieving baseline equivalence is crucial in behavioral trials because it diminishes the

chances that post-intervention differences were artifacts of the intervention rather than pre-existing conditions. Thus, post intervention measures can be taken with greater internal validity to determine true differences between conditions.

Intervention Effects on Moderate-to-Vigorous Physical Activity

Both intervention strategies caused a noteworthy increase in weekly moderate to vigorous physical activity (MVPA), with the gamified digital intervention showing greater improvement than the digital intervention in a non-gamified condition. The moderate effect size (Cohen's $d = 0.67$) indicates that the combination of a digital prompt structure and a gamified digital prompt may increase behavioral activity in university students' populations. The results are in line with some of the physical activity interventions for university students that demonstrate a moderate effect size ($d \approx 0.52$) (Favieri et al., 2022). Also, a considerable number of randomized control trials that focused on physical activities among university students noted a significant increase in total physical activities as well as MVPA with program components that are of moderate to large in effect size (Yuan et al., 2024). The results suggest that the addition of a gamified prompt will most likely strengthen the intervention effects.

Previous digital health interventions in university settings show a lack of consensus, especially concerning higher-intensity activities. While digital health interventions are successful in increasing step counts, they do not result in improvements in multiple-vigorous physical activities (MVPA) of college students (Bi et al., 2024). The present research contributes to the body of literature by demonstrating improvements in MVPA and not just step counts. Distinguishing between MVPA and step counts is important both in research and practice since MVPA provides greater cardiometabolic health advantages than low-intensity physical activities. Therefore, digital health interventions seem to show gamification as a tool to facilitate increases in both the frequency of target behaviors and the intensity of those behaviors to increase the positive physiological effects.

The benefit of the gamified condition being the best out of the other conditions is not surprising as previous studies have shown that gamification elements such as the use of feedback loops, progress tracking, and social comparisons boost persistence in behavior.

In the case of Mazeas et al. (2022), a meta-analysis of gamified physical activities shows small to moderate effects in comparison to other control conditions, while large-scale research integrating the behavioral economics shows sustained improvement in physical activities that are gamified (Fanaroff et al., 2024). Under Self-Determination Theory, gamification is likely to enhance perceived competence and strengthen the internalization of self-regulation which leads to more profound behavioral engagement than self-regulation via cue-based self-monitoring. All things considered, gamified digital interventions are a valid and empirically sound method to increase MVPA among university students.

The increase of approximately 77 minutes per week in the gamified condition is a significant improvement towards adhering to the recommended guidelines. Looking at the epidemiological data, the more people participate in moderate to vigorous physical activities, the more they observe a decrease in their cardiometabolic risk, so it is important to encourage participation in physical activities. The observed magnitude of effect ($d = 0.67$) is greater than the average effect size in the most recent university-based physical activity interventions meta-analyses ($d = 0.52$). Therefore, gamified augmentation may increase the effectiveness of interventions more than standard digital prompting.

Motivational Regulation within the Self-Determination Theory Framework

The study shows that self-determined types of motivation, especially intrinsic and identified regulation, are positively related to activity and adherence levels. These findings are consistent with self-determination theory (SDT), which states that self-regulation leads to persistent behavioral execution when individuals are affirmed with a sense of competence, autonomy, and relatedness. Both experimental and longitudinal studies have shown that autonomy-supportive strategies increase the range of moderate and vigorous physical activities; intrinsic and identified regulations are strong predictors when students are exercising and are persistent in exercising (Friederichs et al., 2015; Sánchez-Herrera et al., 2022). This study supports continuum-based interpretations of progressively internalized forms of regulation and more stable behavioral engagement.

The more noticeable negative correlation between amotivation and physical activity is in support of this interpretation. Amotivation is a function of low perceived competence and low perceived personal value, which makes engagement harder to sustain. Earlier longitudinal studies have shown that motivational qualities act with self-regulatory capacity to determine long-term adherence, with self-efficacy being the most important mediator between the regulatory mechanism and maintenance of the activity (McAuley et al., 2011). This situational context shows that autonomous motivation is in conjunction with cognitive and behavioral self-regulatory mechanisms, not in isolation.

Some theorists are concerned about the possibility of tension in the implementation of gamified elements that use leaderboards. This may be particularly true when such elements are seen as externally controlling. From the perspective of SDT, however, such elements may have mainly positive motivational effects. Of course, competitive and ranking systems may be experienced as controlling, evaluative, or coercively. However, leaderboards may also be experienced in a more positive light, particularly when they are placed in a more voluntary and informational system. In such a case, they may be seen as feedback relevant to the development of the user's competence and may reflect the user's improvement and/or effort. In the current case, for example, the feedback given by the leaderboard was integrated with self-monitoring, streak and badge bonuses, and participation was decoupled from graded activities. To this end, the result of the research showed a lack of increase that would indicate that the gamified elements created externally or introjected controlling regulations and would indicate the presence of controlling pressures. This leads to the ranking system being interpreted as providing positive information concerning progress and competence, which in turn leads to the development of self-regulation and/or internalization.

Gamification may cause varying effects on the varying motivational quality due to differing contextual framing or differing individual factors including social comparison. Research should investigate the degree to which gamification impacts motivational quality by evaluating the degree to which individual motivational factors (autonomy, competence, and relatedness) need is satisfied. The present findings suggest that the primary motivational factor

that may increase engagement in gamified digital interventions is the autonomous regulation of motivation.

Engagement Dynamics and Adherence Trajectory

The patterns in weekly adherence in Table 7 suggest that rather than showing a straight-line path, there are fluctuations or increases in engagement across the course of the intervention. This kind of engagement variability aligns with previous research which shows that adherence to digital health technologies is not static but develops over time in a dynamic, multi-dimensional way, or actors such as level of adoption, consistency, persistence, duration, and eventual dropout (Figueiredo et al., 2025). Their research shows that persistent or changing levels of disengagement are shaped by personal, technological, and contextual factors. Variations in motivation, perceived usefulness, and external demands keep re-engaging or disengaging users.

Engagement trajectories in digital health interventions have shown that users tend to participate at the beginning of the intervention but then shift to low or no activity levels. In a longitudinal study of over 22,000 users of mHealth, Agachi et al. (2023) identified activity levels of mHealth users, and a significant percentage of participants dropped to low activity or no activity over the study period. This state transition supports the idea that adherence is not a linear process, but rather activity and inactivity levels. The fluctuations in adherence in the present study May reflect changing interactions with the intervention framework.

Using a behavioral framework, maintaining digital engagement means moving past the first interactions with a platform, and doing behaviors consistently. The definition of micro engagement and macro engagement illustrates that behavioral change may be enough for someone to engage with the elements of the platform on a consistent weekly basis and suggests that a habit may have become consolidated and fully reinforced. (Eiselt et al., 2026) Thus, the pattern in Table 7 illustrates that during the intervention period, supportive adaptive mechanisms aimed to stabilize engagement and reduce the risk of disengagement.

Translation to Objective Fitness Adaptation

Improvements in cardiorespiratory fitness and muscular endurance due to the intervention were substantial, but the same could not be said of the changes in anthropometric indices. This observation aligns with randomized controlled trials showing that, without major changes to body composition, substantial adaptations happen during short-term (less than 6 months) structured exercise interventions in university populations (Eather et al., 2018, Godoy-Cumilli et al, 2026). This reflects the primary cardiovascular and neuromuscular adaptations, with focus to these short interventions (8–12 weeks) that range in duration the physiological responsiveness of the young adult subjects.\par The additional improvement in muscular endurance also shows consistency with literature that suggests when university populations are controlled for adherence and progressive overload that almost any combination of exercise types is likely to result in substantial improvement (Hollerbach et al., 2021). Such adaptations are likely to be due to changes in the motor unit recruitment, metabolism, and less than voluntary exotic tolerance to repeated submaximal contractions. Those changes occur before the body experiences changes in fat mass or total body mass.

Short-term interventions, like those in our study, demonstrate limited anthropometric changes, while improvements in cardiovascular markers were noted (Pranoto et al., 2025). The evidence consistently supports a gap in functionality of fitness and body composition in which an increase in moderate to vigorous physical activity leads to enhancement in overall fitness and functionality. In contrast, to achieve changes in body composition a longer period of training, higher volume of activity and possibly alterations in diet are necessary to achieve a clinically significant change.

With a timeline of 8 weeks for the intervention and considering that the participants were predominantly in the norm weight category, anthropometric changes as a result of the intervention were not anticipated and because of the absence of dietary changes were not anticipated. The lack of change in BMI is congruent with the anticipated timeframes in short-term physiological changes from exercise interventions.

Autonomous Motivation as a Plausible Explanatory Pathway

Mediation analysis showed that shifts in autonomous (intrinsic) regulation statistically described a meaningful portion of the relation between intervention condition and logged MVPA. This supports Self-Determination Theory (SDT) where it is suggested that regulation of behavior in a self-autonomous manner leads to the continuation of that behavior over time. In this study, shifts in autonomous regulation explained roughly 29% of the total relation between intervention conditions and MVPA. This points to motivational internalization as a plausible pathway.

Motivational regulation and physical activity were, however, measured in the same pre–post interval which means the results should be viewed as evidence of statistical reasoning rather than actual chronological causation. No precedence can be established for this as the mediator and result were assessed at the same time. Therefore, it is plausible that enhanced intrinsic motivation was a result of increased physical activity, or that during the intervention phase both processes worked in a feedback loop. This analysis is consistent with previous structural and longitudinal studies showing links between autonomous regulation and moderate-to-vigorous physical activity (de Oliveira Barbosa et al., 2024; Navas-León et al., 2025). The continued direct effect of regulation is likely to suggest that other factors beyond intrinsic regulation may also explain behavioral differences, such as reinforcement, competition, or habit strength (O'Loughlin et al., 2022).

Theoretical Contributions

This study enhances the theory of change in digital behavior through the first experimental analysis of the role of change in autonomous motivation as an explanatory variable in the differences between gamified and non-gamified digital tools in relation to moderate to vigorous physical activity among university students. Utilizing Self-Determination Theory and a randomized control trial approach, the study differentiates between digital prompts that encourage compliance and those that foster internal motivational control. Results indicate that gamification in digital tools could enrich the type of motivation and increase the duration of behav-

ioral engagement, thus, aiding in the long-term and functional adjustment of the level of physical activity. The study's integration of psychological factors, physical activity, and health outcomes into a single framework provides valuable insights into the growing body of research on digital interventions to promote physical activity in the university setting.

The results show that certain models of digital health behavior change that emphasize structural incentive, cue, or motivation mechanisms, such as gamification, do not account fully or sufficiently for motivation sustained largely by habit, or reinforcing, mechanisms. Models that are com-b based, or drawn from behavioral economics, focus com-b on 'capability, opportunity, and reinforcements,' yet the results demonstrate that these models can work to reinforce and sustain engagement through habit and, most importantly, intrinsic motivation. In this regard, Self-Determination Theory is of value. These results go further than an increase in the frequency of targeted behavior to suggest that health models of technology may impact on the quality of the intrinsic motivation, and not simply the frequency of the motivation.

Practical Implications

For university health promotion programs, the results suggest that digital interventions should include more than reminder-based prompting and develop more advanced gamification elements that enhance the feelings of competence, visibility of progress, and sustained engagement. Simple, low-tech, and inexpensive motivational internalization, such as point systems, streak tracking, and feedback on leaderboards, can be integrated into existing messaging systems. The use and incorporation of gamification that supports autonomy and is embedded in the required physical education or wellness programs may improve program retention and decrease the decline in participation across academic semesters. Universities wanting to implement large-scale solutions to increase the amount of physical activity should emphasize motivational elements and activity tracking to enhance participation and health of the population.

Conclusions

Digital prompting and gamified digital interventions have shown positive impact on Physical Activity (PA) of university students.

Gamification demonstrated a much higher impact on a variety of activity types including moderate-to-vigorous activity, motivational internalization, adherence stability, and functional fitness. In the example of PA, the role of autonomous motivation was found to be a partial mediator. This finding suggests motivational internalization as a primary mechanism that connects gamified designs to changes in behavior. Additionally, the persistence of a direct effect suggests that the additional role of habit, social, or other behavior processes may exist. Therefore, it is recommended that the autonomy-supportive gamification approach be integrated into digital health interventions. This may be a practical approach to encourage some level of PA engagement, even if it is for a short duration, in higher educational institutions.

Limitations of the Study

There are numerous limitations to consider. Regarding MVPA, there were participant-entered MyFitnessPal logs, most of which were verified through screenshots. Although this method of verification increased traceability, it remained susceptible to self-report bias. In the gamified condition, there may be a reporting bias due to logging behavior, which would create an uneven reporting behavior. In addition to Sensitivity analysis and the improvement of fitness via the objective method, future studies utilizing accelerometry and/or derived-wearable metrics are suggested due to the imprecision of the current measurements. The study was limited to a single university and was only eight weeks, this would limit the cross-context and longitudinal generalizability. Because randomization was done individually within the same courses, there may have been informal interaction between different study groups, though the clustering effects were negligible. Also, there may have been some effects of motivational regulation and physical activity that were assessed within the same pre/post interval, and this may have made mediation pathways less clear. Lastly, while Self-Determination Theory was the basis for this research, the basic psychological needs of autonomy, competence, and relatedness were not assessed, and future studies should include these needs.

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