

Development, Implementation, and Evaluation of a Belief-Targeted Non-Face-to-Face Leisure-Time Physical Activity Promotion Program for South Korean University Students

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Research Article

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Abstract

Background

Despite a sharp decline in physical activity levels among university students since the COVID-19 pandemic, physical activity programs for this population remain limited. Our previous research examined key beliefs influencing physical activity behavior among university students at a Korean university during the COVID-19 pandemic. Accordingly, this study aimed to develop, implement, and evaluate a non-face-to-face leisure-time physical activity (NFTF-LTPA) promotion program for university students, focusing on three beliefs—health, friends, and laziness—identified as key determinants of physical activity behavior in our previous study.

Methods

Undergraduate students were newly recruited from the same university and departments (i.e., the College of Social Sciences and the School of Business) as our prior study. A belief-targeted intervention was implemented for three months. Process evaluations were conducted at mid-, and post-intervention, and outcomes were assessed at pre-, mid-, and post-intervention. A one-month follow-up survey was also conducted after the intervention ended. A 2×4 repeated measures generalized linear model was conducted and subgroup analyses examined participants with high intervention adherence (PHIA) compared with controls.

Results

A significant interaction effect was observed for the control belief laziness ($F = 3.85$; $p = 0.031$). Post hoc analyses indicated that perceived laziness decreased at the midpoint for the PHIA group compared with the control group. Significant group ($F = 4.67$; $p = 0.044$) and time ($F = 3.53$; $p = 0.038$) effects were found for LTPA participation. The PHIA group showed a substantial increase in LTPA participation at the program midpoint compared with baseline, and their LTPA participation time was significantly higher than that of the control group.

Conclusions

The NFTF-LTPA program effectively enhanced beliefs, intentions, and behaviors related to physical activity among inactive university students.

Trial registration:

The trial was retrospectively registered at ClinicalTrials.gov (Identifier: NCT07423403; 19 February 2026).

Background

Physical inactivity is a serious public health concern worldwide, especially in the wake of COVID-19 [1, 2]. Beyond its direct health impacts, COVID-19 has substantially altered economic conditions, social interactions, and individual lifestyles on a global scale [3]. In particular, various measures such as the closure of sports facilities and restrictions on gatherings to prevent COVID-19 infection severely limited opportunities for physical activity (PA) participation [4, 5]. As a result, PA levels among university students worldwide have declined markedly since the COVID-19 pandemic. Empirical evidence further indicates that this decline was particularly pronounced during periods of lockdown, with a systematic review reporting significant reductions in PA among university students during COVID-19 confinements [5].

Korean university students were no exception, with a notable decrease of approximately 23.4% in PA participation compared with the pre-pandemic period [6]. Factors such as the transition to online learning and restricted access to campus facilities may have limited students' opportunities to benefit from on-campus PA resources [7]. Since they are still in a learning phase, there is a possibility for significant improvement in various health behaviors that can impact their later-life health [8]. Furthermore, it is widely

known that PA patterns established in university have a long-term impact on adult PA habits [9, 10]. Therefore, it is essential to provide various policies and programs during this period to enable students to establish PA participation habits. However, there remains a shortage of PA programs for university students, particularly during COVID-19, and research interest in this area is still lacking in Korea.

Based on prior research identifying key beliefs influencing PA among Korean university students during the COVID-19 pandemic [11], this study aimed to develop, implement, and evaluate a leisure-time physical activity (LTPA) promotion program for this population. According to Park and Lee [11], salient beliefs such as ‘builds social relationships,’ ‘takes too much time,’ and ‘friends’ significantly predicted PA intention and behavior prior to the pandemic. During the pandemic, “*participating in physical activity improves my health*” (behavioral belief), “*my family members think that I should participate in physical activity*” (normative belief), and “*I think I am lazy to participate in physical activity*” (control belief) were significant predictors of PA intention and behavior although students’ average weekly PA time declined by half. This shift in salient beliefs likely reflects changes in the social and environmental context during the COVID-19 pandemic, in which restrictions on social interaction, increased health-related anxiety, and altered daily routines reshaped the cognitive determinants underlying PA intention and behavior [11]. These findings highlight the need for tailored PA interventions grounded in pandemic-specific determinants. Accordingly, the present study adopted pandemic-specific behavioral, normative, and control beliefs as key targets for an LTPA promotion program designed to reflect the COVID-19 context. In the case of the normative belief ‘family members,’ it was deemed impractical for the researcher to directly intervene in family-related factors as a target belief. Therefore, ‘friends’ (“my friends think that I should participate in physical activity”) was set as the target belief to develop the program. Importantly, participants in the present study were newly recruited from the same university and academic units as those included in the prior belief-identification study by Park and Lee [11]. This population continuity supports the application of previously identified salient beliefs to the development of the current LTPA intervention.

The COVID-19 pandemic has highlighted the importance of non-face-to-face (NFTF) physical activity interventions and accelerated their implementation across various settings. While such approaches are increasingly being adopted, physical activity interventions have traditionally relied on face-to-face delivery methods [12], and the evidence supporting NFTF models continues to develop [13, 14]. NFTF interventions offer greater efficiency in terms of time and cost, as they do not require direct physical interaction [13], making them particularly suitable during periods of infectious disease outbreaks such as COVID-19. Social media is considered one of the most effective channels for public health interventions in terms of its extensive reach and support for interaction and information [15–17]. Facebook may be well suited for health interventions due to its flexible content format and features such as pages and groups, which support the delivery of multi-component programs [18]. Furthermore, the COVID-19 pandemic has led to increased social media use, including longer daily Facebook usage among university students due to changes in communication patterns [19, 20]. Accordingly, Facebook represents a strategically appropriate platform for delivering physical activity interventions targeting young adults.

For a successful health promotion program, process evaluation is essential to determine whether intervention components were implemented as intended and to what extent [21, 22]. When significant behavioral changes occur, it is particularly important to identify which components contributed to these outcomes [23]. Process evaluation opens the “black box” of program implementation, enabling a deeper understanding of how specific components influenced outcomes [24, 25]. Although such analyses remain relatively limited, they provide critical insights for refining future interventions or identifying barriers when no behavioral change is observed [26, 27]. Therefore, this study incorporated a process evaluation to examine implementation fidelity and to better understand how intervention components contributed to behavioral outcomes.

To sum up, this study aims to develop, implement, and evaluate an NFTF-LTPA promotion program for university students, focusing on the three salient beliefs (i.e., health, friends, laziness) of physical activity that have been validated in the previous research conducted by Park and Lee [11].

Methods

Participants

This study was conducted as a follow-up to a previous study by Park and Lee [11], and participants were undergraduate students recruited from the same department at same university located in Seoul, South Korea. Consistent with the previous study, students were recruited from the College of Social Sciences and the School of Business. Participants were recruited via group email

invitations linking to a pre-intervention questionnaire assessing LTPA-related beliefs, intentions, and behaviors. Those who agreed to participate provided their mobile phone number for program-related communication.

To prevent imbalances in LTPA time and gender distribution between groups [28], stratified random sampling was used to allocate participants to the intervention and control groups. This study was approved by the Institutional Review Board (IRB) of XXX University and written informed consent was obtained from all participants prior to participation. The trial was retrospectively registered at ClinicalTrials.gov (Identifier: NCT07423403; 19 February 2026).

Intervention

The LTPA program, specifically designed based on the aforementioned three salient beliefs (health, friends, and laziness), was developed using Facebook pages and groups, incorporating various strategies to increase LTPA participation rates. In line with previous evidence indicating that participation in web-based PA programs tends to decline after three months [29], the program was conducted from May 8 to August 6, 2023. The intervention group was divided into five subgroups (6–7 members each), following Rote et al.'s recommendation of 5–9 participants per group [30]. The LTPA program consisted of six intervention arms as follows:

1) Providing LTPA related information

Information on the utilization and accessibility of sports facilities, commonly identified as environmental factors affecting PA participation [31–33], was shared on the page (e.g., campus trails). The informational posts targeted three beliefs: health, friends, and laziness.

2) Goal setting

Laziness is primarily described as an emotion caused by a lack of motivation. Goal setting, self-discipline, and reward-based interventions have been shown to be an effective strategy for improving motivation to participate in PA [34–36]. To reduce perceived laziness toward LTPA participation, participants were instructed to post weekly LTPA goals (frequency, duration, and activity type) in their groups every Monday (see Fig. 1).

3) Verification of the LTPA participation

This study assured individuals' actual LTPA participation by having them verify their activities within each group. The verification method is to post photos that included individual's appearance (excluding face), the LTPA location/facility, date, and the starting and finishing time of the activity (see Fig. 2).

4) Group incentive

Regardless of personal goals, when more than 70% of members in a group achieved at least 150 minutes of LTPA per week, all members of the group received an incentive worth approximately \$5, as verified by the researcher. Goal setting, verification of LTPA participation, and group incentives were implemented as interconnected interventions, and these three strategies may help reduce feelings of laziness toward LTPA participation.

5) Normative message

Based on evidence that peer-related social norms influence university students' PA [37–39], normative messages were delivered to promote positive changes in normative beliefs regarding friends and to enhance LTPA-related intentions and behaviors. Specifically, following verification of group posts, the researcher shared the percentage of each group meeting PA recommendations and posted information on incentive-eligible groups, thereby allowing all participants to view weekly LTPA results (see Fig. 3).

6) Role model

A role model interview was included to target behavioral belief 'health' and normative belief 'friends'. Two participants who engaged in at least 150 minutes of LTPA per week during the initial six weeks of the program were selected as role models. They were interviewed via Facebook Messenger regarding program-related changes and personal strategies for LTPA participation, and their responses were shared within each group and on the Facebook page (see Fig. 4).

Since all procedures of this study were conducted remotely, both the process and outcome evaluations of the LTPA program were carried out using a Google online survey. Process evaluations were conducted at mid-, and post-intervention, and outcomes were assessed at pre-, mid-, and post-intervention. A one-month follow-up survey was also conducted after the intervention ended.

Process evaluation by participants

Process evaluation items were included in the main survey administered at the midpoint and post-intervention. Items used at the program midpoint and end are presented in Supplementary Tables S1 and S2, respectively, with three additional items included at post-intervention. All process evaluation items were assessed using dichotomous (Yes/No) responses and were adapted from previous studies [40–42]. These items were administered only to the intervention group. In addition, an open-ended question was included to collect participants’ qualitative feedback on their experiences with the program.

Process evaluation by evaluators

To objectively evaluate LTPA program, a process evaluation was conducted at the midpoint of the intervention by three evaluators. The evaluation panel consisted of one professor with expertise in health behavior and promotion and two doctoral candidates in the same field. All intervention content shared via Facebook was provided to the evaluators, who completed a 10-item process evaluation survey (see Supplementary Table S3) [40–42].

Outcome evaluation

Behavioral, normative, and control beliefs, as well as intentions regarding LTPA participation [43], were evaluated using a nine-point Likert scale (response options ranged from – 4 = extremely unlikely to 4 = extremely likely) at pre, mid, and post intervention stages (See Table 1). The three items of intention were computed to represent an average score for intention to engage in LTPA in the next month. The two items of LTPA participation were analyzed by multiplying frequency and duration to derive the weekly average LTPA participation time over the past month as a single variable. A one-month follow-up was conducted solely to measure the level of LTPA participation.

Table 1
Questions of Behavioral, Normative, and Control Beliefs, Intention and Behavior Regarding LTPA Participation

Outcomes	Questions
BB	"Do you think participating in LTPA can improve your health?"
OE	"Do you think improving health is good or not good?"
NB	"Do you think your friends would agree or disagree with your participation in LTPA?"
MC	"Are you willing to follow your friends' opinions or thoughts?"
CB	"Do you think participating in LTPA is lazy?"
PP	"Do you think the laziness makes LTPA participation difficult or hinders it, or does it help or make it easier?"
Intention	"Do you intend to participate in LTPA in the next month?"
	"Will you make an effort to participate in LTPA in the next month?"
	"Do you plan to engage in LTPA in the next month?"
LTPA	"How many days per week did you engage in LTPA during the past month?"
	"How many minutes per day did you spend on LTPA participation?"
Abbreviation: BB = Behavioral Belief; OE = Outcome Evaluation; NB = Normative Belief; MC = Motivation to Comply; CB = Control Belief; PP = Perceived Power	

Data analysis

The results of process evaluation were presented as mean (standard deviation, SD) and percentage. A 2×4 repeated measures generalized linear model (GLM) analysis was conducted to examine participants' perceptions, intention, and behavior regarding LTPA changed at mid, post, and one-month follow-up compared to before the program. To examine the differences between groups over time in more detail, effect sizes were calculated using Partial η^2 and Cohen's d values. For repeated measures data, the assumption of sphericity, which refers to the consistency of correlations within groups, is required. A sphericity test was conducted prior to analysis since different estimates can be used depending on whether this assumption is met [44]. In the case of significant interaction effects between groups over time, post hoc tests were performed, and the significance level was set to $\alpha = .10$, considering the sample size [45].

Based on the World Health Organization's PA guidelines [46], participants were divided into two subgroups. The first subgroup included participants with baseline weekly LTPA ≤ 150 minutes, and comparisons of LTPA perceptions, intentions, and behaviors were conducted between the intervention and control groups. The second subgroup assessed program effectiveness by comparing these outcomes between participants with high intervention adherence (PHIA) in the intervention group and the control group, all of whom did not meet PA recommendations at baseline. High intervention adherence was defined as responding "yes" to all process evaluation items. All analyses were conducted using IBM SPSS 26.0 and SAS 9.4 statistical programs.

Results

Characteristics of participants

A total of 56 participants (n = intervention: 27, control: 29) completed the LTPA program, including the follow-up survey, with a higher number of female students compared to male counterparts (male: 41.4%, female: 58.6%). The results of the baseline survey revealed that the LTPA participation time of the intervention and control groups was 190.74 and 201.03 minutes, respectively.

Process evaluation

A total of 31 participants completed the process evaluation at the midpoint of the LTPA intervention. Most participants reported viewing LTPA-related posts, with high engagement in viewing posts shared by other participants, while goal-setting and activity logging were reported by approximately two-thirds of participants (presented in Supplementary Table S1).

At post-intervention, overall adherence to the intervention decreased compared with the midpoint evaluation (presented in Supplementary Table S2). Although the proportion of participants who checked page posts remained high, fewer participants reported thoroughly reading the content. Engagement in group activities, including goal-setting and verification posts, also declined. In addition, approximately half of the participants reported checking role model-related posts, with fewer indicating that they read these posts in detail.

The results of the process evaluation conducted by the evaluators are presented in Supplementary Table S3. The evaluators showed the lowest agreement regarding participants' enjoyment of page posts and active engagement in group activities (Mean = 2.3, SD = 0.58; Mean = 2.0, SD = 2.0). Moderate agreement was observed for items assessing careful reading of page posts and attention to textual content (Mean = 3.0, SD = 1.0). For the item assessing participants' understanding of group activities, one evaluator strongly agreed and two moderately agreed (Mean = 3.3, SD = 0.58).

Sphericity test

The results of Mauchly's sphericity test indicated that the assumption of equal covariance matrices across all levels within the group was violated, as the p -value was lower than the $\alpha = .10$ level set in this study ($W = 0.05056189, p < 0.10$). Therefore, this study used the corrected estimates based on the Huynh-Feldt Epsilon (H-F).

Outcome evaluation

Table 2 presents the results of differences in LTPA perception, intention, and behavior among the first subgroup. A significant time effect was observed in LTPA participation at the $\alpha = .10$ level ($F = 2.46$; $p = 0.089$; $\eta^2 = 0.09$), although no significant group effect was found. The intervention group showed a continuous increase in LTPA participation through the follow-up period, whereas the control group showed a decrease after the program ended (see Fig. 5).

Table 2
Differences in LTPA Beliefs, Intention, and Behavior Among the First Sub-Groups (N = 27)

Outcomes	Intervention Group (n = 13)				Control Group (n = 14)				Group	Time	GT
	Pre	Mid	Post	1-month Follow-up	Pre	Mid	Post	1-month Follow-up	F	F	F
Mean (SD)											
LTPA time	78.46 (45.98)	124.31 (143.83)	144.23 (203.26)	146.92 (166.95)	68.57 (50.67)	81.79 (79.85)	128.57 (134.90)	98.21 (82.13)	0.62	2.46*	0.31
Intention	2.31 (1.47)	1.95 (2.00)	2.03 (1.98)		0.95 (1.86)	1.38 (2.21)	2.14 (1.89)		1.05	0.85	1.80
BB	3.15 (0.80)	3.15 (0.99)	3.31 (0.85)		2.93 (0.83)	2.93 (1.21)	3.29 (1.14)		0.27	1.10	0.17
OE	3.69 (0.63)	3.92 (0.28)	3.85 (0.38)		3.93 (0.27)	3.50 (1.09)	3.86 (0.53)		0.14	0.45	2.44
NB	2.46 (1.51)	3.08 (1.12)	3.31 (0.75)		2.50 (2.18)	2.57 (1.50)	2.50 (1.29)		1.16	0.82	0.75
MC	2.23 (1.79)	2.38 (1.45)	2.00 (1.96)		1.29 (2.13)	1.71 (2.05)	1.93 (1.64)		1.07	0.28	0.62
CB	1.62 (2.06)	1.15 (1.82)	1.77 (1.83)		1.50 (1.45)	1.71 (1.54)	1.29 (1.64)		0.00	0.11	1.82
PP	2.38 (1.45)	2.15 (1.68)	2.77 (1.17)		1.64 (2.10)	1.57 (1.83)	1.93 (1.73)		1.83	1.17	0.08
Abbreviation: BB = Behavioral Belief; OE = Outcome Evaluation; NB = Normative Belief; MC = Motivation to Comply; CB = Control Belief; PP = Perceived Power; SD = Standard Deviation; GT = Group × Time											
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$											

The results of differences in LTPA perception, intention, and behavior among the second subgroup (PHIA versus control) are presented in Table 3. There were no main or interaction effects on behavioral beliefs; however, a significant time effect was observed for motivation to comply with normative beliefs at the $\alpha = .10$ level ($F = 2.64$; $p = 0.088$; $\eta^2 = 0.13$). In particular, the intervention group maintained a high level of motivation to comply with their friends even after the midpoint of the program (see Fig. 6).

Table 3
Differences in LTPA Beliefs, Intention, and Behavior Among the Second Sub-Groups (N = 20)

PHIA Intervention Group (n = 6)				Control Group (n = 14)				Group	Time	GT	
Outcomes	Pre	Mid	Post	1-month Follow-up	Pre	Mid	Post	1-month Follow-up	F	F	F
Mean (SD)											
LTPA time	101.67 (24.01)	211.67 (174.63)	257.50 (261.11)	211.67 (219.49)	68.57 (50.67)	81.79 (79.85)	128.57 (134.90)	98.21 (82.13)	4.67**	3.53**	0.94
Intention	2.89 (0.98)	3.28 (0.85)	3.39 (0.95)		0.95 (1.86)	1.38 (2.21)	2.14 (1.89)		5.57**	2.11	0.44
BB	3.17 (0.98)	3.33 (0.82)	3.50 (0.55)		2.93 (0.83)	2.93 (1.21)	3.29 (1.14)		0.59	0.85	0.07
OE	3.33 (0.82)	3.83 (0.41)	3.83 (0.41)		3.93 (0.27)	3.50 (1.09)	3.86 (0.53)		0.19	0.56	2.34
NB	2.33 (1.51)	3.33 (1.03)	3.33 (0.82)		2.50 (2.18)	2.57 (1.50)	2.50 (1.29)		0.78	0.81	0.71
MC	1.83 (2.48)	3.17 (1.33)	3.17 (0.98)		1.29 (2.13)	1.71 (2.05)	1.93 (1.64)		2.10	2.64*	0.50
CB	1.17 (1.94) ^a	0.17 (1.72) ^b	1.33 (1.86)		1.50 (1.45)	1.71 (1.54)	1.29 (1.64)		0.72	1.08	3.85**
PP	2.33 (1.51)	1.33 (1.97)	2.17 (1.47)		1.64 (2.10)	1.57 (1.83)	1.93 (1.73)		0.10	1.14	0.57
Abbreviation: BB = Behavioral Belief; OE = Outcome Evaluation; NB = Normative Belief; MC = Motivation to Comply; CB = Control Belief; PP = Perceived Power; SD = Standard Deviation; GT = Group×Time; a = pre-mid; b = mid-post											
***p < 0.01, **p < 0.05, *p < 0.10											

For control beliefs, a significant interaction effect was observed, with a large effect size ($F = 3.85$; $p = 0.031$; $\eta^2 = 0.18$). Post-hoc tests indicated that laziness decreased at the midpoint for the PHIA group compared to the control group (see Fig. 7). The decrease in laziness regarding LTPA participation at the midpoint of the program showed a large effect size for the PHIA group ($F = 6.07$; $p = 0.024$; $d = 0.90$), whereas the decrease observed in the control group at the end of the program showed a small effect size ($F = 5.62$; $p = 0.029$; $d = -0.02$).

Although a significant group effect was found for LTPA intention ($F = 5.57$; $p = 0.030$; $\eta^2 = 0.24$), baseline differences were observed between groups. Lastly, there was no interaction effect on LTPA behavior; however, group ($F = 4.67$; $p = 0.044$; $\eta^2 = 0.21$) and time ($F = 3.53$; $p = 0.038$; $\eta^2 = 0.16$) effects were found for LTPA participation (see Fig. 8). Specifically, the PHIA group showed an increase of more than 100 minutes in LTPA time compared with baseline.

Discussion

The PHIA group showed a significantly higher intention to participate in LTPA compared to the control group, and this strong intention appears to have influenced actual behavior. Despite having low LTPA participation rates prior to the program, the PHIA group maintained a high intention to participate in LTPA throughout the program. In fact, the LTPA participation rate of the PHIA group more than doubled at the midpoint of the program compared with baseline, and their LTPA participation time was significantly higher than that of the control group. Moreover, the PHIA group exhibited an early increase in motivation to comply with friends that was sustained after the program midpoint, whereas the control group showed only a modest and gradual increase over time. This suggests that interactions with other members within the group led to positive belief changes, and the continuous provision of

normative messages may have indirectly influenced students' perceptions. These findings align with previous research employing subgroup analyses to examine the effects of Facebook-based PA interventions [47].

Moreover, the observed behavioral changes are closely related to the reduction in the control belief of laziness at the midpoint of the program. In terms of effect size, the substantial decrease in perceived laziness among the PHIA group appears to be attributable to the group-based activities embedded in the intervention. Students set weekly LTPA participation goals and worked to achieve them, resulting in increased engagement in PA during their leisure time. Additionally, they tended to set their personal LTPA goals to exceed 150 minutes in line with the incentive conditions. White et al. [36] proposed goal-setting and reward-based strategies as an approach to reduce perceptions of laziness regarding control beliefs and to increase motivation for PA. In this context, the group activities of this program were effective in motivating goal achievement. Moreover, by using the incentive strategy, participants were indirectly encouraged to have a shared goal within the group, which stimulated the group dynamics of students, ultimately leading to effective behavior change. The interaction and sense of fellowship formed among group members to achieve the same goal is likely to have a positive impact on PA behavior change [48]. Estabrooks et al. [49] reviewed the effectiveness of PA interventions based on a group dynamics approach and reported that, regardless of the combination of intervention strategies, the group dynamics approach was generally effective.

According to the process evaluation results, the level of intervention adherence decreased after the program midpoint. This is likely because the program midpoint overlapped with the final exam period, and university students likely prioritized their academic work over participating in the program. In fact, the participants highlighted their lack of active participation due to exam preparations in their responses to the last question of the midpoint process evaluation, saying, 'I couldn't participate due to the exam period, but I plan to rejoin starting today,' 'There was too much to do during the exam period, so I couldn't participate in the program,' and 'If the program were conducted outside the exam period, participation rates would be higher.' These results align with previous research showing that university students face difficulties in engaging in PA during the final exam period [50]. As reflected by the incentive-based engagement patterns, study participants were more actively involved in group activities during the first 6 weeks, before the final exam period and the end of the semester. A study measuring the effectiveness of health behavior interventions targeting university students reported that interventions lasting within one semester are more effective in changing specific health behaviors than those lasting over one semester [8]. Although the duration of this program was shorter than a full semester, it started in the middle of the semester and continued through the vacation period after the semester ended, which is likely why the intervention adherence dropped in the later stages. Therefore, future research should take into account the characteristics of university students and their academic schedules when planning such programs.

This study has several strengths worth highlighting. First, this study conducted a process evaluation to assess the effectiveness of the program, which provided useful information for interpreting the results. In particular, the process evaluation by the evaluators, which was based on the opinions of a third party excluding the researchers and participants, is significant in that it was utilized as relatively objective evaluation data. Moreover, these evaluation results will be used as an important framework by future researchers in the field when developing similar programs. Second, this study developed a NTF-LTPA promotion program based on the changed PA beliefs of university students following the outbreak of COVID-19. While numerous studies have been conducted both domestically and internationally on COVID-19 and university students' participation in PA [5], there has been little research on interventions based on PA beliefs that consider the social atmosphere and environmental circumstances of that period. This study is meaningful in that it implemented a tailored behavior change strategy to promote belief changes among students from the same university, in line with previous studies that examined PA beliefs. Furthermore, since this study developed the program while considering that COVID-19 had not yet ended, the program was implemented in an online format. Therefore, it will serve as valuable data for future situations involving similar diseases and infections. Third, the provision of incentives through exercise verification distinguishes this study from previous PA interventions that used Facebook groups. Students who set LTPA goals and worked towards achieving them through group activities experienced a reduction in the perception of laziness, leading to an increase in their LTPA participation. These results suggest that interventions mediated through groups are an effective strategy for changing university students' perceptions and behaviors regarding LTPA. They will serve as valuable resources for developing PA-related programs and policy elements for university students in the future.

Nevertheless, it is important to acknowledge the following limitations. First, the data for this study were collected through self-administered questionnaires, which may have led to social desirability and recall bias. Although efforts were made to minimize these biases through exercise verification, it cannot be ruled out that participants engaged in LTPA without verification. Future research

should improve the accuracy of the findings by using more objective measurement methods, such as heart rate monitors and accelerometers. Second, in this study, two participants who most actively participated in LTPA during the first 6 weeks of the program were selected as a role model to foster positive changes in LTPA beliefs. This program was developed based on PA beliefs from the previous study conducted with university students, and therefore, influencers [51] or celebrities, who have been shown to effectively influence PA behaviors, were not considered as role model subjects. Future research using social media interventions should consider implementing various role models that have been shown to effectively influence PA intentions and behaviors in university students, not only peer friends. Third, this study did not assess the feasibility or reach of the intervention through metrics such as 'likes', 'comments', or the number of logins. Future research should use more objective assessment tools to evaluate the feasibility and reach of intervention tools.

Conclusion

The belief-targeted, NFTF-LTPA program was particularly effective in changing the perceptions, intentions, and behaviors regarding LTPA of university students, whose participation rate in LTPA was low before the intervention. The present study will provide valuable data regarding LTPA beliefs, intentions, and behaviors, as well as program development, implementation, and evaluation among university students, for future situations involving similar diseases and infections.

Abbreviations

NFTF: Non-Face-to-Face

LTPA: Leisure-Time Physical Activity

PHIA: Participants with High Intervention Adherence

PA: Physical Activity

IRB: Institutional Review Board

SD: Standard Deviation

GLM: Generalized Linear Model

Declarations

Acknowledgements

Not applicable.

Ethics approval and consent to participate

This study was approved by the Seoul National University Institutional Review Board (IRB No. 2301/002-012) and was conducted in accordance with the Declaration of Helsinki. Written consent was obtained from all participants and all methods were conducted according to relevant guidelines. All participants were informed about the study procedures if they agreed to participate in the study.

Consent for publication

Not Applicable.

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to the terms of consent/assent to which the participants agreed, but are available from the corresponding author upon reasonable request.

Competing interests

None to declare.

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Authors' contributions

Junhye Kwon drafted the manuscript and prepared the data; Junhye Kwon and Chung Gun Lee analyzed and interpreted the data; Joon-Ho Kang and Chung Gun Lee helped draft the manuscript and perform the analysis; Junhye Kwon and Chung Gun Lee reviewed and edited the manuscript; Joon-Ho Kang obtained funding for the study; All authors have read and approved the final version of the manuscript.

Authors' information (optional)

Not applicable.

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Figures



Figure 1

Example of participants posting LTPA weekly goals (English translation)

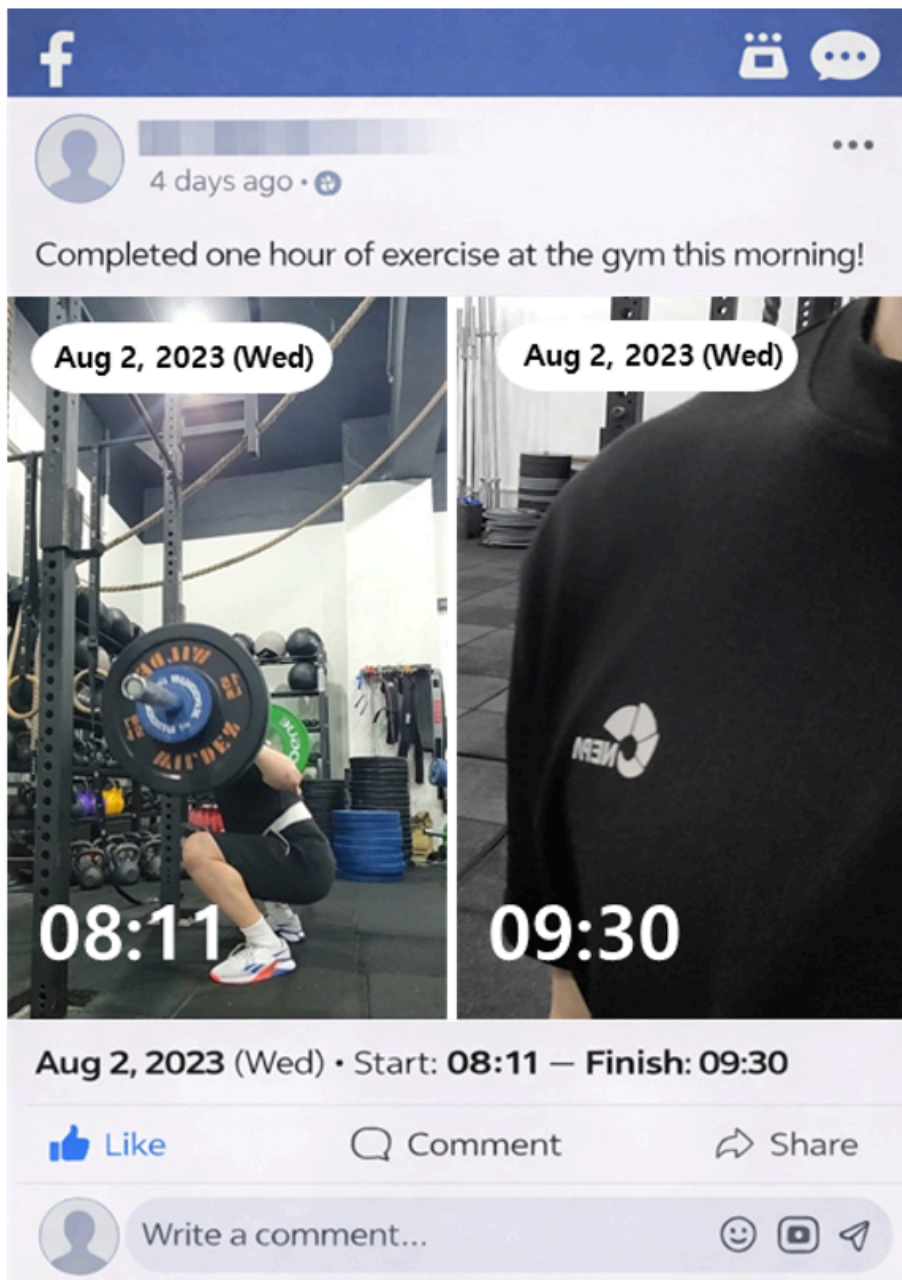


Figure 2

Example of LTPA participation verification images (English translation)

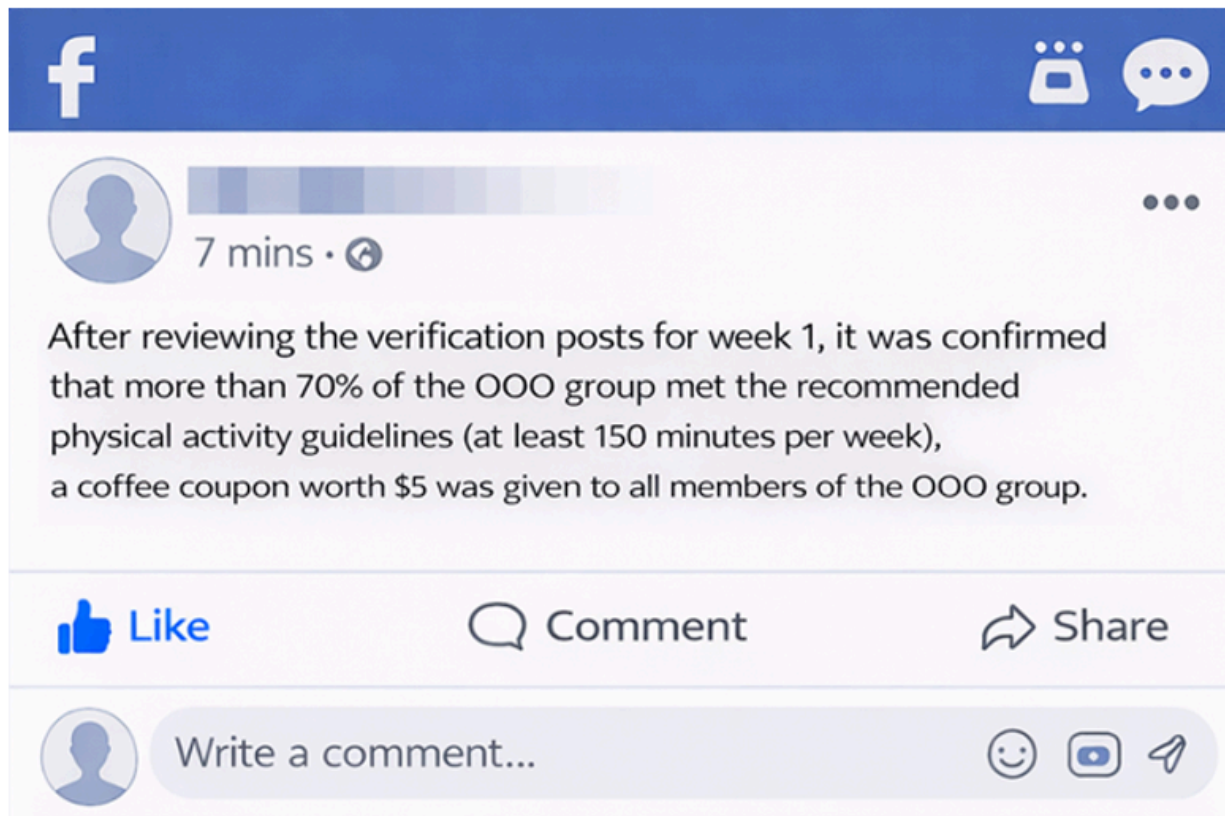
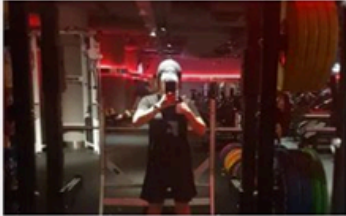


Figure 3

Example of normative messages (English Translation)

LTPA Secrets!

Participant A's LTPA Secrets Interview!



Participant A has been consistently meeting the recommended physical activity levels every week through gym workouts and table tennis. Below is an interview with participant A sharing their secrets to maintaining regular leisure-time physical activity participation.

Q1. What benefits do you get from exercising?

"Working out helps me manage stress and feel better emotionally. It gives me a sense of achievement and makes my day feel more productive. I also enjoy the social aspect of exercise, especially table tennis, because it allows me to meet new people and build friendships."

Q2. How do you manage to meet your weekly exercise goals?

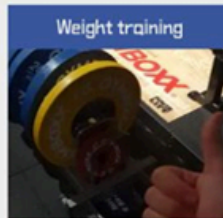
"I try to set weekly goals that are realistic and manageable within my schedule. Instead of pushing myself too hard, I focus on what I can actually achieve and stay consistent in working toward those goals."

Q3. What changes have you noticed since you participated in the LTPA program?

"I feel much fitter than before. With better stamina, I can focus more easily and get things done more efficiently. Having more energy has also made me feel more relaxed mentally, and I find myself paying more attention to and caring more about the people around me."

Weight training: 3-4 times a week

Table tennis: 3-4 times a week



Q4. How did you manage to keep exercising during exams?

"I set a rule for myself to stick to my exercise goals. Since I value keeping my own rules, I try to exercise no matter how busy I am, unless something really unavoidable comes up."

Q5. What keeps you motivated to exercise consistently?

"I enjoy the sense of accomplishment and personal growth that comes from overcoming challenges. Learning new skills such as practicing and improving my table tennis shots makes the process both rewarding and motivating."

Create your own secrets to consistent LTPA participation like Participant A!

Figure 4

Example of a role model interview (English translation)

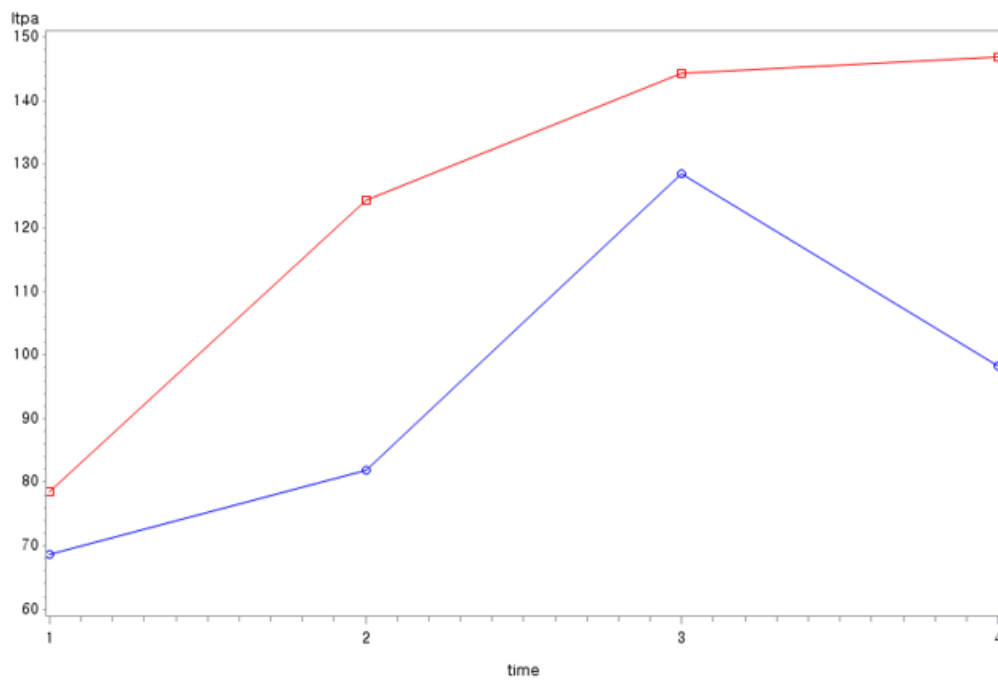


Figure 5. Changes in LTPA participation over time in the first sub-groups

■ ■ ■ Intervention group

● ● ● Control group

Figure 5

See image above for figure legend

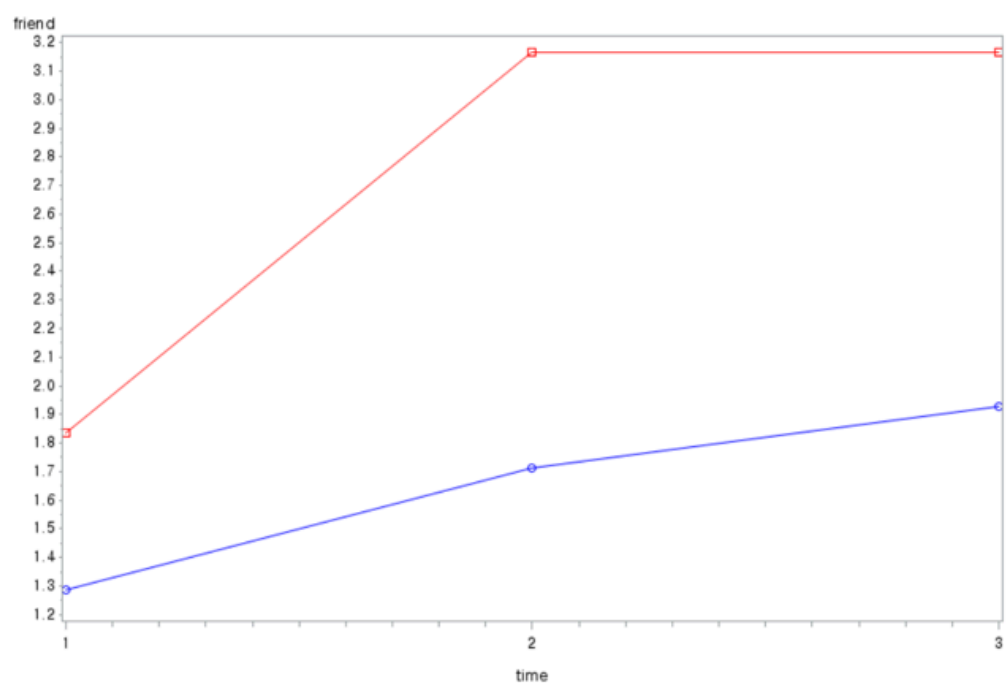


Figure 6. Changes in motivation to comply with friends over time in the second sub-groups

PHIA Intervention group

Control group

Figure 6

See image above for figure legend

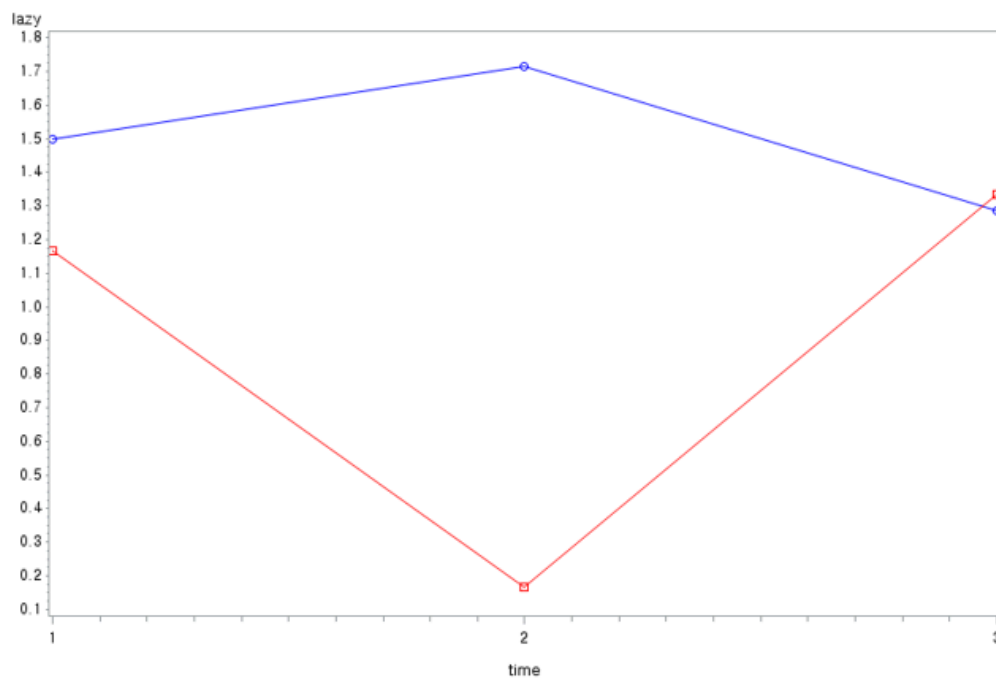


Figure 7. Group $\times$ time interaction in perceived laziness in the second sub-groups

■ ■ ■ PHIA Intervention group

● ● ● Control group

Figure 7

See image above for figure legend

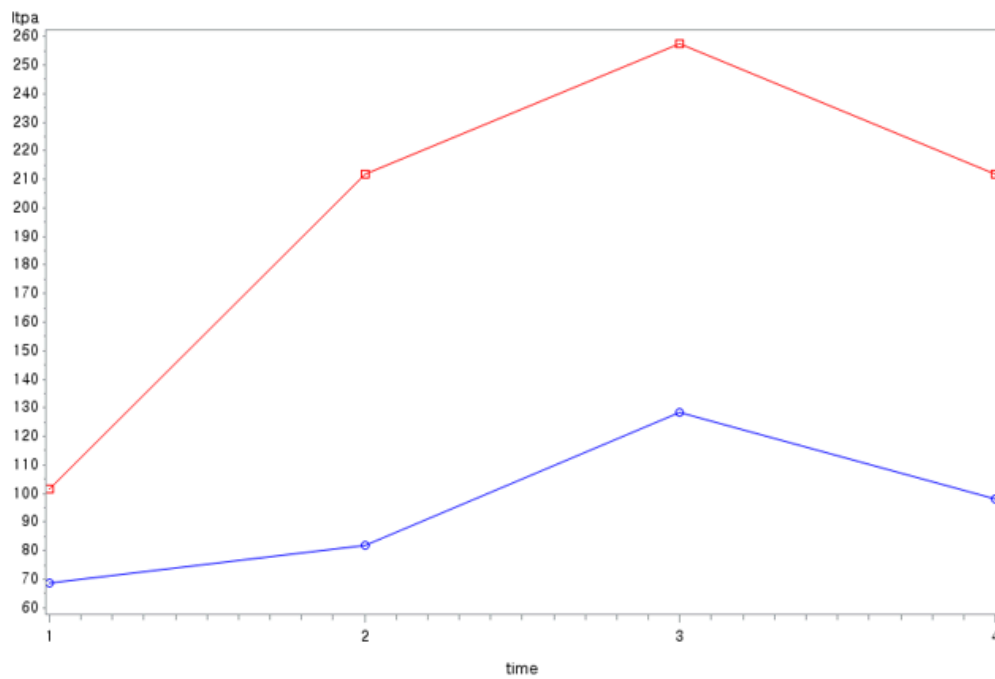


Figure 8. Changes in LTPA participation over time in the second sub-groups

PHIA Intervention group

Control group

Figure 8

See image above for figure legend

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