A BELIEF-BASED JUMP ROPE INTERVENTION TO PROMOTE LEISURE-TIME PHYSICAL ACTIVITY AMONG INACTIVE UNIVERSITY STUDENTS IN SOUTH KOREA: A PERCEPTION AND PROCESS EVALUATION

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Abstract. Despite persistently low levels of physical activity among university students following the COVID-19 pandemic, theory-driven interventions targeting inactive students remain limited. The study developed, implemented and evaluated a belief-based leisure-time physical activity promotion program for inactive university students. Inactive undergraduate students engaging in less than 150 minutes of physical activity per week were recruited from a South Korean university. A four-week jump rope intervention was implemented. Process evaluations, including reach, dose delivered, dose received, and fidelity, were assessed at the midpoint and the post-intervention stages. Group-by-time effects on leisure-time physical activity-related beliefs, intentions and behaviors were assessed using a generalized linear model with repeated measurements at four time points (pre-intervention, midpoint, post-intervention, and one-month follow-up). Significant changes in the intervention effects were observed for key leisure-time physical activity-related beliefs. Compared with the control group, physically inactive students with high intervention adherence demonstrated greater increases in perceived mental and physical health benefits from the post-intervention period through to the one-month follow-up. Improvements were also observed in the perceived "friends' approval" and control beliefs related to exercise facilities and exercise partners, particularly at the midpoint assessment. These findings indicate that belief-based leisure-time physical activity interventions informed by empirically identified beliefs can effectively modify targeted beliefs among physically inactive university students. Future studies should determine whether sustained belief changes can

translate into longer-term improvements in physical activity behavior.

Keywords: belief-based intervention, leisure-time physical activity, physical inactivity, university student

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INTRODUCTION

Globally, physical inactivity remains a major public health concern. Recent global estimates indicate that approximately one-third of adults, around 1.8 billion people, fail to achieve recommended levels of physical activity, defined as engaging in at least 150 minutes of moderate-intensity activity per week among those 18-64 years of age (Strain *et al*, 2024). Physically inactive young adults represent a key population for public health intervention due to their increased risk of future health problems without sustained behavior change, and evidence shows that interventions targeting this group can be effective in promoting an increase in physical activity (Howlett *et al*, 2019).

Within the university-age population, low levels of physical activity appear to be particularly common. A meta-analysis by Keating *et al* (2005) revealed that approximately 40-50% of college students are classified as physically inactive, with a major proportion of students not achieving the recommended physical activity guidelines. In South Korea, only 20.8% of university students were reported to engage in regular physical activity (Kim *et al*, 2010), and participation in sports declined by approximately 23.4% following the COVID-19 outbreak (Park *et al*, 2020).

In addition, while previous research primarily documented a decline in physical activity during periods of COVID-19-related restrictions (López-Valenciano *et al*, 2021), recent studies showed that altered physical activity patterns among university students have not fully returned to pre-pandemic levels (Muntean *et al*, 2025). These findings indicate an ongoing reduction in physical activity and that the effects of the COVID-19 pandemic on students' health behavior may extend beyond the acute phase of the outbreak. In this context, promoting physical activity interventions online may be appropriate for university students who have become accustomed to obtaining information *via* digital media.

Moreover, college attendance marks a pivotal stage in an individual's development from late adolescence into early adulthood (Arnett, 2000). Importantly, physical activity patterns established during early adulthood tend to persist and shape physical activity behavior later in life (Fish and Nies, 1996). Therefore, promoting physical activity during the college years is critical in instilling long-term health behavior habits. However, interventions focusing on promoting physical activity among South Korean university students, particularly among inactive individuals, remain limited in their application (Jeong *et al*, 2024).

To address this gap, our previous study conducted elicitation studies to examine differences in leisure-time physical activity-related beliefs among South Korean university students who met the recommended physical activity guidelines and those who did not (Lee *et al*, 2025). The study was guided by the Theory of Planned Behavior (TPB), which posits that behavioral, normative and control beliefs shape individuals' attitudes, subjective norms and perceived behavioral control (Ajzen, 1991). According to TPB, behavioral intention is a key predictor of behavior, which is influenced by attitudes toward the behavior, subjective norms and

perceived behavioral control (Ajzen, 1991). Based on this theoretical framework, in the aforementioned study, we identified several salient beliefs related to participation in leisure-time physical activity: that physically active and inactive participants exhibit heterogeneous belief structures regarding participation in leisure-time physical activity. In particular, the behavioral beliefs, viz, "enhances appearance", "improves mental health", "improves physical health", and "causes injury" emerged exclusively among the active participants, whereas beliefs such as "improves physical fitness" and "causes fatigue" were identified among both active and inactive participants. With respect to normative beliefs, *eg*, "other family members approve," emerge exclusively among the physically active participants, while beliefs that "friends approve" and "parents approve" are reported by both active and inactive participants. Moreover, a salient control belief identified only among active students is that "having an exercise partner" or "being part of a sports club" facilitates engagement in leisure-time physical activity. Other control beliefs, such as "lack of time" and "good accessibility to exercise facilities," were identified among both active and inactive participants. Our aforementioned study is significant in the field of health promotion as it is the first report comparing physical activity-related beliefs between active and inactive university students (Lee *et al*, 2025), thereby providing a foundation for the development of subsequent belief-based interventions for physically inactive students.

Building on these findings, the present study developed several strategies to promote changes in leisure-time physical activity beliefs, intentions and behaviors among inactive university students from the same target population of our previous study (Lee *et al*, 2025). This leisure-time physical activity promotion program included the following interventions: (i)

providing a jump rope to promote beliefs regarding physical activity participation in resource-limited settings (*eg*, limited time, space and facility) (Ha *et al*, 2014; Maria *et al*, 2025); (ii) sharing articles describing celebrities' successful weight loss and physical fitness improvement through use of the jump rope as role models to strengthen positive outcome-related beliefs (Durau *et al*, 2022; He *et al*, 2025); (iii) sharing interviews of peer role models to promote beliefs of "friends' approval" of physical activity participation and positive health-related outcomes (Madtha *et al*, 2023); and (iv) organizing group missions to promote physical activity-related communications among participants and encourage supportive peer norms (Zahnow and Corcoran, 2026; Buja *et al*, 2024). These multiple interventions might appear complex because they concurrently target not only individuals but also the physical and social environment (Lee *et al*, 2022). Understanding whether such a multi-component, belief-targeted intervention is implemented as intended requires careful process evaluation (Cook and Campbell, 1979; Baranowski and Stables, 2000). When interventions result in effective health behavior change, process evaluation provides essential data for guiding future interventions (Israel *et al*, 1995; Wight and Obasi, 2003; Spillane *et al*, 2007). Likewise, if no impact on behavior change is observed, process evaluation can help pinpoint factors that may have hindered implementation of the intervention process (Flowers *et al*, 2002; Plummer *et al*, 2007; Spillane *et al*, 2007). Therefore, process evaluation is not an optional step but a necessary procedure that should be incorporated into any evaluation of health promotion programs.

Accordingly, we evaluated the process and results of a leisure-time physical activity intervention developed based on the salient beliefs identified in our previous report (Lee *et al*, 2025) using the same target population, *ie*,

physically inactive South Korean university students.

MATERIALS AND METHODS

Study location and participants

Students attending a university in South Korea during (28 April – 25 May 2025), who spent less than 150 minutes per week on leisure-time physical activity, were recruited *via* group email invitations that included a link to a pre-intervention questionnaire. Participants were without physical activity limitations.

Participants were first stratified according to weekly physical activity time and sex. Within each group, participants were sequentially assigned to the intervention or control group using an alternating allocation procedure. Subsequently, participants were systematically distributed into ten subgroups, five students per subgroup, using a repeating ascending/descending sequence. A formal a priori sample size calculation was not performed. The sample size was determined based on feasibility considerations (Fig 1).

Intervention

A leisure-time physical activity program, developed based on the salient beliefs identified in our previous research (Lee *et al*, 2025), was sent through a KakaoTalk Open Chat mobile messaging platform incorporating various intervention materials designed to promote changes in physical activity beliefs, intention and participation behavior. In addition, a main chat group that included both researchers and all participants was provided throughout the intervention period of four weeks. Following completion of the baseline survey, participants in the control group were included in the KakaoTalk Open Chat room for survey administration and not provided with any intervention materials or program-related content during the intervention period.

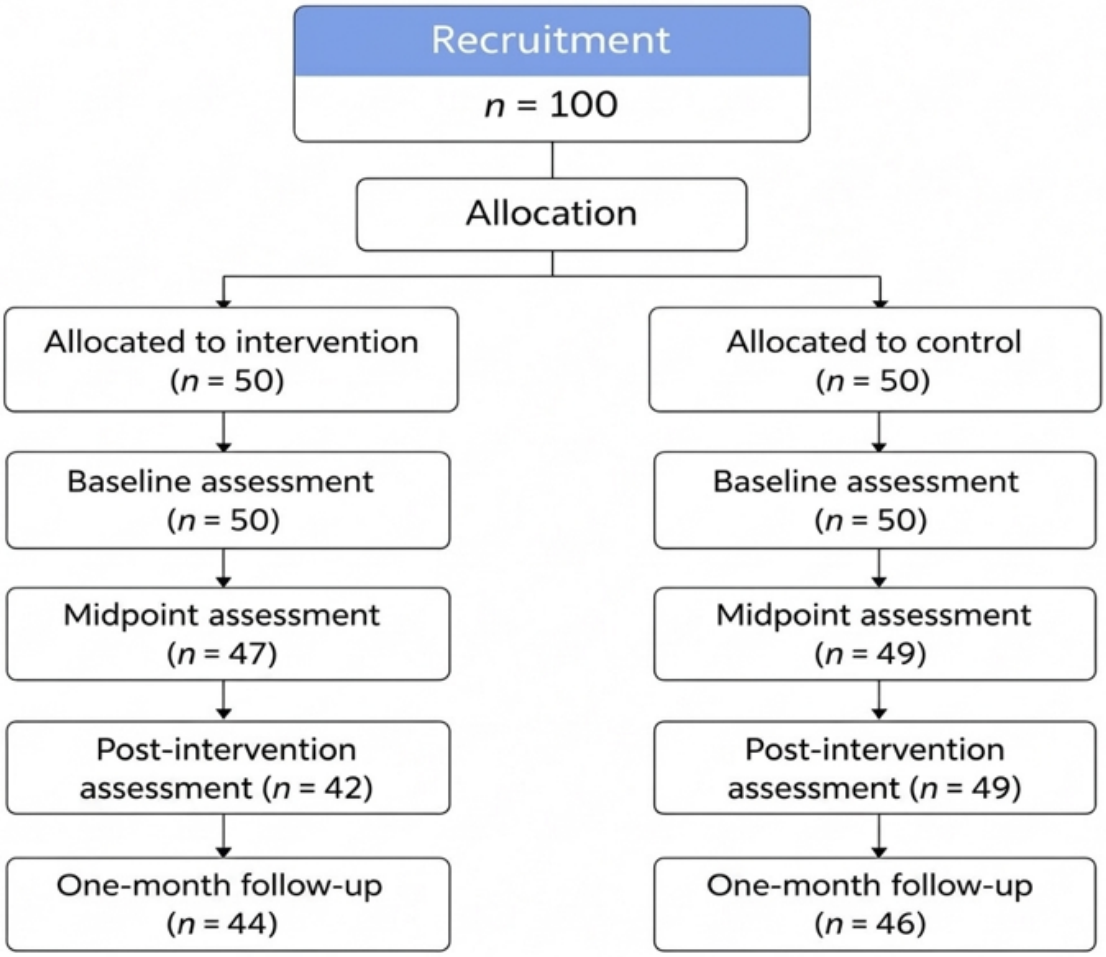


Fig 1 - Flow chart of university student participants during the course of the study

The intervention contents were as follows:

(i) A jump rope. This is widely recognized as a cost-effective and accessible physical activity equipment due to its low requirements for time, space and additional equipment, making it particularly suitable in resource-limited settings (Ha *et al*, 2014; Maria *et al*, 2025). The jump rope was provided to target control

beliefs, such as "lack of time makes it difficult" and "good accessibility to exercise facility makes it easy".

(ii) Information materials on role models. Role models can influence physical activity behavior by providing salient and relatable examples of successful engagement (Yancey, 1998; Lyle, 2009). The role model materials were to target the behavioral beliefs, such as "improves physical fitness" and "enhances appearance". Given the evidence that people can be motivated by celebrities, influencers and peers (Durau *et al*, 2022; He *et al*, 2025), information on celebrities' successful weight loss and physical fitness improvement through the use of jump rope was made available in the main chat room. Fig 2 illustrates a typical example.

(iii) Materials on a peer role model's personal experience. As a peer influence has been observed across multiple lifestyle behaviors among university students, including physical activity (Madtha *et al*, 2023). These items targeted the behavioral beliefs of "improves physical and mental health" and the normative belief of "friends approve". Participants who had successfully achieved their personal physical activity goals during the first two weeks of the program were selected as role models. They were asked about perceived changes resulting from the program as well as their individual strategies for engaging in continual leisure-time physical activity. The researchers then converted the interviews into blog articles and made them available in the main chat room. Fig 3 depicts a typical example.

(iv) Group missions and incentives. Since interventions that include group activities are more effective among university students (Harden *et al*, 2015; Buja *et al*, 2024), incentive-based group missions were implemented. Students were asked to share their physical activity experiences with members of their KakaoTalk Open Chat group. Firstly, participants were instructed to download an application that records the actual

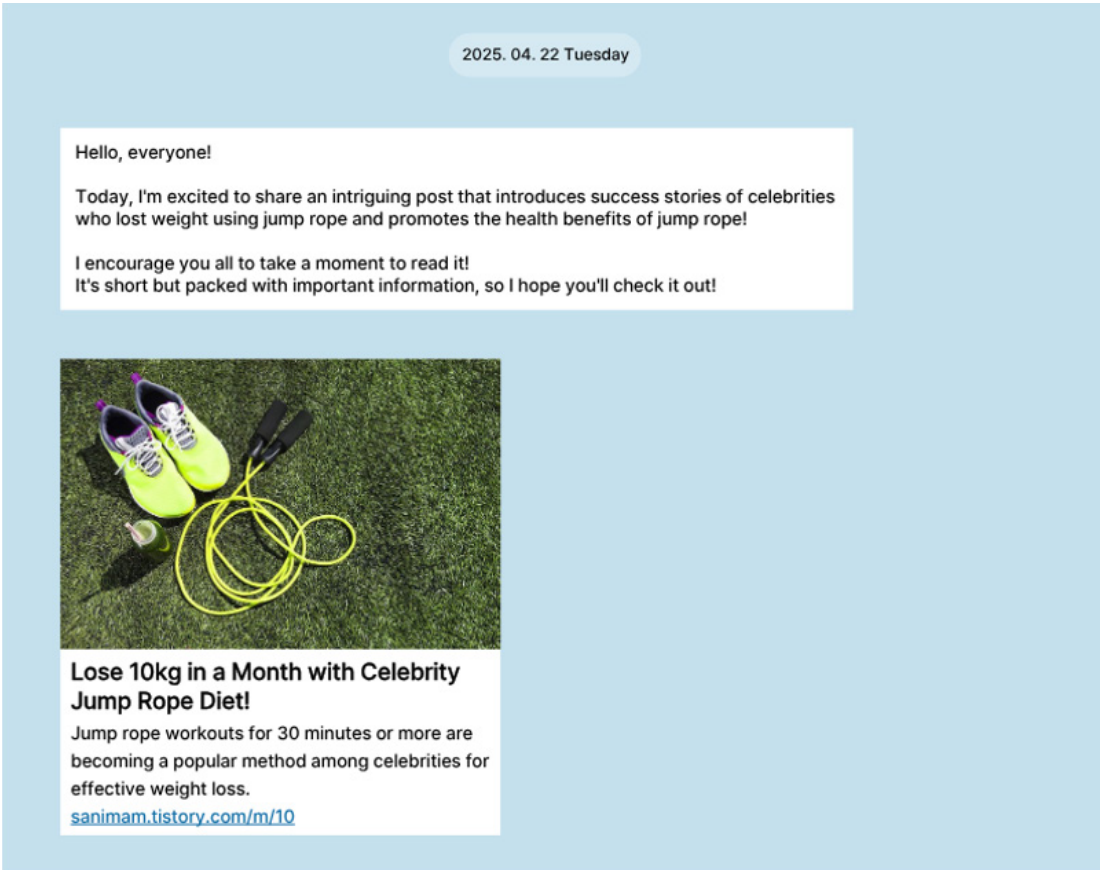
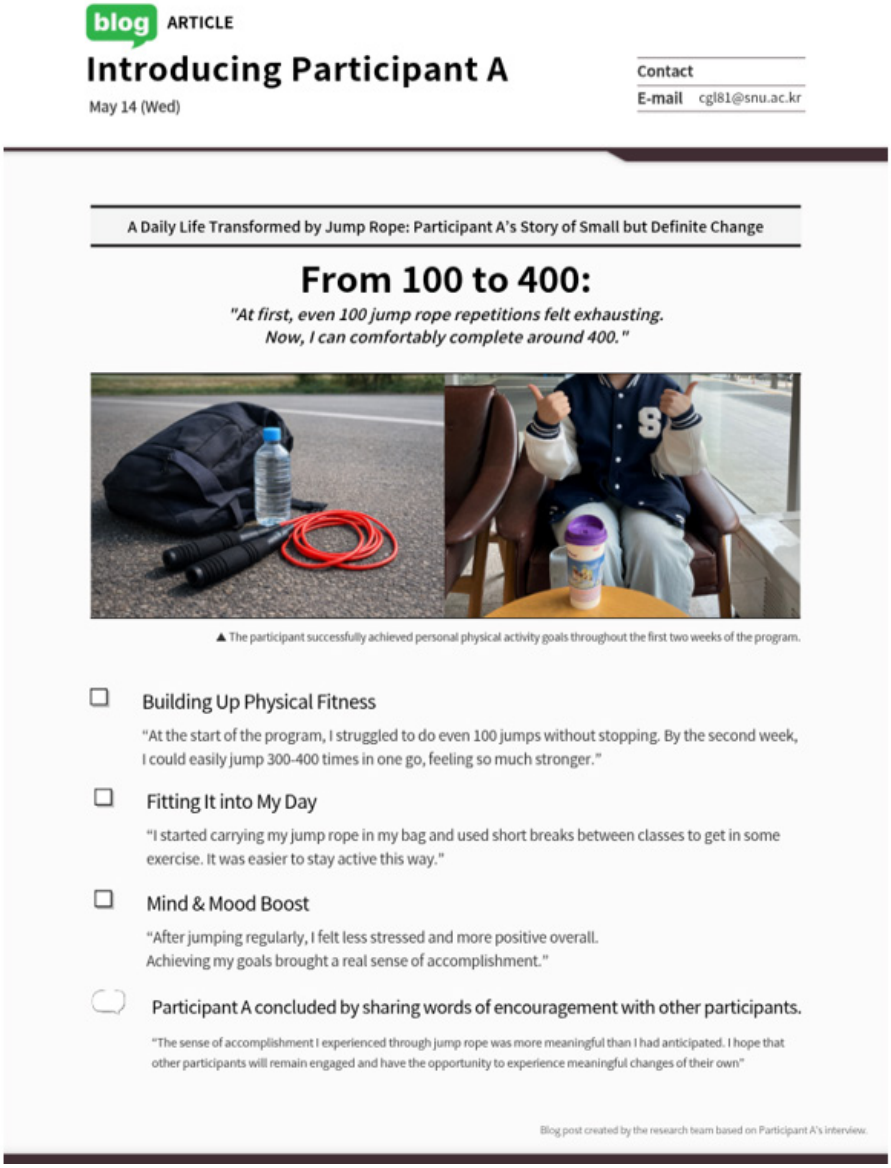


Fig 2 - Example of an article URL featuring celebrity jump rope workout posted in KakaoTalk Open Chat (English translation)

kg: kilogram; URL: uniform resource locator

date and time of photos and videos. And secondly, they were asked to film and upload a video clip each time they engaged in their jump rope exercise.

The researchers set weekly individual physical activity goals consisting of 60, 90, 120, and 150 minutes of jump rope exercise from the first to the last week, respectively of the intervention. Students were also instructed to perform jump



blog ARTICLE

Introducing Participant A

May 14 (Wed)

Contact
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A Daily Life Transformed by Jump Rope: Participant A's Story of Small but Definite Change

From 100 to 400:

"At first, even 100 jump rope repetitions felt exhausting. Now, I can comfortably complete around 400."

▲ The participant successfully achieved personal physical activity goals throughout the first two weeks of the program.

☐ Building Up Physical Fitness

"At the start of the program, I struggled to do even 100 jumps without stopping. By the second week, I could easily jump 300-400 times in one go, feeling so much stronger."

☐ Fitting It into My Day

"I started carrying my jump rope in my bag and used short breaks between classes to get in some exercise. It was easier to stay active this way."

☐ Mind & Mood Boost

"After jumping regularly, I felt less stressed and more positive overall. Achieving my goals brought a real sense of accomplishment."

Participant A concluded by sharing words of encouragement with other participants.

"The sense of accomplishment I experienced through jump rope was more meaningful than I had anticipated. I hope that other participants will remain engaged and have the opportunity to experience meaningful changes of their own"

Blog post created by the research team based on Participant A's interview.

Fig 3 - Example of blog-style article curated by the research team based on an interview with a participant (English translation)

rope exercise for at least 10 minutes per session. When at least four out of five group members achieved their personal goals, a monetary incentive of a coupon equivalent to USD 5 was provided that week to all group members, regardless of the individual's achievement status.

In addition, a bonus group mission was implemented requiring at least four out of five group members to complete 50, 100, 150, and 200 consecutive rope skips in a single attempt from the first to the last week, respectively of the program. When this condition was met without failure, all group members received the USD 5 coupon. These group missions are intended to target the normative belief of "friends approve" and the control belief of "having an exercise partner" or "being part of a sports club".

Data collection

Both the process and outcome evaluations of the leisure-time physical activity program were administered using a Google online survey. Process evaluations were performed at the mid- and post-intervention periods. In addition, a process evaluation was conducted after the post-intervention period by two graduate research assistants who were involved in implementing the intervention. Outcome evaluations were conducted at pre-, mid-, and post-intervention periods as well as at a one-month follow-up after the program ended.

Process evaluation

The study evaluated intervention reach, dose delivered/received and fidelity during and after the program (Steckler and Linnan, 2002; Saunders *et al*, 2005; Glasgow and Linnan, 2008). Intervention reach refers to the extent to which the intended population participates in the intervention and is usually assessed by attendance rates. Dose delivered reflects the extent to which the planned components of the intervention are delivered as intended by researchers or intervention staff and can be evaluated through direct

observation. Dose received refers to the degree to which participants are receptive to, engage with and utilize program materials. Intervention fidelity refers to the quality of implementation and reflects the extent to which the intervention is delivered in accordance with the underlying theory.

Questions assessing reach and dose received among participants at mid- and post-intervention periods used a dichotomous (Yes/No) and frequency-based response format respectively (Tables 1 and 2). In addition, process evaluation measures were performed by the program staff to assess the dose delivered and intervention fidelity using a four-point Likert scale (Table 3).

Outcome evaluation

Outcome evaluation was conducted in the form of questions (Table 4). Behavioral, normative and control beliefs, and intention regarding leisure-time physical activity participation were measured using a seven-point Likert scale (ranging from -3 = extremely unlikely to 3 = extremely likely). Leisure-time physical activity participation was assessed by measuring frequency and duration; weekly average participation time over the past month was calculated by multiplying these two components (Table 4).

Data analysis

A 2×4 repeated-measures generalized linear model (GLM) analysis was used to assess changes in participants' beliefs, intentions and behaviors related to leisure-time physical activity across baseline, midpoint, post-intervention, and one-month follow-up. Subgroup analysis was performed to assess program effectiveness by comparing the performance of participants in the high intervention adherence group with that of the control group. High intervention adherence is defined as participants responding "yes"

to process evaluation questions regarding reading posts, awareness of group missions and reading other participants' postings. All analyses were conducted using the SAS 9.4 statistical program (SAS Institute Inc, Cary, NC).

Ethical consideration

The study protocols were approved by the Seoul National University Institutional Review Board (IRB no. 2504/003-021) and were conducted in accordance with the Declaration of Helsinki. Prior written consent was obtained from each participant.

RESULTS

Characteristics of participants

One hundred participants were recruited at baseline, and 90 participants (44 in intervention and 46 in control group) completed the leisure-time physical activity program, including the one-month follow-up survey (Fig 1). Among the participants, a higher proportion were female students compared to males (female, 58%; male, 42%). The results of the baseline survey indicated that the leisure-time physical activity participation time of the intervention and control groups was 45 and 44 minutes respectively.

Reach and dose received

Forty-seven participants responded to the mid-point process evaluation. The majority of the participants reported reading posts related to the jump rope exercise, with 93% indicating they read both posts and 33% reporting having read the posts from beginning to end (Table 1). Overall adherence to the intervention had declined at the mid-point process evaluation (Table 2). Although the proportion of participants who read the interview posts was quite high (77%), fewer than one-third of the participants reported thoroughly reading the content. In addition, approximately two-thirds of participants reported checking other participants' jump rope videos, whereas 44% reported posting their own video clips.

Dose delivered and fidelity.

The results of the 12-item process evaluation survey indicated that most intervention components were delivered with high fidelity, except the group mission (Table 3). Specifically, the mean score for the item assessing participants' active engagement in group missions was 2.00, whereas all other items showed higher mean scores, ranging from 3.0 to 4.

Table 1

Process evaluation at mid-period of jump rope intervention of physically inactive university students (N = 47), South Korea (28 April – 25 May 2025)

	Question	Response, *n* (%)
1.	Were you provided with a jump rope for the leisure-time physical activity program? (Yes/No)	Yes, 46 (98)
2.	Did you join the KakaoTalk Open Chat? (Yes/No)	Yes, 47 (100)
3.	Were you assigned to KakaoTalk Open Chat group? (Yes/No)	Yes, 47 (100)
4.	Have you ever read any posts related to jump rope in the main chat room? (Yes/No)	Yes, 46 (98)
5.	Of the two posts, how many did you read? (0/1/2)	2, 44 (93)
6.	Of the two posts, how many did you read from beginning to end? (0/1/2)	2, 16 (35)
7.	Were you aware of the group missions? (Yes/No)	Yes, 47 (100)
8.	Have you posted your jump rope video clip in the group chat room? (Yes/No)	Yes, 22 (46)
9.	Have you looked at other participants' jump rope video clips? (Yes/No)	Yes, 28 (60)

Table 2

Process evaluation at post-process of jump rope intervention of physically inactive university students (N = 43), South Korea, (April 28–May 25, 2025)

	Question	Response, *n* (%)
1.	Have you read interview posts from peer participants in the main chat room? (Yes/No)	Yes, 33 (77)
2.	Of the two posts, how many did you read? (0/1/2)	2, 18 (41)
3.	Of the two posts, how many did you read from beginning to end? (0/1/2)	2, 12 (28)
4.	Were you aware of the group missions? (Yes/No)	Yes, 42 (97)
5.	Have you ever posted your jump rope video clip in the group chat room? (Yes/No)	Yes, 19 (44)
6.	Have you ever checked other participants' jump rope video clips? (Yes/No)	Yes, 29 (67)

Outcome evaluation

Differences in leisure-time physical activity beliefs, intention and behavior among the subgroups (high intervention adherence versus control) are presented in Table 5. Marginally significant intervention effects were observed for perceived mental health and physical health benefits of leisure-time physical activity ($F = 2.29$, $p = 0.080$; $F = 2.37$, $p = 0.072$, respectively; Table 5). As shown in Fig 4A and B, the high intervention adherence group had a high likelihood of perceiving that leisure-time physical activity improved mental and physical health at post-intervention and one-month follow-up. Notably, mental and physical health-focused content was delivered after the midpoint assessment, which may be associated with the subsequent improvement observed after the midpoint.

Table 3

Process evaluation of jump rope intervention by program staff (N = 2), South Korea (28 April – 25 May 2025)

	Item	Mean (SD)*
1.	Staff provided a jump rope to all participants.	4 (0.0)
2.	Participants appear to like the jump rope intervention.	4 (0.0)
3.	Number of role model related posts on the Open Chat is appropriate.	4 (0.0)
4.	Participants appear to like the role model related posts on the Open Chat.	3.0 (0.0)
5.	Participants carefully read the role model related posts provided on the Open Chat.	3.0 (0.0)
6.	Number of peer role model-related posts on the Open Chat is appropriate.	4 (0.0)
7.	Participants appear to like the peer role model-related posts on the Open Chat.	4 (0.0)
8.	Participants carefully read the peer role model related posts provided on the Open Chat.	3.0 (0.0)
9.	Staff provided a detailed explanation regarding group missions related to LTPA participation.	4 (0.0)
10.	Number of participants in the group is appropriate.	4 (0.0)
11.	Participants fully understood the group missions.	4 (0.0)
12.	Participants actively engaged in the group missions.	2.0 (0.0)

*Based on a 4-point Likert scale ranging from 1 = strongly disagree to 4 = strongly agree

LTPA: leisure-time physical activity

Table 4

Questions on behavioral, normative and control beliefs, intention and time spent on leisure-time physical activity participation

Category	Question
BB	1. Do you think participating in leisure-time physical activity can improve your physical fitness?
	2. Do you think participating in leisure-time physical activity can make you feel fatigued?
	3. Do you think participating in leisure-time physical activity can make improve your appearance?
	4. Do you think participating in leisure-time physical activity can improve our mental health?
	5. Do you think participating in leisure-time physical activity can improve your physical health?
NB	1. Do you think your friends would approve or disapprove your participation in leisure-time physical activity?
	2. Do you think your parents would approve or disapprove your participation in leisure-time physical activity?
CB	1. Do you think that you lack sufficient time to engage in leisure-time physical activity?
	2. Do you think that there is a lack of exercise facilities available to engage in leisure-time physical activity?
	3. Do you have an exercise partner at the sports club to participate in leisure-time physical activity?
Intention	Do you plan to engage in leisure-time physical activity in the following month?
LTPA time	1. How many days per week did you engage in leisure-time physical activity during the past month?
	2. How many minutes per day did you spend on leisure-time physical activity during the past month?

BB: behavioral belief; CB: control belief; LTPA: leisure-time physical activity; NB: normative belief

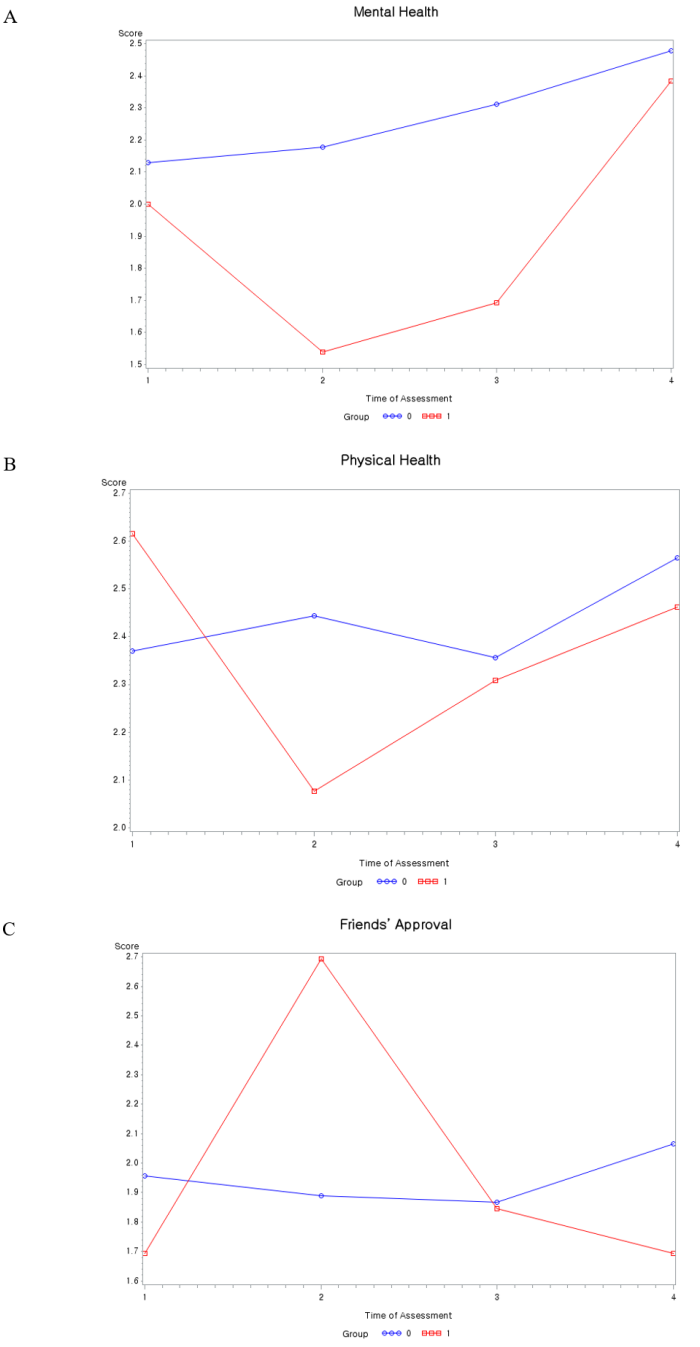

Fig 4 - Changes at various times of the leisure-time physical activity intervention in the university students' perceived
(to be cont.)

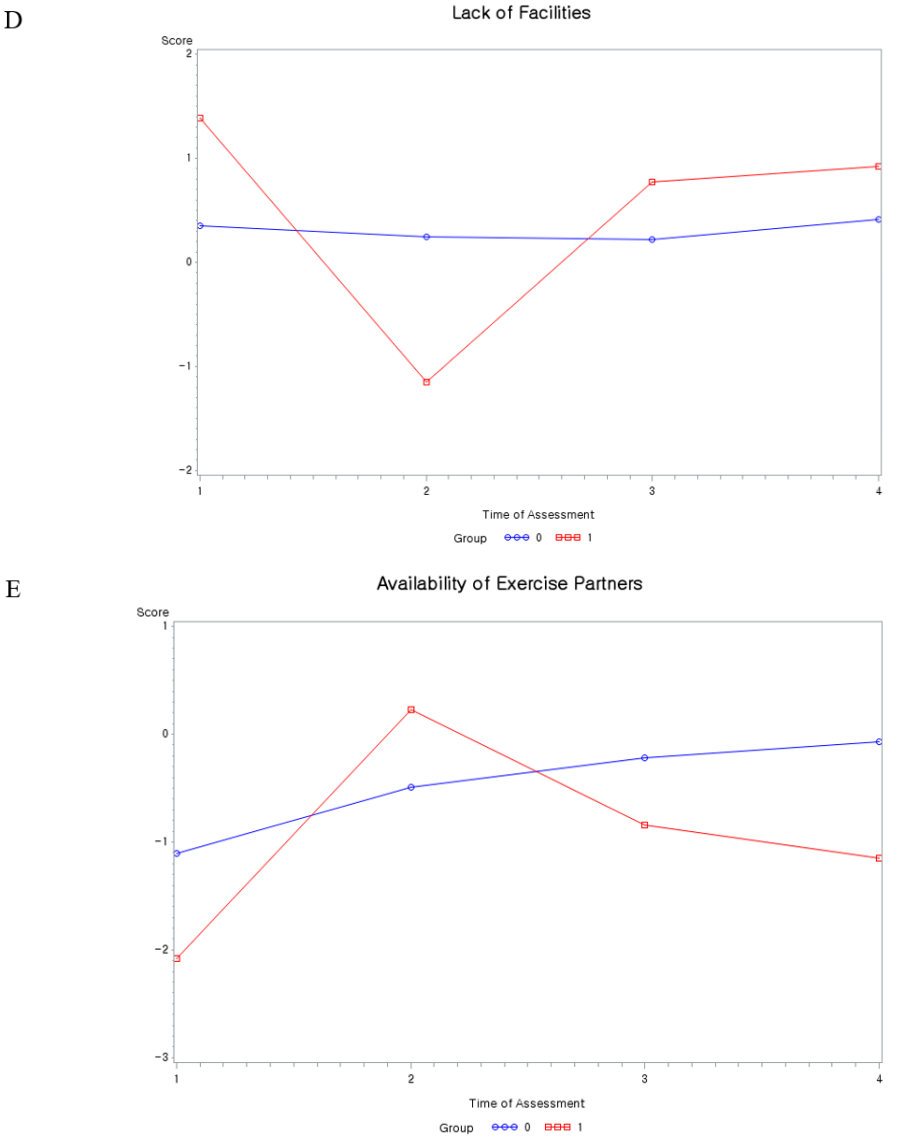

Fig 4 - Changes at various times of the leisure-time physical activity intervention in the university students' perceived

The scores of perceived parameters (y-axis) were based on a Likert scale with a higher score indicating a greater perception, and the time of assessment (x-axis) is denoted by 1 (pre-intervention), 2 (intervention midpoint), 3 (post-intervention), and 4 (1-month follow-up). Group is denoted by 1 (high intervention adherence group) and 0 (control group).

Table 5

Statistical association between demographic variables and cancer awareness categories among students (N = 429), King Khalid University, Abha, Saudi Arabia, August to December 2025

Item[a]	High intervention adherence group, score, mean (SD)[b]				Control group score, mean (SD)[b]				Group *F*	Time *F*	GT *F*
	Pre-intervention	Mid-intervention	Post-intervention	1-month follow-up	Pre-intervention	Mid-intervention	Post-intervention	1-month follow-up			
LTPA, minutes/ week	41 (47)	40 (27)	95 (93)	72 (65)	41 (38)	68 (65)	83. (105)	105 (141)	0.50	4.02‡	0.83
Intention	6.2 (0.9)	5.9 (0.5)	5.8 (1.1)	6.3 (0.8)	6.1 (0.7)	5.6 (1.3)	5.5 (1.3)	5.8 (1.3)	1.19	3.26†	0.54
BB1	2.1 (0.5)	2.08 (0.5)	2.1 (1.0)	2.1 (1.6)	2.2 (1.0)	2.3 (0.7)	2.3 (0.6)	2.5 (0.7)	1.35	0.50	0.15
BB2	1.6 (0.6)	1.7 (0.9)	1.0 (1.5)	1.2 (1.4)	1.7 (0.7)	1.7 (0.9)	1.7 (0.9)	1.6 (1.0)	1.22	2.19*	1.78
BB3	0.9 (1.8)	1.3 (1.3)	1.4 (1.2)	1.8 (1.1)	1.4 (1.4)	1.8 (1.1)	2.0 (1.1)	2.0 (1.1)	1.87	5.01‡	0.35
BB4	2.0 (1.0)	1.5 (1.0)	1.7 (1.0)	2.4 (0.8)	2.1 (0.8)	2.1 (1.0)	2.3 (0.8)	2.5 (0.6)	3.20*	5.66‡	2.29*
BB5	2.6 (0.5)	2.1 (0.3)	2.3 (0.8)	2.5 (0.9)	2.4 (0.7)	2.4 (0.7)	2.4 (0.9)	2.6 (0.6)	0.13	2.06	2.37*
NB1	1.7 (1.2)	2.7 (0.8)	1.8 (1.2)	1.7 (1.6)	2.0 (1.0)	1.9 (1.2)	1.9 (1.0)	2.1 (0.9)	0.03	3.63†	4.95†
NB2	2.5 (0.7)	2.8 (0.6)	2.4 (1.1)	2.5 (0.7)	2.7 (0.7)	2.6 (0.7)	2.5 (0.9)	2.7 (0.7)	0.04	1.43	0.66

Table 5 (cont)

Item[a]	High intervention adherence group, score, mean (SD)[b]				Control group score, mean (SD)[b]				Group *F*	Time *F*	GT *F*
	Pre-intervention	Mid-intervention	Post-intervention	1-month follow-up	Pre-intervention	Mid-intervention	Post-intervention	1-month follow-up			
CB1	0.8 (1.7)	1.5 (1.6)	0.9 (1.7)	0.8 (1.5)	1.2 (1.2)	1.3 (1.1)	1.0 (1.2)	1.0 (1.5)	0.11	1.87	0.45
CB2	1.4 (1.6)	-1.1 (1.5)	0.8 (1.6)	0.9 (1.5)	0.3 (1.5)	0.2 (1.5)	0.2 (1.4)	0.4 (1.5)	0.30	11.70‡	10.70‡
CB3	-2.1 (1.3)	0.2 (2.3)	-0.8 (1.6)	-1.1 (1.8)	-1.1 (1.4)	-0.5 (1.5)	-0.2 (1.9)	-0.1 (1.7)	1.24	11.10‡	4.39‡

[a]From Table 4; [b]Based on Likert-type scale, higher score indicating stronger belief

*p-value <0.10; †p-value <0.05; ‡p-value <0.01; comparing changes between groups over time using a repeated-measures generalized linear model

BB: behavioral belief; CB: control belief; F: F statistics from repeated-measures generalized linear model analyses; Group: between-group effect; GT: Group × Time interaction; LTPA: leisure-time physical activity;

NB: normative belief; SD: standard deviation; Time: within-subject effect

There was no interaction effect for perceived parental approval; however, a significant intervention effect was observed for friends' approval (F = 4.95; p-value = 0.003; Table 5). Post-hoc tests showed a dramatic increase in perceived friends' approval at the midpoint for the high intervention adherence group compared with the control group (F = 8.12; p-value = 0.006; Fig 4C).

For control beliefs, a significant interaction effect was identified for perceived lack of exercise facilities (F = 10.72; p-value <0.0001; Table 5). Post-hoc tests indicated that the high intervention adherence group was less likely to perceive a lack of exercise facilities available for leisure-time physical activity at the midpoint compared with the control group (F = 21.54; p <0.0001; Fig 4D). In addition, a significant intervention effect was observed for having exercise partners (F = 4.39; p-value = 0.005; Table 5), with post-hoc tests showing that the high intervention adherence group was more likely to perceive having exercise partners for engaging in leisure-time physical activity at the midpoint compared with the control group (F = 10.54; p-value = 0.002; Fig 4E). Although several significant intervention effects were observed for leisure-time physical activity beliefs, no significant intervention effects were found for intention and behavior.

DISCUSSION

The process and outcome evaluations of the intervention promoting leisure-time physical activity among inactive, high intervention adherence university students revealed several important findings. Specifically, the post-intervention assessment showing an increase in perceived mental and physical health benefits appeared to be closely aligned with the timing of the belief-targeted intervention content. Mental and physical health-focused materials were provided after the midpoint assessment, coinciding with the emergence of an upward trend that was maintained through to the

one-month follow-up. Previous research demonstrated that peer influence plays a crucial role in shaping physical activity behaviors among university students (Madtha *et al*, 2023) and that the perceived role model beliefs are strongly associated with physical activity behaviors in this population (Thompson *et al*, 2020). In line with this evidence, exposure to peer role models who shared their experiences of positive changes in physical and mental health may have contributed to reinforcing those two behavioral beliefs after the midpoint assessment. A possible explanation for the sharp decline observed at the midpoint assessment in perceived mental and physical health benefits was that individuals who had rarely engaged in physical activity before the intervention were exposed to higher levels of physical activity than usual, leading to physical fatigue or negative response behaviors. Indeed, previous research reported that physically inactive university students tend to exhibit less positive or relatively more negative responses to aerobic exercise compared to their physically active counterparts (Sala *et al*, 2024).

Another behavioral belief, namely "enhances appearance", identified exclusively among physically active university students in our previous study (Lee *et al*, 2025), did not exhibit a significant group-by-time effect following the intervention. Nevertheless, considering that the belief was originally derived from individuals with relatively high levels of physical activity experience, applying the belief to a physically inactive group represented a meaningful attempt. In our current study, we noted that inactive students might not have sufficient experience with physical activity and might not perceive the importance of participating in physical activity, indicating issues that needed to be addressed to promote their participation in physical activity.

Other than behavioral beliefs, the high intervention adherence group reported a higher rating of "perceived friends' approval" and "availability of exercise partners for leisure-time physical activity participation", particularly at the midpoint of the program. In our previous study (Lee *et al*, 2025), the control belief of "having an exercise partner" emerged exclusively among physically active university students; however, in our present study, this belief was reported among physically inactive students with high intervention adherence. This finding suggested that the group missions and incentive-based strategies implemented in the present study might have fostered a sense of belonging and social connectedness among participants. Indeed, there is evidence that indicates a positive association between physical activity and sense of social belonging, with social interaction and active participation contributing to the enhancement of this sense of belonging (Marchant *et al*, 2025). Furthermore, the group missions implemented in our present study might have strengthened group cohesion through repeated interaction and shared participation, thereby facilitating collective engagement towards common goals (Estabrooks, 2000). Therefore, students might have perceived that they had exercise partners through engagement in group activities, even though jump rope exercise is typically an individual activity.

Moreover, changes in perceived "friends' approval" for leisure-time physical activity among inactive students might have been influenced by social norms through shared exposure and behavioral expectations, as shared exposure to social norms facilitates the spread of behavioral expectations and contributes to the development of shared understandings within a group (Zahnow and Corcoran, 2026). Accordingly, social norms have been shown to exert a positive impact on physical activity behavior (Abraído-Lanza *et al*, 2017; Wally and Cameron, 2017). Even in

the absence of direct behavioral engagement (ie, uploading one's own exercise videos), observing other group members' jump rope videos might have contributed to motivating participation in leisure-time physical activity.

Additionally, the high intervention adherence group became less likely to perceive a "lack of exercise facilities" as a barrier when assessed at the midpoint of the program. This change in belief could be attributed to the characteristics of the jump rope exercise (Ha *et al*, 2014; Maria *et al*, 2025), which requires minimal space and facilities and thereby, enforcing students' perception that they could easily engage in physical activity without access to facilities dedicated to such function. Consequently, as documented in previous reports, the incentive (Mitchell *et al*, 2020) and group based intervention (Harden *et al*, 2015) strategies implemented in our current study might have been effective in promoting belief changes, particularly in perceived "friends' approval", "availability of exercise partners" and "lack of facilities" related to leisure-time physical activity among inactive university students. Additionally, these belief changes were most pronounced in the intervention group compared to the control group during the early phase of the intervention, which might explain the relatively high level of participant engagement during the initial two weeks of the intervention, as evidenced by the process evaluation.

One possible explanation for the decline in adherence to the intervention could be attributed to the increasing demands of the jump rope exercises during the later stages of the program. As the required jump rope counts increased, some participants could have perceived the goal as burdensome, thereby reducing their individual engagement and commitment to the group's goal. Future interventions should benefit from designing more flexible activity goals to sustain participants' engagement

(Takemura *et al*, 2023; Xu *et al*, 2024).

Despite the observed changes in salient beliefs regarding leisure-time physical activity among inactive students with high intervention adherence, no significant effects were found for intention or behavior. This might be attributed to the relatively short duration of the intervention. According to TPB, belief change precedes changes in intention and behavior (Ajzen, 1991; Fishbein and Ajzen, 2011); thus, the short intervention period might not have been sufficient to translate belief changes into the corresponding behavioral changes. Future research should develop interventions that can influence both intentions and behaviors related to leisure-time physical activity among inactive university students.

Our current study has several limitations that need to be addressed. i) The findings of the present study may have limited generalizability to the broader population of South Korean university students, as the program was conducted using a small cohort from a single university. Nevertheless, our study was significant in that the intervention was developed and implemented in the same target population based on beliefs identified in prior research (Lee *et al*, 2025). ii) The use of self-reported surveys is susceptible to recall and social desirability bias. Although the program staff members were able to verify certain aspects of leisure-time physical activity participation, the inclusion of objective measures would have strengthened the assessment of physical activity behavior. iii) Participants were allocated using a sequential alternating procedure rather than true randomization, which could introduce a potential allocation bias. iv) The control group in our study did not receive any intervention materials during the study period. In behavioral intervention research, differences in participant commitment between intervention and control

conditions may impact assessments independent of any intervention content (Pagoto *et al*, 2012; LaFave *et al*, 2019). Future studies should consider incorporating an active control condition to account for potential commitment effects associated with intervention delivery. And (v), in addition to the intervention duration, the relatively short follow-up period might not have been sufficient to detect sustained changes in physical activity behavior among inactive university students. Future research should implement longer interventions and follow-up periods to improve understanding of how the transition of belief changes into subsequent changes in intention and physical activity behavior among inactive university students.

In conclusion, our study showed, despite the aforementioned limitations, that a leisure-time physical activity intervention grounded in theoretically derived beliefs could influence targeted beliefs among inactive university students. Although no significant changes were observed in intention or behavior, the study highlighted the potential role of belief-based approaches as an initial step in promoting physical activity. Future interventions should consider extending the intervention duration (*eg*, 8-12 weeks) and incorporating strategies that facilitate the translation of belief changes into sustained behavioral engagements in leisure-time physical activity.

CONFLICT OF INTEREST DISCLOSURE

The authors declare no conflict of interest.

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