International Journal of
Mental Health Promotion

Tech Science Press

http://doi.org/10.32604/ijmhp.2026.080336

ARTICLE

The Effects of Brain Breaks® on Mental Stress, Resilience, Social Support, and Physical Activity among Emerging Adults in China: A Randomized Controlled Trial

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Received: 07 February 2026; Accepted: 21 April 2026; Published: 31 August 2026

ABSTRACT: Backgrounds: Mental health challenges among Chinese emerging adults have increased in recent years, raising concerns about students' psychological well-being in higher education. Brief, scalable interventions such as Brain Breaks® may offer an effective strategy to promote mental health in higher-education settings. This study aims to examine the effects of a four-week Brain Breaks® exercise program on mental stress, resilience, social support, and physical activity levels among Chinese emerging adults. **Methods:** Eighty college students (aged 19 ± 1.41 years) were randomly assigned to an intervention group (IG) or a control group (CG). The IG received Brain Breaks® video-guided sessions twice weekly for four weeks, while the CG received informational brochures on stress reduction. Outcomes included mental stress assessed using a medical device (uBioMacpa), resilience measured by the Connor-Davidson Resilience Scale (CD-RISC), social support assessed using the Social Support Scale for University Students (SSSUS), and physical activity engagement measured by the Global Physical Activity Questionnaire (GPAQ). A repeated-measures ANOVA tested time, group, and interaction effects. **Results:** Significant time × group interactions were observed for mental stress ($p < 0.001$, $\eta^2 = 0.75$), resilience ($p < 0.001$, $\eta^2 = 0.43$), and physical activity ($p < 0.001$, $\eta^2 = 0.22$), favoring the IG. Mental stress decreased substantially ($\Delta = -17.65$), whereas resilience ($\Delta = +1.02$) and physical activity increased significantly. No changes were observed in social support. **Conclusions:** A brief, digitally delivered Brain Breaks® program is effective in reducing stress and enhancing resilience and physical activity among emerging adults. These findings support the integration of Brain Breaks® into university-based mental health promotion strategies. Longer interventions may be necessary to influence social support.

KEYWORDS: Brain Breaks®; mental stress; resilience; physical activity; emerging adults; mental health promotion

1 Introduction

The growing complexity of modern society and increasing academic and social pressures have contributed to rising psychological distress among young people, particularly emerging adults enrolled in universities. As a high-pressure population navigating rapid developmental, academic, and social transitions, college students are especially vulnerable to stress, emotional difficulties, and maladaptive

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coping responses [1–3]. With limited self-regulation abilities, many students struggle to effectively manage stressors, which can lead to heightened mental stress, reduced functioning, and risk of problematic behaviours. National reports highlight this growing concern: the *Report on National Mental Health Development in China (2021–2022)* indicates that youth mental health has shown minimal improvement since 2009, with a depression detection rate of 24.6% [4]. Similarly, the *2022 Survey Report on the Mental Health Status of College Students* from the Chinese Academy of Sciences identifies stress as a major risk factor strongly associated with anxiety and depression among Chinese undergraduates [5].

Multiple factors contribute to the high stress levels observed in this population, including academic demands, social pressures, financial difficulties, living conditions, and concerns related to self-appearance and identity development [6–8]. These stressors negatively affect well-being and academic achievement and may lead to school attrition or long-term mental health concerns [7,9]. Given these trends, the promotion of mental health among emerging adults has become a public health priority in China, aligning with global frameworks emphasizing early intervention, prevention, and the strengthening of psychological resources. Within mental health promotion models, such as the health-promotion paradigm and positive psychology, enhancing protective factors, like resilience, adaptive coping, and physical activity, plays a central role in preventing mental health problems before they escalate.

Physical activity (PA) has been consistently identified as an effective strategy for improving mental well-being among youth [10–13]. Evidence suggests that PA reduces stress, enhances self-esteem, promotes positive stress appraisals, and modulates emotional responses through physiological mechanisms and neurobiological pathways [14–17]. Nevertheless, university students frequently fail to engage in adequate PA due to academic responsibilities, low motivation, and time constraints [7,9,18,19]. This is problematic because physical inactivity is associated with adverse mental and physical health outcomes, particularly during adolescence and emerging adulthood, a critical developmental window for long-term health trajectories [20].

To address these barriers, Chinese universities have expanded mental health education and counselling services [21,22]. However, these traditional approaches can be resource-intensive, difficult to scale, and often insufficient for meeting the needs of large student populations. Consequently, there is a growing emphasis on brief, scalable, and settings-based interventions that can be seamlessly integrated into daily student routines. Within this context, innovative digital health-promotion tools such as Brain Breaks® have gained attention.

Brain Breaks® is a technology-delivered micro-physical activity program designed to provide short, engaging exercise sessions lasting 3–5 min. These sessions incorporate a variety of enjoyable activities, such as rhythmic movement, music, dance, and culturally adapted PA, that can be easily implemented in classroom or campus environments [23]. Previous research has shown that Brain Breaks® can improve emotional well-being, cognitive engagement, self-confidence, and motivation for PA across diverse populations [24–27]. As a digital, time-efficient intervention, Brain Breaks® aligns well with mental health promotion principles, offering an accessible, low-barrier method to enhance resilience and reduce stress through routine PA engagement. Despite its potential, limited research has examined its use as a mental health promotion strategy among Chinese emerging adults.

Therefore, guided by the proposed multi-pathway framework integrating physiological, psychological, social, and behavioral mechanisms, the present study aims to investigate the effectiveness of a four-week Brain Breaks® intervention on mental stress, resilience, social support, and physical activity among Chinese college students. By focusing on emerging adults, a group at heightened risk for stress-related psychological problems, and employing a brief, technology-enabled, settings-based intervention, this study seeks to provide empirical evidence on how structured activity breaks may influence multiple dimensions of mental health. Specifically, it is hypothesized that Brain Breaks® participation will lead to reduced stress and improvements in resilience, social support, and physical activity. The findings are expected to contribute to the development of scalable mental health promotion strategies for university environments in China.

2 Materials and Methods

2.1 Participants

A priori power analysis was conducted using G*Power 3.1 to determine the minimum required sample size for detecting a moderate effect size (f = 0.25) with 80% power at an alpha level of 0.05. The analysis indicated that at least 62 participants were needed to detect statistically meaningful changes over time [28]. To account for potential attrition, a total of 80 eligible college students from Shangrao Normal University were recruited for the study. Participants were included if they met the following criteria: (a) aged between 18 and 25 years, (b) had a psychological stress level of 45 or higher, as measured by uBioMacpa. Students were excluded if they reported a history of major physical illness, psychiatric disorders, or any contraindications to moderate-to-vigorous physical activity.

All participants provided written informed consent prior to data collection. Ethical approval for the study was obtained from the Universiti Sains Malaysia Human Ethics Committee (Approval No: USM/JEPeM/KK/23030207), and all procedures adhered to institutional and national guidelines for research involving human participants.

2.2 Research Design

This study adopted a two-arm randomized controlled trial (RCT) design to evaluate the efficacy of the Brain Breaks® exercise program in improving mental stress, resilience, social support, and physical activity engagement among college students. RCT designs are regarded as the gold standard for establishing causal relationships in behavioral and mental health research and are well aligned with prevention-focused mental health promotion frameworks.

Randomization was performed using a computer-generated allocation sequence prepared by a research assistant not involved in participant recruitment or data collection. After baseline assessment, participants were randomly assigned in a 1:1 ratio to the intervention group (IG) or control group (CG). Allocation concealment was maintained through sealed, opaque envelopes to reduce selection bias. Because of the nature of the intervention, participants and trainers were not blinded; however, the assessors scoring the psychological measures were blinded to group assignments to minimize detection bias.

The study included two assessment points: pre-test (baseline) and post-test (after the 4-week intervention). Fig. 1 in the original manuscript outlines the study flow and measurement timeline.

2.3 Intervention Protocol

2.3.1 Intervention Group (IG)

Participants assigned to the IG completed Brain Breaks® video-based exercise sessions twice weekly for four consecutive weeks. Each session lasted approximately 20 min and consisted of a series of 3- to 5-min guided exercise videos. These videos were selected from the Brain Breaks® library provided by HOPSports Brain Breaks® Physical Activity Solutions (https://www.brain-breaks.com/). The videos provide moderate-to-vigorous physical activities designed to be engaging, time-efficient, and accessible. The content includes elements such as aerobic movements, rhythmic coordination, martial arts, Pilates, and dance-based exercise routines.

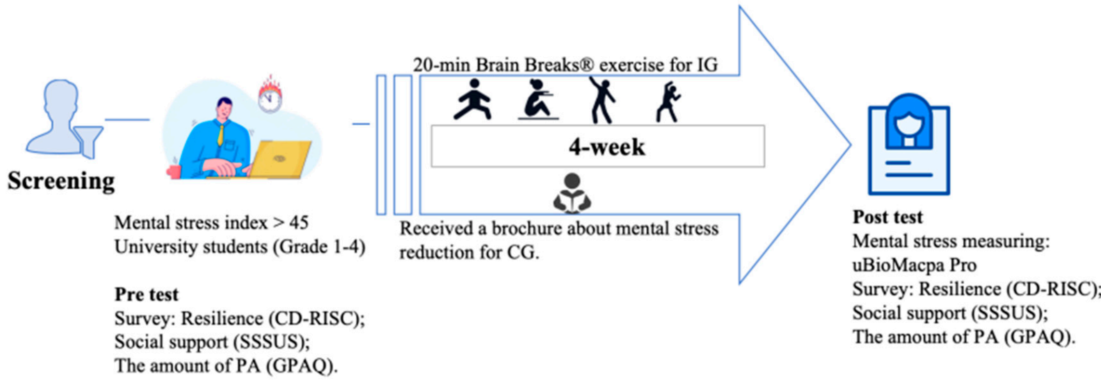

Figure 1: Study design for 4 weeks of Brain Breaks exercise group (IG) and a control group (CG). Notes: CD-RISC: Connor-Davidson Resilience Scale; SSSUS: The Social Support Scale for University Students; GPAQ: Global Physical Activity Questionnaire.

Prior to implementation, all selected videos were reviewed by a panel of sports science experts for appropriateness, safety, and suitability for students experiencing moderate psychological stress. Ten videos were approved and incorporated into a structured four-week intervention plan (see Table 1). Each session included warm-up and cool-down components to minimize injury risk.

Two certified fitness trainers facilitated the sessions in the university's sports science laboratory. Trainers received standardized training from the research team regarding session procedures, safety protocols, and participant monitoring. During each session, the trainers demonstrated proper movement techniques, ensured students followed the video instructions, and supervised exercise intensity. These safeguards were implemented to reduce the likelihood of exercise-related injuries such as muscle strain or fatigue.

Table 1: Brain Breaks intervention program.

Week	Times	Intervention	Specific Steps
1st W	1	Functional Fitness	Warm-up; Lunge grid; Core grid
	2		Warm-up; Fun with fitness; Speed grid
2nd W	1	Cardio exercises	Cardio Balance Dojo ∗ 2 times (9 mins/session, 3 mins break)
	2		Cardio Dojo ∗ 2 times (10 mins/session, 3 mins break)
3rd W	1	Cardio exercises	Cardio kickboxing ∗ 2 times (10 mins/session, 3 mins break)
	2		Jungle fitness ∗ 2 times (10 mins/session, 3 mins break)
4th W	1	Pilates exercises	HOPStick Pilates ∗ 2 times (5 mins/session); Pilates ∗ 1 time (8 mins/session)
	2		HOPStick Pilates ∗ 2 times (5 mins/session); Pilates ∗ 1 time (8 mins/session)

Note: W: week.

2.3.2 Control Group (CG)

Participants in the control group did not receive the Brain Breaks® intervention. Instead, they were provided with a brochure on mental stress management. The distribution of such educational materials is a primary approach for psychological health promotion and monitoring within Chinese higher education institutions. The brochure included general information about stress, its psychological effects, and commonly recommended relaxation strategies. The CG received no structured physical activity component and continued their usual routines throughout the intervention period.

2.4 Implementation of the Blinding Procedure

This study implemented a single-blind design with a robust allocation concealment mechanism to minimize potential biases. During enrollment, participants randomly drew Arabic numerical codes (1–80) from opaque cards without group identifiers, ensuring they remained unaware of their specific assignments to prevent expectancy effects. To enhance methodological rigor, a clear separation of roles was implemented. Research A recorded participant names and codes, while Research B, blinded to baseline characteristics and assigned groups based on a block randomization sequence generated using a specialized web-based randomization tool (Seed: 23103). Furthermore, all outcome assessments and data analysis were conducted by independent evaluators masked to group allocations. This methodological approach aligned with the principles of the CONSORT 2010 guidelines to ensure experimental transparency and scientific rigor. The flowchart is shown in Fig. 2.

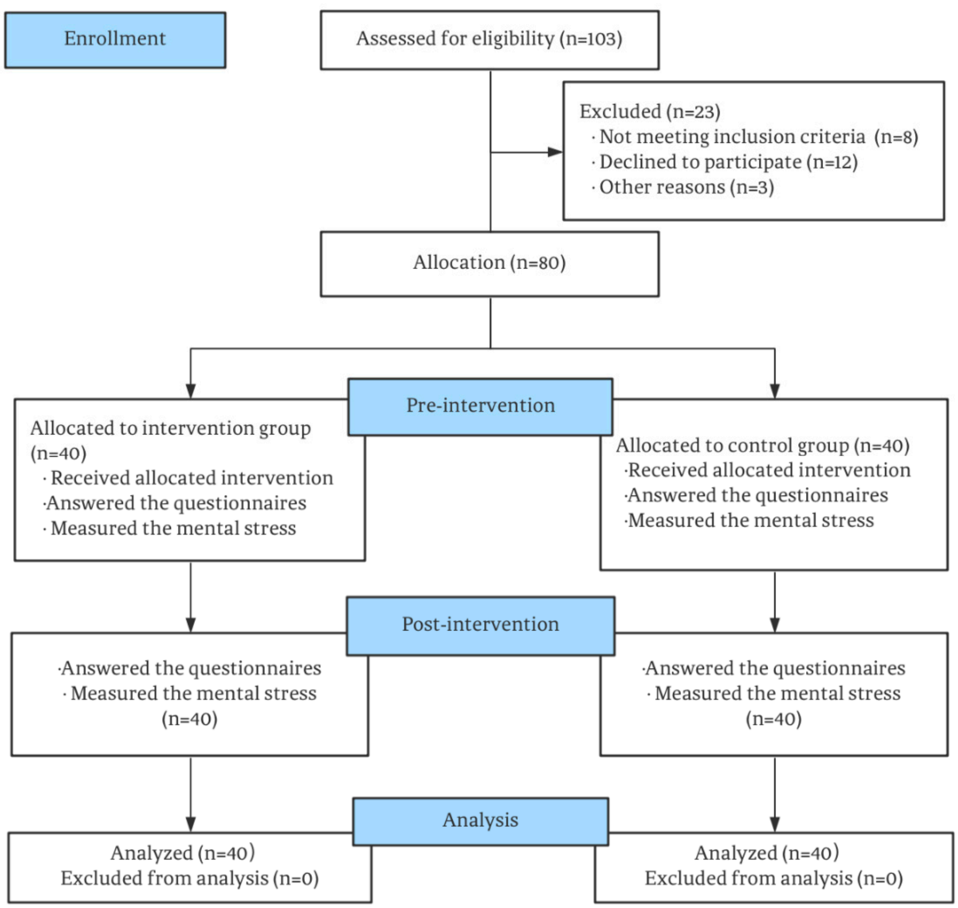

Figure 2: CONSORT flowchart of the study.

2.5 Measures

All participants completed an anonymous self-report questionnaire and an objective stress assessment at baseline and after the 4-week intervention. The total assessment time was approximately 30 min. The following validated instruments were used.

2.5.1 Mental Stress

Mental stress was measured using the uBioMacpa (South Korea), which is produced in South Korea. uBioMacpa has been validated in a previous study of the Chinese population, demonstrating test-retest reliability, inter-rater reliability (ICC > 0.75), and concurrent validity (r = 0.246) [29]. The device measures Heart Rate Variability (HRV) over a 2.5-min measurement period, capturing parameters such as low frequency (LF), high frequency (HF), LF/HF ratio, mean beat per minute (Mean BPM), standard deviation of NN intervals (SDNN), and root mean square of successive differences (RMSSD). These HRV-derived parameters are integrated through a proprietary algorithm to generate a stress index (0–100) that provides a quantitative estimate of accumulated physiological stress, reflecting autonomic nervous system activity. The stress index is divided into 5 groups: <25 (Healthy stress level), 25–35 (Temporary stress), 35–45 (Primary stress); 45–60 (Accumulated stress and weakened stress tolerance), and >60 (Chronic stress requiring medical attention).

2.5.2 Resilience

Resilience was measured using a validated Chinese version of the Connor-Davidson Resilience Scale (CD-RISC) [30]. It's a self-report tool that measures the ability to handle mental stress, adversity, and stressful events. The CD-RISC is a 25-item scale, including "Able to adapt to change", "Close and secure relationships", "Sometimes fate or God can help me", etc. The scale is a five-point Likert-type scale, ranging from 0 (not true at all) to 4 (true nearly all the time). The resilience (CD-RISC) scale consists of three dimensions: tenacity, strength, and optimism. The reliability of the three subscales and the full scale was good, with Cronbach's alpha coefficients of 0.88, 0.88, and 0.60, respectively, and 0.91 for the total scale. The sum of the mean scores for each dimension is used to reflect an individual's level of psychological resilience, with higher scores indicating higher levels of psychological resilience.

2.5.3 Social Support

The Social Support Scale for University Students (SSSUS-17), developed by Ye & Dai (2008), is a 17-item self-report instrument designed to assess social support among university students [31]. The scale is rated on a 5-point Likert scale from 1 (disagree) to 5 (agree) and comprises three subscales: subjective support, objective support, and support utilization. The item discrimination indices range from 0.26 to 0.52, and Cronbach's alpha coefficients for the overall scale and its subscales vary between 0.81 and 0.91, indicating high internal consistency. The scale has been recognized as a reliable and valid measurement tool for measuring university students' social support.

2.5.4 Physical Activity Engagement

Participants' physical activity engagement was estimated using the Chinese version of the Global Physical Activity Questionnaire (GPAQ) [32]. The GPAQ is a 19-item self-report scale, encompassing four different behavioral domains: work-related activities, transportation-related activities, recreational activities, and sedentary behaviors. Levels of total physical activity were classified into three levels: high, moderate, and low. The coefficients of this questionnaire ranged from 0.31 to 0.99, with most over 0.55. For concurrent validity, the correlation coefficients of GPAQ ranged from 0.12 to 0.42 (r = 0.28).

2.6 Data Analysis

The statistical analyses were performed using SPSS 29.0 (IBM Corp., Armonk, NY, USA). The descriptive analysis of the sample utilised the mean and standard deviation (Mean ± SD) to express continuous variables following a normal distribution. An independent sample *t*-test was used to determine if the experimental and control groups were comparable at the pre-test. Assumptions of repeated measures ANOVA, including normality and homogeneity of variance, were evaluated prior to analysis. Upon verification that these assumptions were satisfied, repeated measures ANOVA was employed to examine changes from pre-test to post-test, aiming to identify differences in time, group, and time * group interactions. The level of statistical significance was set as *p*-value < 0.05. Partial eta-squared (η^2) values were calculated as indices of effect size, with 0.01 representing small effects, 0.06 medium effects, and 0.14 large effects.

3 Results

Table 2 presents the characteristics of the participants in the study, with a total of 80 college students. The mean age of all participants was 19 ± 1.41 years. In terms of gender distribution, the IG consisted of 65% females (n = 26) and 35% males (n = 14), while the CG had 57.5% females (n = 23) and 42.5% males (n = 17). Regarding academic grades, 25% of the participants in the IG were freshmen (n = 10), while 32.5% of the CG were freshmen (n = 13). Sophomores made up 25% (n = 10) of the IG and only 7.5% (n = 3) of the CG. Juniors comprised 15% (n = 6) of the IG and 27.5% (n = 11) of the CG. Seniors accounted for 35% (n = 14) of the IG and 32.5% (n = 13) of the CG. Table 1 presents the characteristics of the participants. No statistically significant differences between the groups were identified (p > 0.05).

Table 2: Characteristics of the participants.

Variables	Total (*n* = 80) Mean (SD)	IG (*n* = 40) Mean (SD)	CG (*n* = 40) Mean (SD)	*p*-Value
Age (years)	19 (1.41)	19.9 (1.39)	20.38 (1.44)	0.138[a]
Sex				0.491[b]
Female (n, %)	49 (61.3%)	26 (65%)	23 (57.5%)	-
Male (n, %)	31 (38.7%)	14 (35%)	17 (42.5%)	-
Grade				0.129[b]
Freshman (n, %)	23 (28.8%)	10 (25%)	13 (32.5%)	
Sophomore (n, %)	13 (16.3%)	10 (25%)	3 (7.5%)	-
Junior (n, %)	17 (21.2%)	6 (15%)	11 (27.5%)	-
Senior (n, %)	27 (33.8%)	14 (35%)	13 (32.5%)	-

Notes: IG = Intervention group, CG = Control group. SD = Standard Deviation. [a]Independent *t*-test. [b]Chi-squared test.

Table 3 shows the comparison scores of mental stress, resilience, social support, and physical activity for the two groups from baseline to post-intervention. Meanwhile, Fig. 3 illustrates the mean scores of the IG and CG groups at pretest and posttest. After 4 weeks of intervention, the mental stress score was significantly decreased by −17.65 ± 5.32 with a larger effect size (d = 4.66) in the IG. The interaction effect between time and group was significant ($F_{1,78}$ = 235.09, p < 0.001, η^2 = 0.75), indicating that the reduction in mental stress was significantly greater in the IG compared to CG.

Table 3: Descriptive statistics and ANOVA at pre-test/post-test for Chinese college students in the intervention group (IG, n = 40) and control group (CG, n = 40).

Variables	Group	Pre-Test Mean (SD)	Post-Test Mean (SD)	Mean Change	Effect Size	Time			Group			Time * Group		
						$F_{1,78}$	p	η^2	$F_{1,78}$	p	η^2	$F_{1,78}$	p	η^2
Mental stress	CG IG	50.13 (3.75) 49.35 (3)	49.10 (5.15) 31.70 (4.44)	−1.03 ± 4.50 −17.65 ± 5.32**	0.23 4.66	296.64	<0.001	0.79	144.23	<0.001	0.65	235.09	<0.001	0.75
Resilience	CG IG	3.30 (0.45) 3.34 (0.42)	3.44 (0.36) 4.31 (0.38)	0.14 ± 0.49 1.02 ± 0.58**	−0.34 −2.42	108.04	<0.001	0.58	38.02	<0.001	0.33	59.76	<0.01	0.43
Tenacity	CG IG	2.99 (0.82) 3.01 (0.58)	3.06 (0.66) 4.22 (0.72)	0.07 ± 0.82 1.21 ± 0.89**	−0.09 −1.85	44.47	<0.001	0.36	22.86	<0.01	0.28	36.00	<0.001	0.32
Strength	CG IG	3.61 (0.58) 3.74 (0.89)	3.77 (0.65) 4.49 (0.66)	0.16 ± 0.58 0.75 ± 0.98**	−0.26 −0.96	25.78	<0.001	0.25	10.51	<0.05	0.12	10.63	<0.05	0.12
Optimism	CG IG	3.29 (0.77) 3.27 (0.63)	3.49 (0.66) 4.21 (0.67)	0.20 ± 0.55 0.94 ± 0.95**	−0.28 −1.45	43.29	<0.001	0.36	7.60	<0.05	0.09	18.2	<0.01	0.19
Social support	CG IG	3.37 (0.51) 3.39 (0.58)	3.34 (0.49) 3.39 (0.61)	−0.03 ± 0.38 0.09 ± 0.67	0.06 −0.053	0.28	0.724	0.004	0.69	0.42	0.01	1.06	>0.05	0.013
Subjective support	CG IG	3.58 (0.77) 3.42 (0.69)	3.54 (0.86) 3.61 (1.21)	−0.05 ± 0.55 0.19 ± 1.44	0.049 −0.19	0.33	0.794	0.004	0.077	0.783	0.001	0.529	>0.05	0.011
Objective support	CG IG	3.09 (0.77) 3.35 (0.68)	3.00 (0.82) 3.33 (1.23)	−0.09 ± 0.71 −0.02 ± 1.16	0.113 0.02	0.27	0.547	0.004	3.15	0.08	0.039	0.11	>0.05	0.001
Support utilization	CG IG	3.43 (0.83) 3.40 (0.91)	3.48 (0.86) 3.53 (0.93)	0.05 ± 0.78 0.12 ± 1.11	−0.05 −0.13	0.603	0.766.	0.008	0.003	0.958	0.00	0.125	>0.05	0.002
Physical activity	CG IG	1.65 (0.80) 1.83 (0.75)	1.48 (0.64) 2.41 (0.71)	−0.18 ± 0.59 0.58 ± 0.90**	−0.94 −0.78	4.27	<0.005	0.05	14.01	<0.001	0.15	22.31	<0.001	0.22

Notes: CG: Control group; IG: Intervention group; SD: Standard Deviation. $^{**}p < 0.01$.

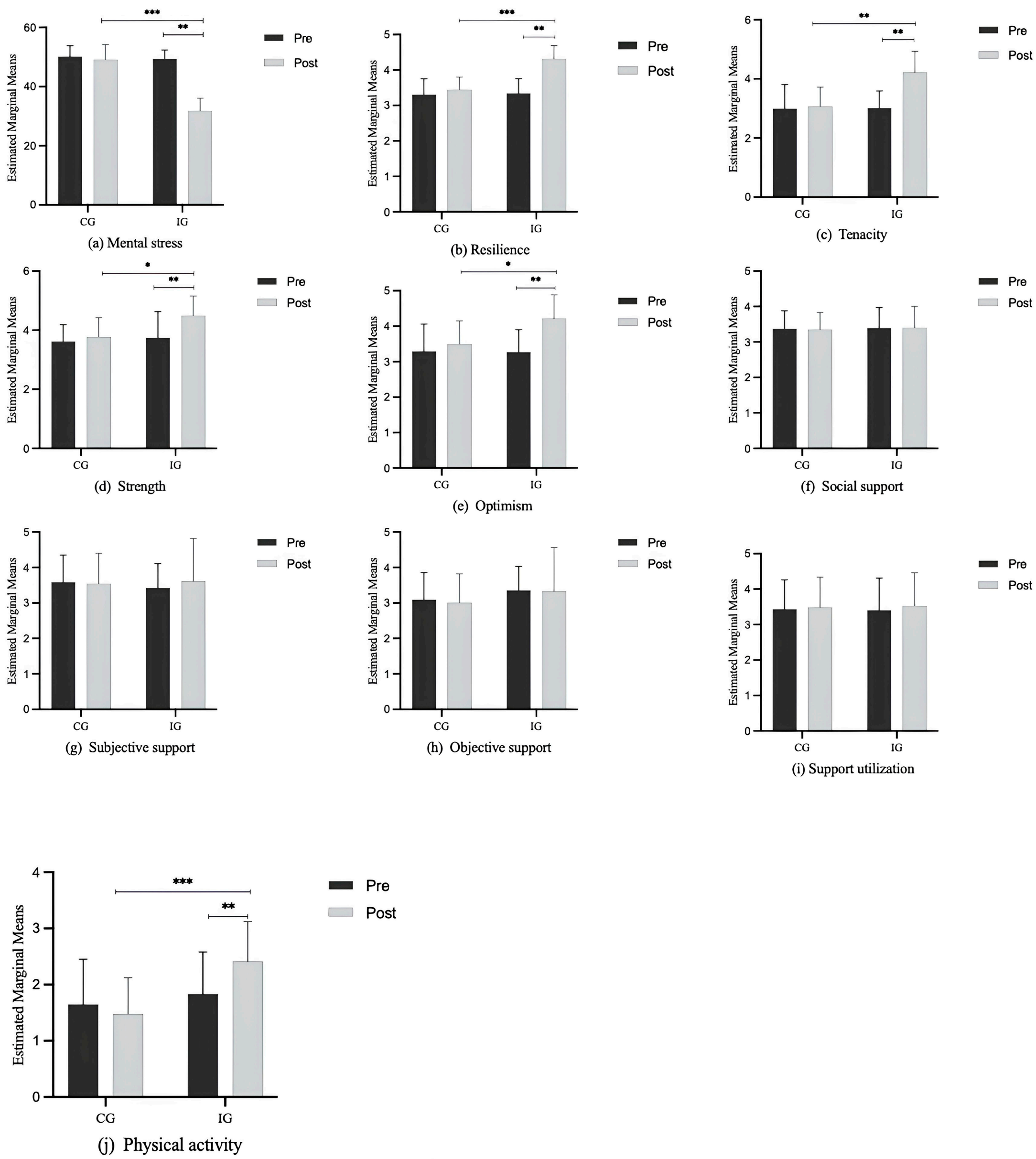

Figure 3: Mean scores of the IG and CG groups at pretest and posttest. Notes: CG: Control group; IG: Intervention group; (**a**) Mental stress, (**b**) Resilience, (**c**) Tenacity, (**d**) Strength, (**e**) Optimism, (**f**) Social support, (**g**) Subjective support, (**h**) Objective support, (**i**) Support utilization, (**j**) Physical activity. $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

The resilience score was significantly improved by 1.02 ± 0.58 with an effect size of −2.42 in the IG, meanwhile CG showed no significant change. There were significant improvements in the three subscales in the IG (Tenacity: $F_{1,78} = 36.00$, $p < 0.001$, $\eta^2 = 0.32$; Strength: $F_{1,78} = 10.63$, $p < 0.05$, $\eta^2 = 0.12$; Optimism: $F_{1,78} = 18.2$, $p < 0.01$, $\eta^2 = 0.19$), with no significant change observed in the CG.

For social support, both IG and CG displayed no significant changes from baseline to post-intervention ($p > 0.05$). Concurrently, no significant changes were shown in either group for subjective support, objective support, and support utilization ($p > 0.05$).

For the IG, the amount of PA significantly increased by 0.58 ± 0.90 with an effect size of −0.78. A significant interaction effect was found between time and group ($F_{1,78} = 22.31$, $p < 0.001$, $\eta^2 = 0.22$), indicating that the IG experienced a greater increase in the amount of PA compared to the CG.

4 Discussion

The present RCT examined the effects of a four-week Brain Breaks® intervention on mental stress, resilience, social support, and physical activity engagement among Chinese emerging adults. The findings demonstrated that participation in brief, structured, video-guided physical activity sessions resulted in significant reductions in mental stress, as well as improvements in overall resilience and physical activity levels compared to the control group. These results support existing health promotion frameworks emphasizing the value of brief, feasible, and enjoyable interventions in enhancing psychological functioning among young adults [10–13].

Consistent with earlier evidence linking physical activity to stress reduction [14–17], the intervention produced a substantial decrease in physiological stress. One possible reason for the large observed effect is the relatively high baseline stress levels in our sample, which may have allowed for greater reductions over a brief intervention period. In addition, Brain Breaks® combines multiple elements, short bouts of enjoyable movement with rhythmic music, which may have synergistically enhanced both physiological and psychological stress recovery. Physiological mechanisms such as modulation of the autonomic nervous system and release of neuropeptides (e.g., β-endorphin) may contribute to improved affective states and stress recovery [16,17]. Psychological mechanisms, such as increased perceived competence, enhanced self-efficacy, and positive mood activation, likely also played a role [14,15]. Given the high prevalence of stress and psychological burden among Chinese college students [4,5], these findings highlight Brain Breaks® as a promising approach to stress reduction in university settings.

The intervention also yielded statistically significant gains in resilience and its subcomponents (tenacity, strength, and optimism). These results align with previous studies demonstrating that participation in structured physical activity can enhance adaptive coping skills and psychological resilience among youth and young adults [33–36]. The design of Brain Breaks®, which encourages mastery of small, attainable goals and integrates enjoyable and rhythmic movement, may facilitate positive cognitive appraisals and strengthen internal psychological resources. PA engagement has also been linked to neurobiological factors such as increased brain-derived neurotrophic factor (BDNF), which supports neural plasticity and emotional regulation [37–39]. Collectively, these mechanisms may help explain the observed resilience improvements.

The significant increase in PA among participants in the IG suggests that micro-interventions such as Brain Breaks® can effectively overcome common barriers reported by university students, including lack of time, fatigue, and low motivation [7,9,18,19]. This is noteworthy in the Chinese university context, where academic pressure often limits engagement in health-enhancing behaviours [21,22]. By offering brief, easy-to-implement, and enjoyable activities, Brain Breaks® may help students incorporate physical movement into their daily routines, contributing to long-term health promotion.

Unlike the other outcomes, social support did not significantly change over the intervention period. A potential explanation for this finding is the relatively short duration of the intervention, which consisted of only four weeks with two sessions per week. This finding contrasts with some previous Brain Breaks® studies reporting increases in perceived support and social connectedness [40]. However, changes in social support often require longer exposure durations, opportunities for interpersonal interaction, and the development of meaningful relationships [41,42]. Because Brain Breaks® sessions in this study were focused primarily on individual participation and brief activity engagement, they may not have provided sufficient time or social context to affect perceptions of support.

Taken together, the study's findings support the use of Brain Breaks® within settings-based mental health promotion, particularly in higher-education environments. The intervention's brevity, low cost, digital delivery, and minimal resource requirements make it highly scalable. Its capacity to reduce stress and enhance resilience aligns with preventive mental health strategies that aim to strengthen protective factors before mental health conditions escalate. Given China's growing concern regarding youth mental health [4,5], integrating Brain Breaks® into university wellness curricula, classroom sessions, or campus-wide initiatives could serve as an effective and sustainable component of a broader mental health promotion framework.

5 Limitations

Despite the positive outcomes observed, several limitations should be considered when interpreting the present findings. First, data were collected from a single university, which may limit the generalizability of the results to other regions and student populations. Given the specific academic environment and lifestyle of our participants, future research should examine the intervention across diverse academic institutions, cultural contexts, and varied age groups. Second, the four-week intervention period may have been insufficient to influence outcomes that rely on interpersonal processes, such as social support. Longer intervention periods or designs incorporating peer-interaction or collaborative activities may be needed to detect meaningful changes in this domain. Third, several outcome measures relied on self-report instruments, which are subject to social desirability, recall bias, or subjective appraisal. These biases could potentially affect the magnitude and direction of observed associations, leading to over- or underestimation of relationships among these variables. While validated instruments were used, interpretation of the findings should be made with caution. Incorporating objective measures of psychological functioning or ecological momentary assessment could provide greater precision in future studies. Fourth, the study did not include neurobiological or physiological markers (e.g., BDNF, dopamine activity, cortisol levels) that could help elucidate the mechanisms underlying the observed improvements in stress and resilience. Integrating psychophysiological measures in future research would contribute to a more comprehensive understanding of how brief PA interventions promote mental health. Fifth, the control condition may not have provided a comparable level of engagement relative to the intervention. Although the use of a mental health brochure reflects a common approach to psychological health promotion in Chinese university settings, it lacked the structured supervision, interaction, and social engagement inherent in the Brain Breaks® sessions. Consequently, some of the observed effects may be partially attributable to non-specific factors such as attention, participant engagement, or social interaction rather than the intervention itself. Future studies should consider employing more active control conditions to better isolate the specific effects of the intervention.

6 Conclusions

The findings from this RCT indicate that a brief, technology-delivered Brain Breaks® intervention can significantly reduce mental stress, enhance psychological resilience, and increase physical activity engagement among emerging adults in China. As a feasible, scalable, and low-resource digital tool, Brain Breaks® has strong potential for integration into university-based mental health promotion programs. Future studies should examine the long-term effects of Brain Breaks®, explore mechanisms related to social support enhancement, and evaluate implementation strategies for embedding this intervention within campus health initiatives.

Acknowledgement: We are deeply grateful to all the anonymous participants who took part in this research. Their contributions have been invaluable to the successful completion of this study. The authors would like to acknowledge Ming-Kai Chin for his guidance and for providing the Brain breaks platform, under the GCH and HOPSports® Inc.

Funding Statement: This research was supported by the Humanities and Social Science Fund of the Ministry of Education of China (24YJC890073), the Social Science Foundation of Jiangxi Province (Grant No. 24TY12), and the Research Project of the Jiangxi Provincial Sports Bureau (Grant No. 2025099). These funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Author Contributions: The authors confirm contribution to the paper as follows: Conceptualization, Mingzhu Pan, Garry Kuan and Yanjie Zhang; methodology, Mingzhu Pan, Garry Kuan and Yee Cheng Kueh; investigation, Mingzhu Pan and Linghong Liu; formal analysis, Mingzhu Pan, Linghong Liu and Xinxing Li; data curation, Xinxing Li and Linghong Liu; writing-original draft preparation, Mingzhu Pan and Xinxing Li; writing—review and editing, Mingzhu Pan, Yanjie Zhang, Yee Cheng Kueh and Garry Kuan. All authors reviewed and approved the final version of the manuscript.

Availability of Data and Materials: The data that support the findings of this study are available from the corresponding author.

Ethics Approval: The study involving humans was approved by the Universiti Sains Malaysia Human Ethics Approval Committee (Approval No: USM/JEPeM/KK/23030207). The study was conducted in accordance with the local legislation and institutional requirements. The participants provided their informed consent to participate in this study.

Conflicts of Interest: The authors declare no conflicts of interest.

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